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Physical and Mental Health of Chinese Grandparents Caring for Grandchildren and Great-grandparents

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Abstract

The increasing worldwide prevalence and intensity of grandparenting has attracted an attention to its health implications for caregivers against the backdrop of population aging. Thanks to prolonged life expectancy and reduced infant mortality, extended families that comprise four generations, co-residential or not, are no longer rare in China. The current study examines health consequences when Chinese grandparents provide care to not only grandchildren but also their own elderly parents or parents-in-law (i.e., great-grandparents). Drawing on data from the 2011–2013 China Health and Retirement Longitudinal Study (CHARLS), mental health was captured by levels of life satisfaction and depressive symptoms, and physical health was measured by levels of high sensitivity C-reactive protein (CRP), hypertension, high-risk pulse rate, and diabetes. Overall grandparents who cared for grandchildren only had better mental and physical health, compared with non-caregivers. There was some evidence that the 'sandwich' grandparents who cared for both grandchildren and great-grandparents reported greater life satisfaction, fewer depressive symptoms, and reduced hypertension compared with non-caregivers. The health advantage of caregiving was most pronounced in urban grandfathers whose caregiving conformed to the norm of filial piety and who did so most likely to seek emotional reward instead of an intergenerational time-for-money exchange. In contrast, rural grandmothers were the most vulnerable group and their health disadvantage seemed to arise from caring for great-grandparents. These findings highlight the importance of rural-urban context and gender role in studying the health effects of intergenerational caregiving on Chinese grandparents.

Keywords

China; grandparent; great-grandparent; intergenerational caregiving; mental health; physical health

Introduction

Grandparents play a pivotal role in providing grandchild care, although the associated cultural values and family norms vary from one society to another. For example, American grandparents often value their independent living and social activities and are accustomed to

providing supplementary assistance in caring for grandchildren (Cherlin & Furstenberg, 1992; Jendrek, 1993; Neugarten & Weinstein, 1964; Pruchno, 1999). They are not culturally expected to assume full-time, custodial responsibility of care for grandchildren unless adult children are in times of crisis such as divorce, poverty, substance abuse, mental health problems, and incarceration (Burnette et al., 2013; Goodman & Silverstein, 2001, 2002; Minkler, 1999). In contrast, traditional family norms in East Asia highly value multigenerational co-residence as an ideal living arrangement that promotes filial piety, family solidarity and collective family interests over individual interests. Multigenerational co-residence, as well as the 'networked' living arrangement – living apart but in close proximity (Logan et al., 1998), allows grandparents to be involved in grandchildren care on a daily basis without claiming a custodial responsibility (Chen et al., 2000; Short et al., 2001). These norms are validated by the Chinese tradition and Philosophy of Confucianism which emphasizes the importance of family harmony.

Since the early 1990s, the increasing worldwide prevalence and intensity of grandparenting has attracted an attention to its health implications for caregivers against the backdrop of population aging. Earlier research in the U.S. reported negative health effects of caring for grandchildren. In particular, extensive and custodial grandparenting has been associated with poor health outcomes including elevated depressive symptoms (Blustein et al., 2004; Minkler et al., 1997), declined life satisfaction (Szinovacz et al., 1999) and more functional limitations (Minkler & Fuller-Thomson, 2001), although these health disadvantages may have been pre-existing (Arpino & Bordone, 2014; Hughes et al., 2007). In contrast, recent research in China, Hong Kong, and Taiwan often found health advantages for grandparents who provide occasional, extensive, or even custodial care to grandchildren. Relative to non-caregivers, caregiving grandparents experience reduced depressive symptoms (Cong & Silverstein, 2008b; Silverstein et al., 2006; Tsai et al., 2013), better self-rated health (Ku et al., 2013), greater life satisfaction (Ku et al., 2013; Silverstein et al., 2006; Xu et al., 2012), and fewer functional health limitations (Guo et al., 2008), although some studies reported negative or absence of health effects (Chen & Liu, 2011; Lo & Liu, 2009; Lou, 2011).

Building on this literature, the current study examines health consequences when Chinese grandparents provide care to not only grandchildren but also their own elderly parents or parents-in-law (i.e., great-grandparents). As the average life expectancy in China grew from 66.3 to 72.4 years in men and from 69.3 to 77.4 years in women between 1981 and 2010, and infant mortality rate dropped from 32.9 per 1,000 live births in 1990 to 13.9 in 2010 (NBSC, 2012), extended families that comprise four generations, co-residential or not, are no longer rare. Despite the lack of official statistics, nearly 29% of the sampled middle-age or older adults in the 2011 China Health and Retirement Longitudinal Study (CHARLS) were grandparents in lineages that comprised four generations with at least one grandchild under the age of 16 and at least one living great-grandparent (author's calculation).

The first set of research questions in this study asks, in the context of four-generation Chinese families: How does caring for grandchildren affect grandparents' health? Does caring for great-grandparents, independent of caring for grandchildren, have any health impact? Does simultaneously caring for grandchildren and great-grandparents impose dual health burden on grandparents? China's traditional family norms prescribe gendered roles

and responsibilities in domestic life and caregiving practice (Cong & Silverstein, 2008b; Lou, 2011; Short et al., 2001). These norms have also evolved to varying degrees in rural and urban areas due to uneven economic growth and social change (Chen & Liu, 2011; Xuan & Merril, 2000). Therefore, the second set of research questions in this study asks: Does the health effect of caregiving for grandchildren and great-grandparents vary by the gender of grandparents or their rural-urban residence?

This study expands the growing literature on the health implications of grandparents' caregiving in developing countries in several ways. First, it situates grandparenthood and caregiving in a new context in which aging grandparents are involved in caregiving for their elderly parents in addition to their grandchildren. Such dual burden of caregiving is likely to increase at a population level as life expectancy and health status of older adults continues to improve. Second, although several studies in China have noticed gender or rural-urban difference in the health effects of caring for grandchildren, this study is one of the few that systematically investigates the gender and rural-urban contexts (for exception, see Chen & Liu, 2011). Third, unlike most previous studies of Chinese grandparents that rely on regional, non-representative samples, this study draws on publicly available data from a nationally representative longitudinal survey, making the findings more generalizable, transparent, and replicable. Third, in terms of health outcomes, most previous studies are restricted to grandparents' psychological well-being. In a few studies that incorporate physical health, only crude measures such as self-reported general health status and functional limitations are assessed (Chen & Liu, 2011; Guo et al., 2008; Ku et al., 2013). In addition to psychological health, this study also examines physical health with biomarker data which sheds new light on the biological pathway linking grandparents' caregiving to their disease risks.

Theoretical Background

Health risks of intergenerational caregiving

The literature on grandparenting has suggested several pathways through which caring for grandchildren may be detrimental to health. First of all, caregiving can be physically demanding for grandparents who themselves are experiencing normal, age-related health decline (Jendrek, 1993). Second, caring for grandchildren may limit grandparents' time and opportunities for participation in leisure and recreational activities (Jendrek, 1993), social engagement (Minkler, 1999; Pruchno, 1999), self-care, and medical care (Baker & Silverstein, 2008b; Minkler et al., 1992), all of which undermine their health status. Third, caregiving for grandchildren, especially in an intensive manner, imposes a financial burden for grandparents (Emick & Hayslip Jr., 1999; Szinovacz et al., 1999). Fourth, intergenerational conflicts between grandparents and parents may arise from co-parenting of grandchildren. This may be particularly relevant in the Chinese context where multi-generational co-residence is a traditional ideal yet the younger generations have adopted different cultural values and social norms compared to the older generations. One study found that Chinese grandparents and parents differed in their perceptions of the role of non-custodial caregiver, resulting in intergenerational conflicts with each other with respect to the management of grandchildren (Leung & Fung, 2014). Another study found no deficit in

self-reported health among custodial grandparents whose grandchildren lived with them but the parents did not (i.e., skipped-generation households), whereas caregiving grandparents who lived with their grandchildren and the parents, experienced faster health decline (Chen & Liu, 2011).

Lastly, some grandparents may be facing economic hardship and health problems before taking on new caregiving roles. In the U.S., grandparents who assume the role of custodial caregivers tend to be racial and ethnic minorities who have low socioeconomic status (Burnette et al., 2013; Goodman & Silverstein, 2001, 2002; Minkler, 1999). In China, grandparents in rural areas who lack social security benefits and appropriate health care enter into custodial caregiving in skipped-generation households when their adult children migrate to urban areas for better job opportunities, leaving the grandchildren behind (Silverstein & Cong, 2013; Silverstein et al., 2006). The health disadvantage caused by preexisting socioeconomic and physical strains can be further elevated by transition into caregiving grandparenthood (Arpino & Bordone, 2014; Baker & Silverstein, 2008a; Hughes et al., 2007).

It is possible that many of these pathways also operate in similar ways to link caring for great-grandparents to grandparents' health risks. To the extent that participation in multiple caregiving roles may act as a stressor in and of itself (Baker & Silverstein, 2008a), caring for grandchildren and great-grandparents simultaneously is expected to further aggravate the physical, psychological, and economic strains experienced from participation in a single caregiving role.

Health benefits of intergenerational caregiving

Providing care to grandchildren and great-grandparents is one strategy for grandparents to stay active at older ages (Hilbrand et al., 2017). Such caregiving behavior can provide health benefits to grandparents through a psychosocial pathway. The literature on grandchild care has suggested that grandparent caregivers enjoy enhanced feelings of self-efficacy and self-esteem, a stronger sense of self-worth, a new purpose of life in later life, and more intimate ties within extended families, all of which contribute positively to their subjective well-being and psychological health (Emick & Hayslip Jr., 1999; Goodman & Silverstein, 2002; Guo et al., 2008; Lou, 2011; Mahne & Huxhold, 2015). The boost in psychological well-being may translate into better physical health (Di Gessa et al., 2016; Ku et al., 2013) and increased longevity (Hilbrand et al., 2017) for grandparent caregivers, compared with non-caregivers.

The psychosocial health benefits of grandchild care may be more salient in the Chinese context than in Western countries. Even though the notion of filial piety itself does not charge grandparents with primary responsibility for the care of grandchildren (Short et al., 2001), grandparents, especially paternal grandmothers, are culturally permitted to intervene if they perceive inappropriate child rearing by daughters-in-law (Cong & Silverstein, 2008b). Moreover, despite changes in living arrangements and child-rearing practices in recent decades, there is evidence that the corporate group model, characterized by mutual aid and interdependence across generations, still persists in Chinese families, especially in rural areas (Cong & Silverstein, 2012a; Y.-J. Lee & Xiao, 1998; Silverstein et al., 2006; Sun, 2002). In such corporate families, Chinese grandparents tend to place a stronger emphasis on

the collective well-being of their extended families and value family solidarity, harmony, and continuity more than their peers in Western cultures (Burnette et al., 2013; Xu et al., 2012). As a way for grandparents to fulfill these cultural values, caring for grandchildren or great-grandparents should be emotionally rewarding and life affirming, thereby promoting mental health.

The corporate group model of the Chinese family also describes an intergenerational time-for-money exchange in which grandparents spend time providing grandchild care to allow their adult children to seize economic opportunities and as a result contribute to the material well-being of the Grandparents through reciprocal transfers of money or living necessities (Cong & Silverstein, 2008b, 2011; Y.-J. Lee & Xiao, 1998; Sun, 2002). Financial support from adult children is particularly important for Chinese grandparents in rural areas where the poverty rate remains high and a formal social security system is absent. Using data from a rural region in China with massive labor force migration, several studies found that the amount of grandchild care provided by grandparents was positively related to the amount of remittance received from their migrant children, which in turn not only improved their nutrition and physical health by allowing them to purchase food and afford health care, but also improved life satisfaction and reduced depressive symptoms (Cong & Silverstein, 2008b, 2011, 2012a; Silverstein et al., 2006).

In addition to psychosocial and financial benefits, there is some evidence that grandparents may derive physical benefit directly from grandchild care in a Chinese society. Using nationally representative data from Taiwan, one study found that all caregiving grandparents, whether those living in multi-generational families or skipped-generation households, or who did not reside with grandchildren, suffered fewer mobility limitations than non-caregivers, and this health benefit could be attributable to increased physical activity from interacting with grandchildren (Ku et al., 2013).

The same health benefits of caring for grandchildren do not necessarily hold with respect to great-grandparents. For example, even though it fulfills an obligation culturally scripted by filial piety, caring for great-grandparents may not be viewed as an equal contribution to the succession of generations as caring for grandchildren, and thus it can be psychologically less rewarding. In terms of intergenerational transfer, caring for great-grandparents involves mainly upstream personal care, emotional support, and financial assistance from grandparents, which in the view of filial piety are in exchange for great-grandparents' investment in grandparents' early life. In addition, compared with caring for grandchildren, grandparents may be less likely to derive pleasure or life satisfaction from caring for aged great-grandparents whose declining health status induces negative emotions.

Rural-urban context

The discussion above has already alluded to the significance of rural-urban context in understanding intergenerational caregiving in Chinese families. Several aspects of rural-urban differences are relevant to this study. First, China's rapid urbanization, unprecedented economic growth, and dramatic social change in the past decades have weakened various traditional norms and cultural values, but less so in rural areas compared to urban areas (Raymo et al., 2015; J. Yu & Xie, 2015). Second, in the absence of a sound social security

system and affordable high quality health care, rural Chinese older adults have to rely heavily on the corporate group model for elderly support (Cong & Silverstein, 2008b, 2011; Y.-J. Lee & Xiao, 1998; Sun, 2002). Third, rural Chinese grandparents are more likely than their urban peers to become custodial caregivers in skipped-generation households because of adult children's labor force migration from rural to urban areas and various *hukou* (household registration)-based institutional barriers for grandchildren to migrate with their parents (Silverstein & Cong, 2013). Fourth, China's one-child policy was strictly implemented in urban areas but not in rural areas. As a result, better-off urban grandparents tend to compete for the opportunity to nurture and care for a shrinking number of grandchildren to meet their need for grandchildren's love and company (Tsai et al., 2013; Xie & Xia, 2011), whereas financially unstable rural grandparents tend to struggle to care for multiple grandchildren from different adult children's families (Cong & Silverstein, 2011, 2012b).

These rural-urban differences suggest that on one hand, rural Chinese grandparents may be more accustomed to fulfill intensive caregiving obligations and cope with the associated physical and psychological strains, compared with their urban peers. However, rural grandparents are also more likely to be financially dependent on their adult children and consider grandchild care as a reciprocal form of intergenerational exchange instead of an emotionally rewarding, altruistic activity (Chen & Liu, 2011). Their subjective well-being tends to be more sensitive to a sense of financial security which can be easily threatened when, for example, grandchild care is not appropriately compensated in monetary terms. In fact, one study found that rural Chinese grandparents reported greater life satisfaction when they received care and monetary assistance from grandchildren but not when they cared for grandchildren (Xu & Chi, 2011).

Gender context

Gender context is another important aspect in considering the health implications of Chinese grandparents' caregiving. In fact, in many Western and East Asian societies, social norms and practices of intergenerational caregiving are divided along gender lines. Women are typically expected to be responsible for domestic affairs in family life (e.g., housekeeping and childcare), play a nurturing role, and serve as kin-keepers, while men are expected to fulfil the role of breadwinners. The traditional patrilineal culture and filial piety in East Asia further prescribe that unmarried daughters and daughters-in-law are obligated to provide personal care, instrumental support, and emotional support to elderly parents, whereas sons, married or not, are primarily responsible for providing financial support (Cong & Silverstein, 2008a; Y.-J. Lee et al., 1994; L. C. Yu et al., 1990).

There is evidence that these gender stereotypes have been carried over among grandparent caregivers. In the U.S., early national estimates showed that less than a quarter of grandparent caregivers were grandfathers (Fuller-Thomson et al., 1997), although the gender gap was narrowed over time (Hughes et al., 2007). In China, one study found that in multigenerational co-residential households, grandmothers spent a comparable amount of time to mothers in childcare, which was three times as much time as grandfathers spent in childcare (Chen et al., 2011). When Chinese grandfathers are involved in grandchild care,

they tend to play such roles as fun-seeker, playmate, and companion rather than fulfilling more intensive responsibilities, such as feeding, bathing, and dressing (Lo & Liu, 2009; Xie & Xia, 2011).

The gendered norm of intergenerational caregiving suggests that compared with grandmothers, grandfathers may have acquired fewer skills and resources over the life course to appropriately care for their parents and grandchildren. Grandfathers may also experience additional role strain or even social stigma if they are heavily involved in intergenerational caregiving, which deviates from the traditional norm. Therefore, the same amount of intergenerational caregiving may be more psychologically stressful to grandfathers than grandmothers. In the U.S., two studies reported that intensive grandchild care was associated with more depressive symptoms for grandmothers, but less so for grandfathers (Blustein et al., 2004; Szinovacz et al., 1999). Another study found a positive association between babysitting and self-rated health among grandmothers but not grandfathers (Hughes et al., 2007). In Europe, a positive association between grandchild care and physical health was found only for grandmothers but not for grandfathers (Di Gessa et al., 2016). In China, among grandparents who provided intensive grandchild care, grandfathers were found to experience a faster decline in self-rated health than grandmothers (Chen & Liu, 2011).

Research hypotheses

The discussion above suggests that compared with non-caregivers, the net health effect tends to be positive for Chinese grandparents who care for grandchildren only (*Hypothesis 1a*), but negative for Chinese grandparents who care for great-grandparents (including in-laws) only (*Hypothesis 1b*) or who care for both grandchildren and great-grandparents (*Hypothesis 1c*). To the extent that urban grandparents have more resources available, they are expected to experience less severe strain and derive greater health benefits from caregiving, compared with rural grandparents (*Hypothesis 2*). In a similar vein, grandmothers are expected to enjoy more health benefits from caregiving than grandfathers (*Hypothesis 3*).

Data and Measures

Individual-level data were drawn from the 2011 baseline and 2013 follow-up surveys of the China Health and Retirement Longitudinal Study (CHARLS), a nationally representative longitudinal survey of adults aged 45 and older and their spouses, if available. CHARLS sampled 17,708 residents from 150 counties across 28 provinces in China, with a response rate of 80.5%, in 2011. This study focused on middle-aged and older adults who were grandparents in four-generation families and who might provide care to their parents or parents-in-law (i.e., great-grandparents), grandchildren, or both.

In the CHARLS baseline survey, 4,971 out of 17,342 (or 28.7% of) respondents had at least one parent or parent-in-law alive and at least one grandchild under age 16 at the time of interview. In other words, they were the grandparents in four-generation families, irrespective of co-residence or not. Among them, 86 respondents were excluded because of missing data on any covariate, and another 240 respondents were dropped because of no valid data on any baseline outcome, resulting in a sample size of 4,645. To maximize

statistical power, the analytical sample size was allowed to vary depending on the number of valid responses for each outcome variable. As a result, the sample sizes ranged from 3,346 to 4,473 for analyzing baseline cognition. In the analysis of longitudinal change over the two-year follow-up, 491 baseline participants who were not tracked in 2013 were further excluded. The longitudinal sample sizes ranged from 2,663 to 3,770, depending on the outcome of interest. Statistical adjustment for missing data is described in the next section.

The outcomes of interest are mental and physical health. Mental health was captured by two continuous variables: life satisfaction and depressive symptoms, both of which have been the focus of psychological well-being in the literature (Xu et al., 2012). Life satisfaction was derived from the survey question: “Please think about your life-as-a-whole. How satisfied are you with it?” The responses were recorded on a 5-point Likert scale and ranged from “not at all satisfied” (=1) to “completely satisfied” (=5). This measure reflects the cognitive dimension of general satisfaction with life (Boey, 1999) and has been used as an indicator of subjective well-being in both young and old Chinese adults (Appleton & Song, 2008; Ren & Treiman, 2015; Zhou & Xie, 2015). Depressive symptoms were measured by the 10-item Center for Epidemiologic Studies Depression Scale (CESD-10) and used in prior studies of CHARLS data (Li et al., 2016; Li et al., 2015). The sum of the CESD-10 scores ranges from 0 to 30, with higher values indicating more depressive symptoms. Data on life satisfaction and CESD-10 were collected in both the 2011 baseline and 2013 follow-up surveys.

The CHARLS baseline survey collected physical-performance measures from 79% of the respondents and fasting blood samples from 67% of the respondents (Zhao et al., 2014), providing measures of physical health in cardiovascular, metabolic, and immune systems. Cardiovascular disease has become the leading cause of mortality in China (Zhou et al., 2016). Cardiovascular disease risk was captured by two dichotomous variables: hypertension (diastolic blood pressure >=90 mmHg or systolic blood pressure >=140 mmHg) and high-risk resting pulse (>90 beats/minute; Gruenewald et al., 2012). Diabetes is a major risk factor for cardiovascular disease and stroke and its prevalence rate among Chinese adults has increased from 0.9% in 1980 to 11.6% in 2010 (Chan et al., 2014). Diabetes status was also measured as a dichotomous variable (fasting glucose >=126 mg/dL or HbA1c >=6.5%). Inflammation has been implicated in a critical biological pathway through which psychosocial stress induces irregular neuroendocrine response and impairs the immune system, leading to increased risk of chronic illness (Acabchuk et al., 2017; Hänsel et al., 2010; Simons et al., 2017). As an inflammatory marker, levels of high sensitivity C-reactive protein (CRP) were divided into three categories: normal (<=3 mg/L), moderate elevation (>3 and <=10 mg/L) indicating chronic systemic inflammation, and acute elevation (>10 mg/L) indicating short-term infection (Pearson et al., 2003; Thompson et al., 2014a; Thompson et al., 2014b).

The key independent variable is grandparents’ self-reported family caregiving in the past year, which consists of four categories: giving care to one or more grandchildren (under age 16) only, giving care to one or more great-grandparents (including in-law) only, giving care to at least one grandchild and one great-grandparent, and no care given to grandchild or great-grandparent. Gender and rural-urban residence were not treated simply as control variables, but used to stratify the full sample into four subsamples: urban men, rural men,

urban women, and rural women. This approach avoids creating three-way interaction terms (between caregiving, gender, and rural-urban residence) and makes it easier to discern and interpret the moderating roles of gender and rural-urban residence in the association between caregiving and health.

Other control variables include age (measured in years and mean-centered), age-squared, educational attainment (illiterate, primary school, middle school, and high school or above), annual household income, difficulty in activities of daily living (ADLs), difficulty in instrumental activities of daily living (IADLs), number of adult children, having weekly contact with adult children (coded 1) or not (coded 0), and having weekly contact with great-grandparents (coded 1) or not (coded 0). Annual household income was summarized across self-reports from multiple sources (e.g., salary and wage, capital income, pension, government transfer, and other unspecified sources) and divided into quartiles when entering regression models. The ADLs include dressing, bathing and showering, eating, getting into and out of bed, using the toilet, and controlling urination and defecation. The IADLs include managing money, taking medications, grocery shopping, preparing meals, and cleaning house. Having difficulty in each ADL or IADL was coded 1 (otherwise coded 0) and then summarized across all the activities to derive a composite score.

Statistical Methods

In cross-sectional analysis at baseline, each outcome variable was regressed on family caregiving and control variables. Ordinary least squares (OLS) models were fitted to life satisfaction and CESD-10. Logit models were fitted to hypertension, high-risk pulse, and diabetes. Multinomial logit models were fitted to CRP because moderate and acute elevations reflected different disease pathologies rather than ordered categories on the same latent scale. In longitudinal analysis, lagged dependent variable models were used to examine the association between caregiving at baseline and changes in life satisfaction and CESD-10 over time. That is, each outcome variable at Wave 2 was regressed on its baseline value as well as on family caregiving and control variables at baseline (Baker & Silverstein, 2008a; Cong & Silverstein, 2008b). Biomarker data on diabetes and CRP were not collected at Wave 2 and excluded from longitudinal analysis. Despite the short time span between Wave 1 and 2, using baseline covariates to predict health outcomes at the follow up may mitigate (but not eliminate) potential reverse causal effects of health on selection into caregiving when interpreting the regression estimates.

Sample selection and missing data on outcome variables were accounted for by applying the inverse probability weighting method (Hernán & Robins, 2006; Wooldridge, 2007). Specifically, the baseline individual-level weights with household and individual non-response adjustment were used for modelling baseline life satisfaction and CESD-10. These weights were constructed by the CHARLS research team and calculated as the product of the household sample selection weight, an inverse probability weighting factor for household non-response, and an inverse probability weighting factor for individual non-response conditional on household participation (Zhao et al., 2013). Similar weights that adjusted for additional sample selection in fasting blood data collection were used for modelling CRP.

The individual-level longitudinal weights were used for modelling changes in life satisfaction and CESD-10 over the 2-year follow-up period. These weights were also constructed by the CHARLS research team. The longitudinal weights were calculated as the baseline weights multiplied by an inverse probability weighting factor which was constructed from a logit regression of whether a respondent participates in the second wave conditional on the participation in the baseline (CCER, 2015). These weights were designed to adjust for individual non-response and longitudinal attrition.

As an alternative, multiple imputation using ten random replications was employed to impute missing values of the outcome variables in the sensitivity analysis. However, because less than two percent of observations (79 out of 4,971) had missing data on the independent variables, using imputed values of the outcome variables would simply add noise to the regression estimates (Little, 1992; von Hippel, 2007).

All the models were fitted to each of the four subsamples (urban men, rural men, urban women, and rural women). Preliminary analysis revealed model convergence problems using multilevel regression to adjust for hierarchical sampling design, likely due to relatively few observations nested within the same communities. Therefore, throughout the regression analysis, p-values were calculated based on robust standard errors that adjust for the potential correlation of observations clustered within the same communities.

Results

Descriptive statistics

Table 1 summarizes the distributions of the independent variables at baseline. The average age ranged between roughly 54 and 57 years old for the grandparents in four-generation families in different subsamples, regardless of whether or not they took care of the great-grandparents or the grandchildren in the past year. Both rural-urban gaps and gender differences were evident in socioeconomic status. About 54.9% of urban grandfathers completed secondary education (middle school or above), which was three times as high as that in rural grandmothers (16.9%). The average annual household income was above 45,000 Chinese yuan for urban grandparents, which was more than 70% higher compared with their rural counterparts. Disparities in functional limitations were smaller, but on average urban grandfathers appeared to be the healthiest whereas rural grandmothers experienced the highest level of disability. Urban grandparents had slightly fewer adult children but more frequent contact with them than rural grandparents. There was no discernible between-group difference in weekly contact with great-grandparents.

The pattern of family caregiving is more complex. Relatively speaking, rural grandfathers assumed the least responsibility of caregiving as nearly 43% of them did not provide any care to great-grandparents or grandchildren. Urban grandmothers faced the greatest burden of caregiving as two thirds of them took care of great-grandparents, or grandchildren, or both in the past year. When the grandparents in these four-generation families undertook the caregiving task, the grandchildren were more likely to be the care receivers than the great-grandparents. The proportion of the ‘sandwiched’ grandparents was not trivial, ranging from

12.5% in rural grandfathers to 16.4% in urban grandmothers, which was even greater than the corresponding figure for giving care to the great-grandparents only (9–10%).

Table 2 reports the descriptive statistics of the outcome variables. The average rating of life satisfaction at baseline was about 3 on a 5-point Likert scale across all subsamples, which translated into being 'somewhat satisfied' with one's life as a whole. Rural-urban and gender disparities emerged in depressive symptoms. Consistent with recent research on late-life depression in China (Li et al., 2016; Li et al., 2015), on average rural grandmothers reported the greatest number of depressive symptoms at baseline (a CESD-10 score of 9.7), followed by urban grandmothers (8.4), rural grandfathers (7.6), and urban grandfathers (6.0). However, this gradient was more or less reversed with respect to physical health. Urban grandfathers had the highest rates of hypertension (28.6%), high-risk pulse (8.1%), diabetes (16.5%), and chronic and acute inflammation (19.8% combined), whereas rural grandmothers had the lowest rate in each biomarker. In terms of longitudinal change over the two-year follow-up, life satisfaction remained stable whereas depressive symptoms decreased slightly in each subsample. Prevalence of hypertension and high-risk pulse increased slightly in each subsample to varying degrees, with one exception – fewer urban grandfathers with high-risk pulse at the follow-up.

Cross-sectional regression estimates

To save space, Table 3 shows only the main coefficient estimates of interest – that is, the estimated associations between caregiving and health outcomes at baseline in each subsample. Non-caregivers served as the reference group in all comparisons. In terms of mental health, there is evidence supporting *Hypothesis 1a* in that caring for grandchildren only was associated with lower CESD-10 scores, but this relationship was found for urban grandparents only, which was consistent with *Hypothesis 2*. There is also evidence against *Hypothesis 1c* in that caring for both grandchildren and great-grandparents was associated with lower CESD-10 scores for urban grandfathers and greater life satisfaction for rural grandmothers. The mental health consequence of caring for great-grandparents only depends on both rural-urban and gender contexts. Specifically, caring for great-grandparents only was associated with greater life satisfaction and lower CESD-10 scores for urban grandfathers (contrary to *Hypothesis 1b*), but higher CESD-10 scores for rural grandmothers (consistent with *Hypothesis 1b*).

In terms of physical health, there was a notable rural-urban difference in that intergenerational caregiving was beneficial to urban grandparents but detrimental to rural grandparents (consistent with *Hypothesis 2*). Specifically, caring for both grandchildren and great-grandparents was associated with a reduced hypertension risk for urban grandfathers (contrary to *Hypothesis 1c*). Caring for great-grandparents only was associated with a lower risk of high pulse rate for urban grandfathers (contrary to *Hypothesis 1c*) but an elevated risk of high pulse rate for rural grandfathers, as well as an increased risk of acute inflammation for rural grandmothers (consistent with *Hypothesis 1b*). Consistent with *Hypothesis 1a*, caring for grandchildren only was protective against high pulse rate for urban grandfathers and chronic inflammation for urban grandmothers. No significant association was found

between caregiving and inflammation for rural or urban grandfathers, which partially supported *Hypothesis 3*..

Longitudinal regression estimates

Table 4 reports coefficient estimates from the lagged dependent variable models of changes in life satisfaction, CESD-10, hypertension, and high pulse rate over the two-year follow-up period. There was some evidence that intergenerational caregiving was positively associated with mental health but negatively associated with physical health. Caring for grandchildren only at baseline was positively associated with life satisfaction at Wave 2 for urban grandmothers and lower CESD-10 scores at Wave 2 for urban grandfathers, supporting *Hypothesis 1a*. In contrast, caring for grandchildren only at baseline was related to an elevated risk of high pulse rate for rural grandfathers. Similarly, caring for both grandchildren and great-grandparents at baseline was marginally associated with greater life satisfaction at Wave 2 for rural grandmothers (contrary to *Hypothesis 1c*) but also marginally associated with a higher risk of hypertension at Wave 2 for urban grandfathers (consistent with *Hypothesis 1c*). Lastly, caring for great-grandparents only at baseline was associated with an increased risk of hypertension at Wave 2 for urban grandfathers but a reduced risk for rural grandfathers.

Sensitivity check

As a sensitivity check, the same analyses in Tables 3 and 4 were repeated using multiple imputations to adjust for missing data on the outcome variables. There are some numerical discrepancies in terms of coefficient size and significance level for certain estimates, but the main findings remain qualitatively unchanged. In cross-sectional analysis (see Appendix Table A1), intergenerational caregiving was generally beneficial to urban grandfather's mental health but detrimental to rural grandmothers' mental health. In terms of physical health, intergenerational caregiving was unrelated to inflammation for rural or urban grandfathers (consistent with *Hypothesis 2*), protective against hypertension for urban grandfathers and chronic inflammation for urban grandmothers (consistent with *Hypothesis 1a*), and detrimental to rural grandfathers with respect to high pulse rate (consistent with *Hypothesis 1b*) and rural grandmothers with respect to acute inflammation (inconsistent with *Hypothesis 1a*). Significant longitudinal associations were only observed in rural grandparents (see Appendix Table A2). Caring for grandchildren only at baseline was associated with more depressive symptoms for rural grandmothers and an elevated risk of high pulse rate for rural grandfathers.

Discussion

Four-generation families are no longer rare in China. According to the nationally representative CHARLS data collected in 2011, more than one quarter of the sampled grandparents had at least one parent or parent-in-law alive and at least one grandchild under age 16. In the Chinese context, a patrilineal extended household with multiple generations living under the same roof is considered the ideal living arrangement (Bian et al., 1998; Whyte, 2004) and intensive or even custodial care of grandchildren is increasingly viewed normative (Chen et al., 2011; Silverstein & Cong, 2013). A few studies have found caring

for grandchildren is associated with better subjective well-being and health outcomes for Chinese grandparents' (Cong & Silverstein, 2008b; Guo et al., 2008; Ku et al., 2013; Silverstein et al., 2006; Tsai et al., 2013; Xu et al., 2012) in three-generation lineages. However, the health implications of intergenerational caregiving remains unclear as grandparents take on the new challenge of caring for their elderly parents, independent of or in addition to caring for grandchildren.

The current study addresses this gap and contributes to the literature in important ways. First, drawing on publicly available, nationally representative data, findings from this study have greater generalizability than existing studies using regional samples. Second, unlike existing studies that rely on self-reported physical health, this study capitalizes on the rick biomarker data from CHARLS to more accurately capture cardiovascular, metabolic, and immune functions. Third, by considering the intersection of rural-urban and gender contexts, this study paints a complex picture of the health implications of intergenerational caregiving for Chinese grandparents in four-generation lineages.

Overall the net health effects for grandparents varied by types of caregiving. Consistent with previous studies of three-generation families (and *Hypothesis 1a*), urban grandparents who cared for grandchildren only had better mental and physical health, compared with non-caregivers. Rural grandparents did not suffer any significant health disadvantage from caring for grandchildren. However, contrary to *Hypothesis 1c*, caring for both grandchildren and great-grandparents did not impose dual burden on grandparents. Instead, there was some evidence that the 'sandwich' grandparents reported greater life satisfaction (rural grandmothers), fewer depressive symptoms, and a reduced risk of hypertension (urban grandfathers) compared with non-caregivers. One possible explanation is that the health benefits from caring for grandchildren slightly outweigh the physical, psychological, and financial strains of caring for great-grandparents.

The health implications for grandparents who cared for great-grandparents depended only on their gender and rural-urban context. Rural grandparents tended to have worse mental and physical health when they cared for their own parents, providing evidence for *Hypothesis 1b*. However, urban grandfathers who cared for great-grandparents experienced greater life satisfaction, fewer depressive symptoms, and a lower risk of high pulse rate. Contrary to *Hypothesis 3*, these health benefits were not observed in urban grandmothers. The traditional patrilineal culture and filial piety prescribe the responsibility of elderly care to adult sons and daughters-in-law. The caregiving burden is often shared disproportionately between adult sons who assume a greater financial responsibility and their wives who provide more emotional and instrumental support (Cong & Silverstein, 2008a). Therefore, compared with their female counterparts, urban grandfathers may derive a greater sense of self-efficacy and self-esteem and hence more health benefits by providing great-grandparents with limited amount of personal care which nonetheless is beyond social expectation.

Consistent with *Hypothesis 2* and previous research on grandchild care (Chen & Liu, 2011), urban grandparents enjoyed more health benefits from intergenerational caregiving than rural grandparents. This is likely attributable to the more resources available for urban grandparents to be involved in caregiving. In particular, urban grandparents on average are

more financially secure, and so are urban great-grandparents, thanks to the wide coverage of state pension in urban areas. As a result, urban grandparents are exposed to less financial strain when they provide care to grandchildren or great-grandparents. In addition, relatively fewer grandchildren per family and lower prevalence of skipped-generation households in urban areas imply that urban grandparents tend to provide supplementary assistance instead of custodial care (Tsai et al., 2013; Xie & Xia, 2011), and thus caregiving tends to be rewarding rather than stressful.

These findings together highlight the importance of rural-urban context and gender role in studying the health effects of intergenerational caregiving. In this study, the health advantage of caregiving was most pronounced in urban grandfathers whose caregiving conformed to the norm of filial piety and who did so most likely to seek emotional reward instead of an intergenerational time-for-money exchange. However, as mentioned above, it is somewhat surprising that urban grandmothers did not benefit from caregiving as much as urban grandfathers. This may be attributed to gender difference in the division of labor such that urban grandmothers provide more intensive care (e.g., cooking, housekeeping, feeding, bathing, and dressing) than urban grandfathers (e.g., playing). Additional analysis (not shown) also suggested that providing care to grandchildren or great-grandparents, or both could significantly improve urban grandmothers' mental health without controlling for number of adult children and weekly contact with great-grandparents. Future research is needed to examine the roles of quantity and quality of family relationship emotional cohesion in shaping health effects of intergenerational caregiving. In contrast, rural grandmothers were the most vulnerable group and their health disadvantage seemed to arise from caring for great-grandparents. To the extent that married daughters are traditionally expected to co-reside with and provide care to parents-in-law instead of their own parents and such a norm remains stronger in rural areas, it is possible that rural grandmothers are at an elevated risk of chronic stress due to personal conflicts with their parents-in-law. In short, without paying attention to the differences between rural and urban grandparents, and between grandfathers and grandmothers, the estimates of the relationships between intergenerational caregiving and health outcomes, averaged across these four subgroups, would be biased towards zero.

One limitation of this study is the relatively crude typology of grandparent caregivers. Characterizing detailed nature and intensity of caring for grandchildren and great-grandparents (including in-laws) is non-trivial and beyond the scope of this study. In a handful of studies of grandparents caring for grandchildren in China, there is little consensus on the definition of intensive versus non-intensive care. Even treating co-residence in skipped-generation households can be problematic because both qualitative and quantitative studies have revealed substantial difference between grandfathers and grandmothers in amount of time and effort devoted to grandchild care (Chen et al., 2011; Xie & Xia, 2011). In addition, grandparents' self-reports of caregiving activities can be subject to recall bias and social desirability bias. Exploratory analysis of the CHARLS data (not shown) indicated a considerable amount of unreliable values of self-reported hours spent in caregiving. Future research is needed to design and implement better survey instruments to collect time use data in the Chinese elderly.

Another limitation pertains to incomparable measures between the baseline and follow-up of CHARLS. Blood data was not collected in the 2013 follow-up, preventing longitudinal analyses of diabetes and inflammation. Furthermore, a structural change in the 2013 questionnaire design made it impossible to determine the status of caring for parents or parents-in-law in a third of the eligible sample. As a result, the incomparable sample with respect to caregiving measures makes it infeasible to better control for time-constant unobserved heterogeneity using a fixed-effects approach. In addition, the two-year follow-up period was probably too short to observe substantively meaningful longitudinal changes in caregiving patterns and health outcomes. This limitation may have prohibited the current study from obtaining longitudinal regression estimates that are robust against different model specifications (i.e., inverse probability weighting versus multiple imputations). Future research that covers a longer time span is warranted to more accurately assess the long-term health effects of grandparents' intergenerational caregiving.

Despite these limitations, this study extends the literature on the health of caregiving grandparents to a non-Western context and to a four-generation lineage. Similar to their Chinese counterparts, grandparents in many other Asian countries are often involved in providing supplementary or intensive care to their grandchildren (Ko & Hank, 2014; J. Lee & Bauer, 2010). Yet, only a few studies have been carried out to investigate the health implications of grandchild caregiving in other parts of Asia (Ku et al., 2013; Tsai et al., 2013). Four-generation extended families may be increasing in low- and middle-income Asian countries where life expectancy continues to grow, or have already become a common demographic phenomenon in developed countries such as Japan, South Korea, and Singapore. Therefore, the findings from this study can provide valuable insights for understanding productive aging in other parts of Asia.

This study also has important implications for policy makers in China. Despite the Chinese government's recent effort to reform its pension system (Lu et al., 2014), instrumental care for its elderly population remains largely a family responsibility (Giles et al., 2010). This study suggests that it is urgent to extend policy focus to alleviating the family responsibility for a large share of Chinese grandparents who, in addition to facing their own aging challenges, have to care for grandchildren, great-grandparents, or both. Given the variations in intergenerational caregiving patterns and health consequences observed in this study, any new policy design needs to be tailored to heterogeneous subgroups of Chinese grandparents living in different rural-urban and gender contexts.

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Appendix

Appendix Table A1

Estimated coefficients from regression models of the outcomes at baseline using multiple imputations.

	Wave-1 Outcomes						
						C-reactive protein[c]	
Wave-1 predictors	Life satisfaction[a]	CESD-10[a]	Hypertension[b]	High-risk pulse[b]	Diabetes[b]	Chronic inflammation	Acute infection
Urban Grandfathers							
Cared for (ref: none)							
Great-grandparent(s) only	0.224*	−1.111†	0.206	−0.600	−0.339	−0.082	0.477
Grandchild(ren) only	−0.007	−0.154	−0.051	−0.226	−0.194	0.105	0.077
Both	0.046	−1.134†	−0.628*	−0.238	−0.359	0.084	0.041
Rural Grandfathers							
Cared for (ref: none)							
Great-grandparent(s) only	0.066	0.779	−0.170	0.761*	−0.313	−0.177	−0.244
Grandchild(ren) only	0.078†	0.082	−0.190	0.354	−0.046	−0.268	0.312
Both	0.079	−0.050	−0.114	0.360	0.022	0.151	−0.357
Urban Grandmothers							
Cared for (ref: none)							

	Wave-1 Outcomes						
						C-reactive protein[c]	
Wave-1 predictors	Life satisfaction[a]	CESD-10[a]	Hypertension[b]	High-risk pulse[b]	Diabetes[b]	Chronic inflammation	Acute infection
Great-grandparent(s) only	−0.081	−0.024	−0.348	−0.274	−0.202	−0.283	0.407
Grandchild(ren) only	0.025	−0.236	0.021	0.054	0.254	−0.498*	−0.576
Both	0.106	−0.810	−0.109	−0.057	0.122	−0.610	0.619
Rural Grandmothers							
Cared for (ref: none)							
Great-grandparent(s) only	0.051	1.408*	0.199	0.302	−0.118	0.150	1.002*
Grandchild(ren) only	0.058	0.122	−0.003	0.486	−0.057	0.103	−0.028
Both	0.110	0.589	−0.214	0.045	0.050	−0.289	−0.354

Note: ref = reference. All the models control for age, educational attainment, household income, difficulty in activities of daily living, difficulty in instrumental activities of daily living, number of adult children, weekly contact with adult children, and weekly contact with great-grandparent(s).

[a] Ordinary least squares model.

[b] Logit model.

[c] Multinomial logit model and the reference category is normal level of C-reactive protein.

† $p < 0.1$;

* $p < 0.05$;

** $p < 0.01$;

*** $p < 0.001$ based on community-level cluster standard errors.

Appendix Table A2

Estimated coefficients from lagged regression models of the outcomes at Wave 2 using multiple imputations.

	Wave-2 Outcomes			
Wave-1 predictors	Life satisfaction[a]	CESD-10[a]	Hypertension[b]	High-risk pulse[b]
Urban Grandfathers				
Cared for (ref: none)				
Great-grandparent(s) only	0.030	−0.211	0.210	−0.446
Grandchild(ren) only	0.019	−0.167	0.271	−0.270
Both	−0.006	0.200	0.147	−0.519
Rural Grandfathers				
Cared for (ref: none)				
Great-grandparent(s) only	0.052	−0.256	−0.465	0.441
Grandchild(ren) only	−0.008	0.041	−0.007	0.454†
Both	0.049	−0.061	−0.241	0.515
Urban Grandmothers				
Cared for (ref: none)				
Great-grandparent(s) only	0.060	−0.058	−0.481	0.243

	Wave-2 Outcomes			
Wave-1 predictors	**Life satisfaction[a]**	**CESD-10[a]**	**Hypertension[b]**	**High-risk pulse[b]**
Grandchild(ren) only	0.085	0.010	0.112	−0.286
Both	0.095	0.010	−0.133	−0.250
Rural Grandmothers				
Cared for (ref: none)				
Great-grandparent(s) only	−0.056	0.397	−0.293	0.016
Grandchild(ren) only	−0.063	0.721*	−0.026	0.091
Both	0.087	0.017	−0.156	−0.127

Note: ref = reference. All the models control for age, educational attainment, household income, difficulty in activities of daily living, difficulty in instrumental activities of daily living, number of adult children, weekly contact with adult children, and weekly contact with great-grandparent(s).

[a] Ordinary least squares model.

[b] Logit model.

† $p < 0.1$;

* $p < 0.05$;

** $p < 0.01$;

*** $p < 0.001$ based on community-level cluster standard errors.

- About 30% of the Chinese elderly are grandparents in four-generation families.
- The majority of them care for grandchildren, great-grandparents, or both.
- Urban grandfathers enjoy health benefits from intergenerational caregiving.
- Rural grandmothers suffer health risks from intergenerational caregiving.

Table 1

Descriptive statistics of the independent variables at the baseline in Chinese grandparents: CHARLS -2011.

Wave-1 independent variables	Grandfathers		Grandmothers	
	Urban	Rural	Urban	Rural
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Age (years)	56.6 (6.2)	55.5 (6.2)	54.7 (5.8)	53.6 (5.9)
Annual household income (yuan)	45,729 (125,029)	25,752 (37,697)	45,118 (120,972)	26,206 (39,226)
Difficulty in ADL (range: 0–6)	0.2 (0.7)	0.2 (0.8)	0.2 (0.8)	0.3 (0.9)
Difficulty in IADL (range: 0–5)	0.2 (0.7)	0.3 (0.8)	0.3 (0.9)	0.5 (1.0)
Number of adult children	2.3 (1.0)	2.6 (1.0)	2.3 (1.0)	2.6 (1.0)
	%	%	%	%
Educational attainment				
Illiterate	5.1	11.1	25.3	45.5
Primary school	40.1	44.7	38.2	37.6
Middle school	31.4	29.5	22.3	13.8
High school or above	23.5	14.6	14.2	3.1
Cared for				
Neither	36.1	42.9	33.0	38.7
Great-grandparnet(s) only	8.9	10.3	9.0	10.1
Grandchild(ren) only	39.3	34.3	41.5	36.7
Both	15.7	12.5	16.4	14.5
Weekly contact with adult children	95.3	91.6	95.8	92.1
Weekly contact with great-grandparent(s)	56.6	57.8	55.1	56.4
N	830	1,402	908	1,505

Note: ADL = activities of daily living; IADL = instrumental activities of daily living.

Table 2

Descriptive statistics of the outcome variables at Waves 1 and 2 in Chinese grandparents: CHARLS 2011–2013.

	Grandfathers				Grandmothers			
	Urban		Rural		Urban		Rural	
	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N
Life satisfaction (range: 1–5)								
Wave-1	3.1 (0.7)	733	3.1 (0.7)	1,226	3.1 (0.7)	808	3.0 (0.8)	1,333
Wave-2	3.2 (0.6)	575	3.1 (0.7)	1,055	3.1 (0.7)	647	3.1 (0.8)	1,174
CESD-10 score (range: 0–30)								
Wave-1	6.0 (5.2)	789	7.6 (5.9)	1,330	8.4 (6.2)	891	9.7 (6.5)	1,463
Wave-2	5.9 (4.7)	620	7.1 (5.2)	1,141	7.9 (5.7)	715	9.2 (6.4)	1,294
	%	N	%	N	%	N	%	N
Hypertension (diastolic BP >= 90 mmHg or systolic BP >= 140 mmHg)								
Wave-1	28.6	664	23.4	1,223	27.4	734	22.4	1,345
Wave-2	35.4	418	26.5	828	31.9	464	22.5	953
High-risk pulse (> 90 beats/minute)								
Wave-1	8.1	664	5.7	1,223	5.1	733	4.1	1,345
Wave-2	6.9	418	7.5	828	6.9	464	6.1	953
Diabetes (fasting glucose >= 126 mg/dL or HbA1c >= 6.5%) at Wave-1	16.5	570	14.3	1,023	16.4	630	12.4	1,169
C-reactive protein at Wave-1								
Normal (<=3 mg/L)	80.3	568	84.1	845	81.2	511	85.0	977
Chronic inflammation (3–10 mg/L)	14.3	568	11.3	114	13.4	84	10.9	125
Acute infection (>10 mg/L)	5.5	568	4.6	46	5.4	34	4.1	47

Note: BP = blood pressure.

Table 3

Estimated coefficients from regression models of the outcomes at baseline using inverse probability weighting.

	Wave-1 Outcomes						
						C-reactive protein[c]	
Wave-1 predictors	**Life satisfaction[a]**	**CESD-10[a]**	**Hypertension[b]**	**High-risk pulse[b]**	**Diabetes[b]**	**Chronic inflammation**	**Acute infection**
Urban Grandfathers							
Cared for (ref: none)							
Great-grandparent(s) only	0.234 *	−1.675 **	0.233	−1.315 *	−0.364	−0.194	0.476
Grandchild(ren) only	−0.014	−0.899 †	0.132	−0.654 †	0.318	−0.130	0.391
Both	−0.014	−1.244 *	−0.838 *	−0.604	−0.485	0.606	−0.274
Rural Grandfathers							
Cared for (ref: none)							
Great-grandparent(s) only	0.043	0.794	−0.329	0.752 *	−0.613	0.142	−0.120
Grandchild(ren) only	0.076	−0.067	−0.192	0.334	−0.179	−0.217	0.397
Both	0.090	−0.307	−0.154	0.415	0.209	0.493	−0.164
Urban Grandmothers							
Cared for (ref: none)							
Great-grandparent(s) only	−0.123	0.490	−0.584	−0.219	−0.192	−0.266	1.020
Grandchild(ren) only	−0.077	−0.600	0.033	0.251	0.141	−0.892 **	−0.894
Both	0.153	−0.846	−0.466	0.058	−0.225	−0.677	0.860
Rural Grandmothers							
Cared for (ref: none)							
Great-grandparent(s) only	0.074	1.642 *	0.218	0.677	−0.007	0.149	1.307 **
Grandchild(ren) only	0.051	0.181	−0.053	0.535	−0.160	0.037	0.277
Both	0.127f	0.595	−0.206	0.358	0.161	−0.620	−0.217

Note: ref = reference. All the models control for age, educational attainment, household income, difficulty in activities of daily living, difficulty in instrumental activities of daily living, number of adult children, weekly contact with adult children, and weekly contact with great-grandparent(s).

[a]Ordinary least squares model.

[b]Logit model.

[c]Multinomial logit model and the reference category is normal level of C-reactive protein.

[†]$p < 0.1$;

[*]$p < 0.05$;

[**]$p < 0.01$;

[***]$p < 0.001$ based on community-level cluster standard errors.

Table 4

Estimated coefficients from lagged dependent models of the outcomes at Wave 2 using inverse probability weighting.

	Wave-2 Outcomes			
Wave-1 predictors	**Life satisfaction[a]**	**CESD-10[a]**	**Hypertension[b]**	**High-risk pulse[b]**
Urban Grandfathers				
Cared for (ref: none)				
Great-grandparent(s) only	0.113	−0.493	0.868*	−1.379
Grandchild(ren) only	0.004	−0.706†	0.407	−0.758
Both	0.044	−0.060	0.679†	−1.275
Rural Grandfathers				
Cared for (ref: none)				
Great-grandparent(s) only	0.082	−0.607	−0.674*	0.481
Grandchild(ren) only	−0.016	0.071	−0.093	0.865*
Both	0.020	−0.134	−0.294	0.618
Urban Grandmothers				
Cared for (ref: none)				
Great-grandparent(s) only	0.093	0.590	−0.551	0.610
Grandchild(ren) only	0.173*	0.782	0.084	−0.291
Both	0.141	1.002	0.078	−0.275
Rural Grandmothers				
Cared for (ref: none)				
Great-grandparent(s) only	−0.067	0.359	−0.156	−0.026
Grandchild(ren) only	−0.043	0.285	0.008	0.131
Both	0.099†	−0.214	−0.319	−0.417

Note: ref = reference. All the models control for age, educational attainment, household income, difficulty in activities of daily living, difficulty in instrumental activities of daily living, number of adult children, weekly contact with adult children, and weekly contact with great-grandparent(s).

[a] Ordinary least squares model.

[b] Logit model.

† $p < 0.1$;

* $p < 0.05$;

** $p < 0.01$;

*** $p < 0.001$ based on community-level cluster standard errors.