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Original Article

Adult Children's Education and Physiological Dysregulation Among Older Parents

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Abstract

Objectives: Despite growing awareness that children's education benefits the health of older parents, the underlying mechanisms of this relationship are not well-understood. We investigated (a) the associations between children's education and biological functioning of parents, (b) psychosocial and behavioral factors that explain the associations, and (c) gendered patterns in the associations.

Methods: Using longitudinal data from a nationally representative sample of older Taiwanese, we performed mediation analysis of the association between adult children's education and physiological dysregulation of their parents.

Results: Offspring's schooling is inversely associated with parental inflammation after controlling for parental socioeconomic status and baseline health. Parents who have well-educated children report higher social standing and life satisfaction, experience fewer stressful events, and are more likely to engage in healthy behaviors related to smoking and diet. These factors moderately attenuate the associations between children's education and parental inflammation. There is no conclusive evidence that mothers and fathers benefit differently from having well-educated children.

Discussion: Parents who devote family and personal resources to their offspring's schooling may have better biological profiles in later life. Well-educated children may promote their parents' wellbeing by strengthening perceived social status, reducing exposure to stressors, and encouraging a healthy lifestyle.

Keywords: Children—Education—Gender—Physiological dysregulation

Most parents invest enormous amounts of time, effort, and financial assets into their children's schooling because they view education as a pathway to higher social status for their children (Wolf & Zohlnhöfer, 2009). Parents' investment in their offspring's schooling may yield both socioeconomic success for their children and, indirectly, health benefits for parents. Recent studies have highlighted the importance of the education of adult children for the health of aging parents. Older parents who have well-educated children tend to have lower levels of functional limitations (Zimmer, Hermalin, & Lin, 2002), lower levels of depressive symptoms (Lee, Glei, Goldman & Weinstein, 2017), and a longer lifespan than those who have poorly-educated children (Friedman & Mare, 2014; Torssander, 2013; Zimmer, Martin, Ofstedal, & Chuang, 2007). However, the underlying biological mechanisms that produce these health benefits are poorly understood, and few studies have examined psychosocial and behavioral pathways that could explain how well-educated children promote the health of older parents. Using data from the Taiwan Longitudinal Study of Aging (TLSA) and the Social Environment and Biomarkers of Aging Study (SEBAS), the current study is among the first to investigate biological risk and the psychological and behavioral factors associated with offspring's educational levels. Given gender differences in psychosocial resources and parent–child relationships, our study also examined whether mothers and fathers benefit differently from children's education.

Children's Education and Parents' Health in Later Years

A large body of studies has found that social relationships, which can be both supporting and constraining, shape individuals' health and wellbeing (House, Landis, & Umberson,1988; Thoits, 2011). The family has one of the most significant influences on individuals' health, as its high-quality close ties can provide economic, social, and psychological support (or constraints) that can enhance (or impede) the wellbeing of its members (Carr, Springer, & Williams, 2014). Family members can influence an individual's health via several forms of social support. For example, an individual's capacity to cope with stressors improves when family members provide emotional support (e.g., expressions of caring). Instrumental support (e.g., financial aid) and informational support (e.g., dietary guidelines) may promote an individual's overall health (House et al., 1988; Thoits, 1995). In addition, social control perspectives suggest that family members may shape one another's health by fostering positive health behaviors or discouraging unhealthy lifestyles (Lewis & Rook, 1999; Umberson, 1992).

The resources that family members possess may determine the quality or efficacy of the support that they give to other family members. Studies on social capital and health indicate that the educational levels and occupational prestige of network members are positively associated with individuals' health and wellbeing, in terms of depressive symptoms and life satisfaction, even after controlling for individuals' own socioeconomic status (SES) (Acock & Hurlbert, 1993; Song, 2011). The life-course perspective of "linked lives" suggests that the roles, responsibilities, and social identities of individuals in close relationships, for example, children and parents, are mutually influential trajectories over their life courses (Elder, Johnson, & Crosnoe, 2003). The family member who has the most powerful influence on health changes throughout the life course (C. Lee et al., 2017; Umberson, 1992). In early life, children's wellbeing strongly relies on the socioeconomic resources that their parents provide (Steinberg & Morris, 2001), but in later years, the resources and circumstances of adult children have implications for the health and wellbeing of their older parents (Milkie, Bierman, & Schieman, 2008).

Empirical studies have documented an intergenerational impact of adult children's education on parents' health, and these findings are consistent across countries. Zimmer and Colleagues (2002) found that in Taiwan, where the cultural norm of filial piety prompts adult children to be the primary caregivers of their parents, both parents' and children's levels of education are negatively associated with parental disability. Among adults who have some degree of functional limitations, those who have well-educated children are less likely to experience severe forms of their disability. Similarly, Zimmer and Colleagues (2007) found that children's schooling was more important when the sample was limited to older adults who already had a serious disease. These findings suggest that well-educated children may be able to provide better care for their ill and aging parents compared to poorly-educated children. The health benefits from children's education also extend to mental health. Taiwanese parents who have well-educated children show lower levels of depressive symptoms from mid to later life than those who have poorly-educated children, although the effects of offspring's schooling gradually weaken as parents age. The effect of children's education is stronger than that of other family members' education (C. Lee et al., 2017).

These findings from Taiwan are consistent with studies in Western countries, where the co-residence of adult children with older parents and the transfer of financial resources from adult children to parents are relatively rare. Friedman and Mare (2014) reported that in the United States, the education of adult children has an independent effect on parents' mortality even after controlling for parents' own SES. The association is more prominent for specific causes of death closely related to unhealthy behaviors, for example, lung cancer. The health behaviors of parents, including smoking and physical activity, partially mediate the observed association, suggesting that well-educated children might increase their parents' longevity by influencing health-related behaviors. Similar findings have been documented in a welfare state characterized by universal health care and economic security for older people. Torssander (2013) indicated that Swedish parents who have children with tertiary education have a lower risk of mortality than those who have children with only compulsory schooling. The association remains significant using sibling fixed-effects models at the parental level, indicating that health benefits from children's schooling are robust even after adjusting for the unobserved family characteristics of parents. Taken together, prior work has highlighted the importance of children's education as a factor in determining the health of older parents.

We are not aware of studies that have investigated the association between offspring's schooling and the physiological characteristics of older parents. The absence of such research is surprising because (a) allostatic load—biological "wear and tear" in multiple body systems in response to prolonged or repeated stress—plays a central role in the development of chronic diseases, frailty, and disability, as well as elevated risk of mortality (McEwen, 1998; Seeman, McEwen, Rowe, & Singer, 2001) and (b) a growing body of studies has emphasized the importance of biological pathways that link SES to health problems (Crimmins & Seeman, 2004). The first aim of this study is to examine the following hypothesis H1: adult children's education is inversely associated with physiological dysregulation (PD) of older parents.

Processes Linking Children's Education to the Health of Older Adults

Adult children may influence their parents' health through several mechanisms, which can be broadly categorized as psychological or behavioral pathways. First, children's education may affect parents' health by reinforcing social class identification. Class identification can be shaped not only by an individual's own socioeconomic resources, but also by the SES of network members, which may fortify an individual's perception of his or her position in the social hierarchy (Hodge & Treiman, 1968; Lin, 1999). One's location in the social hierarchy is closely tied to various health outcomes even after controlling for objective measures of SES, such as education, income, and occupation (Hu, Adler, Goldman, Weinstein & Seeman, 2005). In the case of Taiwan, where there is a strong cultural emphasis on intergenerational family support for older people, adult children may be central figures in their parents' social networks. Thus, adult children's schooling can have positive effects on the perceived social position of older adults, resulting in better psychological wellbeing and healthier biological profiles.

As another psychosocial mechanism, having well-educated children may protect parents from exposure to stressful life events. For example, older adults may encounter stressful life transitions, including involuntary retirement and financial strain (Gallo, Bradley, Siegel, & Kasl, 2000), involuntary relocation (Anthony, Procter, Silverman, & Murphy, 1987), and deteriorating health (Seeman, Lusignolo, Albert, & Berkman, 2001). Given that education operates as human capital that helps individuals procure other socioeconomic resources (Hout, 2012), children who receive more education may be in a better position to provide financial aid, housing, or legal assistance for parents in need. Adult children may be aware of the health problems of their older parents and help them receive timely health care services. In addition, the life-course perspective of "linked lives" suggests that stressful circumstances encountered by one family member can have negative effects on the health of other family members (Elder et al., 2003). Parents who are in the later stages of life may be vulnerable to negative events that happen to their adult children, for example, illnesses and unemployment (Milkie et al., 2008). Parents' concerns related to such negative events can overtax physiological systems and lead to health-harming behaviors and poor physical health. Given that education is correlated with job stability and earnings, having well-educated children may indirectly promote the health of older parents by reducing their risk of experiencing network stress.

Adults who are more highly educated tend to have more knowledge of the harms of health-related behaviors, for example, smoking and heavy drinking, and are more likely to have access to material resources that promote health, including gym memberships, smoking cessation methods, and advanced health information (Cutler & Lleras-Muney, 2010). Thus, adult children with more schooling are better able to control or manage their parents' health than those who are less educated. They may question their parents' health-harming behaviors and pressure them to give up things like smoking and heavy drinking, while encouraging them to adopt or maintain a healthy diet, exercise regularly, and participate in leisure activities. In addition, as parents seek health care, highly-educated children may have more information about how health care systems operate and be able to use social networks to help their parents find qualified health care professionals. Prior studies have consistently assumed that having well-educated adult children matters for the health of aging parents, yet few studies, such as the one by Friedman and Mare (2014), have empirically tested this premise. One limitation of the study by Friedman and Mare (2014) is that it only explored two behavioral factors, smoking and exercise. Accordingly, the present study extends prior work by investigating the following two hypotheses. H2: older adults who have well-educated children are more likely to have better psychological wellbeing and more frequently engage in healthy behaviors than those who have poorly-educated children and H3: psychological wellbeing and health-enhancing behaviors partially mediate the association between adult children's schooling and biological risk in older parents.

Gender Differences

We know little about how the benefits of children's schooling vary by parent's gender. Only two studies have explicitly tested gender differences, and their findings were inconsistent: gender variation (Torssander, 2013) and no gender variation (C. Lee et al., 2017). Nonetheless, there are at least two reasons why we predict that mothers and fathers will not equally benefit from increasing children's schooling. First, mothers are more likely than fathers to assume the primary caregiving responsibility and thereby form stronger bonds with their children (Bowlby, 1988). Such gendered patterns tend to remain even after children grow up. For example, Silverstein and Bengtson (1997) investigated the typologies of parent–adult child solidarity and reported that mother–adult child ties are stronger than father–adult child ties. In addition, the theory of resource substitution suggests that individuals who are otherwise disadvantaged are more likely to benefit from network resources (Ross & Mirowsky, 2006). Because of gender inequality in SES, women generally have fewer socioeconomic resources than men. Gender inequality is particularly prevalent among older generations, with women having lower educational attainment, more restricted opportunities for paid employment, and more economic dependency (Wang, 2011). Thus, we can expect that women may more strongly rely on children's resources for later life health. Accordingly, we propose H4: women are more likely than men to benefit from their children's education.

Methods

Data and Sample

The current study includes participants in TLSA, a nationally representative survey designed to assess the health of older people in Taiwan. TLSA began in 1989 with a cohort of older adults (aged ≥60; n = 4,049) and in 1993 and1996 followed up with this cohort although adding a younger cohort in 1996 (aged 50–66; n = 2,462). Both cohorts were re-interviewed in 1999 (n = 4,440; response rate = 90% of survivors). Among those who participated in 1999, a random subsample (n = 1,713) was selected for the SEBAS in 2000, which consisted of an in-home interview and a clinical visit. Older adults (age ≥70 in 2000) and residents of urban areas were oversampled. Among the respondents selected for SEBAS, 1,497 completed the interview (92% of survivors) and 1,023 (68% of in-home interviewees) participated in the clinical visit, which included collection of a 12-hour overnight urine sample and a fasting blood specimen, as well as the measurement of physical characteristics, including height, weight, and blood pressure (for details on response rates and attrition, see supplementary Figure S1). Although those who participated in the medical component of SEBAS were younger than non-participants, there were no significant differences in terms of self-rated health status, SES, or gender (Goldman, Turra, Glei, Seplaki, Lin, & Weinstein, 2006).

Among the respondents who completed the medical examination in 2000 (n = 1,023), we limited the sample to those who had at least one living child in 1996 (96% of the respondents) and who participated in the follow-up survey in 1999 (n = 966). Around 17% of respondents had missing data for at least one variable of interest. The range of missing information for individual variables varied, for example, CES-D (6%) and biomarkers (0.02% to 3%). Using the *ice* command in Stata (StataCorp, 2015), we performed 10 imputations to predict missing values. We used "multiple imputation, then deletion." Specifically, we generated imputed values for missing independent or dependent variables, and then deleted observations with imputed dependent variables (Von Hippel, 2007). After deleting observations for at least one biomarker of interest (n = 29), the analytic sample included 937 respondents.

Measures

Children's education

Respondents reported years of education, ranging from 0 to 17, for all living children. For 80% of the respondents who had children, their youngest child was over 25 years old, indicating that most children in the sample were old enough to have completed their formal education. There are many ways to measure the education of children, for example, highest, average, or lowest educational level of children, as well as the educational level of the oldest son. We used the average educational attainment of all living children because having children with various years of schooling can affect parental health in different ways. For example, one child with higher education may positively affect parents' healthy behaviors, although their other child with less education might have a concurrent neutral or negative effect on their health. In preliminary analyses, our findings were generally robust across alternatives, although the association between children's education and outcome variables was strongest using the average. Regarding the age of the youngest child, we conducted sensitivity analyses by (a) limiting our sample to respondents whose youngest child was older than 25 and (b) controlling for the age of the youngest child. Our findings were consistent. In addition, given gender differences in the primary responsibility for providing financial assistance to elderly parents in Taiwan (Lee, Parish, & Willis, 1994), our preliminary analyses controlled for the sex composition of children and confirmed that our findings are consistent regardless of whether these controls are included.

Physiological dysregulation

Following prior work on SES and allostatic load, our score of PD was based on 17 biological indicators in the 2000 SEBAS that reflect three physiological systems: hypothalamic–pituitary–adrenal axis and sympathetic nervous system (HPA/SNS) function, inflammation, and cardiovascular and metabolic (CV/metabolic) function. We selected individual biomarkers representing each domain based on prior studies (Glei, Goldman, Chuang & Weinstein, 2007). *HPA/SNS function* includes four hormones: urinary cortisol, blood dehydroepiandrosterone (DHEA), urinary epinephrine, and urinary norepinephrine. *Inflammation* includes four biomarkers: C-reactive protein (CRP), interleukin-6 (IL-6), soluble intracellular adhesion molecule-1 (sICAM-1), and endothelial leukocyte adhesion molecule-1 (E-selectin). *CV/Metabolic function* includes nine indicators: systolic and diastolic blood pressure, high-density lipoprotein (HDL) cholesterol, total cholesterol/HDL ratio, triglycerides, glycosylated hemoglobin (HbA1c), fasting glucose, body mass index (BMI), and waist circumference. To construct summary scores, we used previously established clinical cutoffs for high-risk biomarker levels. For biomarkers without an established high-risk cutoff, we used the bottom or top quartile (see supplementary Table S2). Biomarker summary scores for each domain individually and all three domains together reflect the number of biomarkers in the high-risk range (possible range: 0–17).

Psychosocial and behavioral mediators

We used eight potential mediators, measured in 1999 (except subjective social status and physical exam, which were first included in the 2000 SEBAS data set), linking children's schooling in 1996 to PD in 2000. *Subjective social status* was measured by the MacArthur Scale of Subjective Social Status. It asks individuals to place an "X" on a 10-rung social hierarchy ladder at the position corresponding to their rank (Adler, Epel, Castellazzo, &

Ickovics, 2000). *Life satisfaction* was measured using 10 items adapted from the 20-item Life Satisfaction Index (LSI) (Neugarten, Havighurst, & Tobin, 1961). TLSA includes a modified subscale of the LSI for use with Taiwanese respondents, and each question requires a Yes/No response (Cronbach's alpha = 0.79). A summary score of life satisfaction ranges from 0 (low) to 10 (high life satisfaction). *Stressful life events* consists of five negative life events that occurred between 1996 and 1999 (possible range: 0–5): marital disruption (becoming divorced or widowed), decline in spousal health from "excellent/good" to "not good/poor," death of a child, residential move, or financially worse off.

We also included five measures of health-related behaviors. *Healthy diet* indicates that respondents eat vegetables or fruits (nearly) every day. *Regular exercise* measures whether respondents exercise at least three times a week for at least for 30 minutes per session. *Physical exam* was coded as 1 for respondents who had a physical examination in the past year; 0 for others. *Smoking status* is a set of three dummy variables: never smoked, formerly smoked, and currently smoking. *Drinking status* is comprised of three dummy variables: abstainer, infrequent drinker (once a week or less) and frequent drinker (at least 2 days a week).

Confounding variables

To isolate the relationship between children's schooling and PD of older parents, we included 12 confounding variables, collected in 1996 or earlier, that fall into three domains. The first set of variables represents *demographic and familial characteristics*: respondent's age, gender, residential area (rural vs. non-rural), marital status (married/cohabitating vs. non-married), number of living children, and parent–child co-residence. The effects of children's education can be biased if family SES characteristics drive any observed relationship between children's schooling and parental health. Therefore, we controlled for two indicators of *respondent's and spouse's SES*: education and occupation. Schooling of both respondent and spouse ranged from 0 to 17 years. To measure the prestige of respondent's and spouse's major lifetime occupation, we used a socioeconomic index (SEI) developed by Tsai and Chiu (1991), based on the strategy of Duncan (1961) and Featherman and Stevens (1982); scores ranged from 55.1 for farm laborers to 76.1 for scientists, doctors, and teachers. Given that 30% of women were missing data for SEI due to not having a paid occupation, we used a continuous measure of SEI ranging from 0 to 76.1 (0 = no paid occupation) in the models, although also recording occupational status as a binary variable (whether respondents have an SEI occupation).

Parents may have had poor health before their children completed their schooling, negatively affecting their children's educational attainment. Under these circumstances, parental health would be the antecedent variable. Therefore, we controlled for *mental and physical health status* at baseline. Depressive symptoms were measured by a 10-item subset of the 20-item Center for Epidemiological Studies Depression scale (CES-D) (Radloff, 1977). Respondents assessed the frequency of each of the following depressive symptoms during the past week, from 0 (rarely or none of the time) to 3 (most or all of the time): "poor appetite," "everything is an effort," "poor sleep," "no energy," "bad mood," "lonely," "sad," "people are unfriendly," "feel happy," and "life is going well." The summary scores of the 10 CES-D items possibly range from 0 to 30 (Cronbach's alpha = 0.84). Shortened forms of the CES-D scale have been validated in detecting depressive symptoms in both Western and Eastern populations (Andresen, Malmgren, Carter, & Patrick,1994; Cheng & Chan, 2005). Based on the major causes of death in China (He et al., 2005), we calculated cumulative serious illnesses by summing six medical conditions that respondents have ever had, including diabetes, hypertension, heart disease, liver disease, kidney disease, and cancer (possible range 0–6).

Analytic Strategy

Using multivariate regression, we performed two sets of analyses. In the first set, we investigated the extent to which children's schooling is associated with each domain of PD (HPA/SNS, inflammation, and CV/metabolic function), as well as overall physiological dysregulation, after adjusting for demographic and familiar covariates (Model 1 in Table 2). We then estimated a series of nested models by adding additional confounding variables: respondent's and spouse's SES, and health status at baseline (Models 2 and 3). Finally, we investigated whether mothers and fathers benefit differently from children's education by adding a gender interaction term (Model 4). We conducted parallel analytic approaches to examine the relationship between children's education and each psychosocial and behavioral factor (Table 3). Given that several covariates measure similar concepts, for example, SES, we performed a preliminary check and confirmed that the degree of linearity among the covariates was low (variance inflation factors < 3).

The second set of analyses tested the extent to which psychosocial and behavioral factors mediate the relationship between children's schooling and physiological dysregulation. For the mediation analysis, the contribution of psychosocial and behavioral factors to PD was evaluated by (a) the percentage of total effects explained by each mediator and (b) the significance of the indirect effect. We used the KHB-method to compare the estimated coefficients of nested nonlinear probability models for mediation analysis with binary and categorical variables, as the KHB-method is useful for decomposing total effects into direct and indirect effects (Kohler, Karlson, & Holm, 2011). Prior to model fitting, the measures of continuous variables (children's education, subjective social status, and life satisfaction) were standardized (mean = 0, *SD* = 1) to facilitate comparison of effect sizes. We used ordinary least squares regression models for the continuous outcomes (subjective social status and life satisfaction), logistic regression models for the binary indicators (diet and exercise), and multinomial logistic regression models for the categorical outcomes (smoking and drinking). For the countable outcomes, we used Poisson regression models (stressful events, HPA/SNS, and inflammation) or negative binomial regression models (CV/metabolic function and overall PD) based on model fit statistics. Univariate statistics were weighted to compensate for oversampling by age group and urban residence. Multivariate models were based on unweighted data, but include age and urban residence to account for oversampling. In all analyses, we used STATA 14.0 (StataCorp, 2015).

Results

Table 1 shows the descriptive characteristics for men and women who had at least one child at baseline. Based on weighted analyses, the mean age of respondents was 62 years old. On average, respondents had four children, and three out of four respondents lived with their children. Overall, women had lower SES than men, as indicated by average years of education (3.23 vs. 6.57), no lifetime job (33% vs. 1%), and occupational prestige score (59.60 vs. 61.84). They also had poorer health than men, in terms of more depressive symptoms (5.24 vs. 4.22) and higher levels of PD (4.67 vs. 3.47). In addition, women showed

Table 1. Descriptive Statistics for Analysis Variables (mean or proportion), by Gender

Variable (observed range)	Women (*n* = 401)	Men (*n* = 536)	Gender difference
Children's schooling (0–17 years)	10.67	11.09	<0.05
Biomarker summary scores			
HPA/SNS function subscore (0–4)	1.40	0.62	<0.001
Inflammation subscore (0–4)	1.03	1.01	ns
CV/metabolic function subscore (0–9)	2.25	1.84	<0.001
Overall PD score (0–13)	4.67	3.47	<0.001
Psychological and behavioral mediators			
Subjective social status (1–10)	4.17	4.42	<0.05
Life satisfaction (0–10)	6.16	6.39	ns
Stressful events (0–3)	0.59	0.51	ns
Regular exercise (0–1)	0.34	0.44	<0.001
Healthy diet (0–1)	0.67	0.58	<0.05
Physical examination (0–1)	0.34	0.34	ns
Smoking			
Never smoked (0–1)	0.96	0.31	<0.001
Formerly smoked (0–1)	0.01	0.25	<0.001
Current smoking (0–1)	0.03	0.44	<0.001
Drinking			
Abstainer (0–1)	0.93	0.54	<0.001
Infrequent drinker (0–1)	0.05	0.26	<0.001
Frequent drinker (0–1)	0.02	0.20	<0.001
Confounding variables			
Age (50–87)	61.41	61.93	ns
Living in rural area (0–1)	0.43	0.38	ns
Married/cohabiting (0–1)	0.72	0.89	<0.001
Number of living children (1–11)	4.35	3.98	<0.001
Co-residence with children (0–1)	0.77	0.79	ns
Respondent's education (0–17 years)	3.23	6.57	<0.001
Spouse's education (0–17 years)	5.61	4.23	<0.001
Respondent's occupation			
No job (0–1)	0.33	0.01	<0.001
SEI score (55.1–76.1)	59.60	61.84	<0.001
Spouse's occupation			
No job (0–1)	0.01	0.55	<0.05
SEI score (55.1–76.1)	59.92	60.35	ns
CES-D (0–30)	5.24	4.22	<0.01
Serious chronic illnesses (0–5)	0.62	0.54	ns

Notes: CV = cardiovascular; CES-D = Center for Epidemiologic Studies Depression scale; HPA/SNS = hypothalamic–pituitary–adrenal axis and sympathetic nervous system; PD = physiological dysregulation; ns= not statistically significant; SEI = socioeconomic index. Descriptive statistics are based weighted analyses to compensate for oversampling by age group and urban residence.

Table 2. Association Between Children's Education and Physiological Dysregulation of Older Parents

	HPA/SNS (P)	Inflammation (P)	CV/metabolic (NB)	Overall PD (NB)
Model (M)1				
Children's education	0.005 (.036)	−0.160 (0.036)***	−0.038 (0.033)	−0.058 (0.023)*
M2: M1 + Respondent's & Spouse's SES				
Children's education	0.012 (.042)	−0.084 (0.041)*	−0.018 (0.038)	−0.025 (0.026)
M3: M2 + Respondent's health				
Children's education	0.012 (.042)	−0.094 (0.042)*	−0.034 (0.037)	−0.038 (0.026)
M4: M3 + Gender interaction term				
Children's education	−0.008 (0.062)	−0.087 (0.053)	0.034 (.048)	−0.013 (0.033)
Female	0.891 (0.103)***	−0.129 (0.101)	0.092 (.084)	0.240 (0.059)***
Children's education × Female	0.030 (0.069)	−0.016 (0.067)	−0.130 (0.058)*	−0.046 (0.040)

Notes: CV = cardiovascular; HPA/SNS = hypothalamic–pituitary–adrenal axis and sympathetic nervous system; NB = negative binomial regression model; P = Poisson regression model; PD = physiological dysregulation. Model 1 (baseline) controls for all confounding variables. The measure of children's education is standardized (mean = 0, *SD* = 1).
**p* < .05, ***p* < .01, ****p* < .001.

lower psychological wellbeing than men, for example, having reported lower subjective social status (4.17 vs. 4.42). However, women were less likely than men to engage in health risk behaviors, such as smoking and drinking.

Table 2 shows the results of a series of nested models that determine the association between adult children's education and physiological dysregulation. Children's schooling is significantly associated with inflammation. The results of Model 1 show that children's education is inversely associated with inflammation even after adjusting for demographic and familiar covariates. A one standard deviation increase in children's schooling is associated with a 0.16 decrease in inflammation scores. Adjusting for respondent's and spouse' SES resulted in a decrease in the magnitude of the effect from −0.16 to −0.08 (Model 2), yet the associations remained statistically significant ($p < .05$). The inclusion of health at baseline slightly strengthened the association between children's education and inflammation (from −0.08 to −0.09 in Model 3). The coefficient of children's education continued to be significant ($p < .05$). Children's schooling is also significantly and negatively associated with overall PD ($b = -0.06$, $p < .01$). When both respondent's and spouse's SES are included in the model, the coefficient of children's education is reduced from −0.06 to −0.03 and is no longer statistically significant. After adjusting for baseline health, the coefficient of children's schooling becomes slightly larger, but remains statistically non-significant ($b = -0.04$). Finally, results from Model 4 show that the effects of children's education vary by respondent's gender. Interaction terms between children's education and gender (female) are negative for three out of four outcomes, but only the interaction term for CV/metabolic function was statistically significant ($b = -0.13$, $p < .05$).

Table 3 shows the results of analyses examining whether children's education has significant associations with eight psychological and behavioral factors. Similar to the analytic strategies in Table 2, three sets of covariates were subsequently included into Models 1 through 3, and gender differences were examined in Model 4. Overall, we found that older adults who have well-educated children are more likely to experience psychological wellbeing and engage in healthy behaviors than those who have poorly-educated children. Even after adjusting for all confounding variables (Model 3), a one standard deviation increase in children's schooling is associated with increased subjective social status ($b = 0.10$), increased life satisfaction ($b = 0.15$), and a decrease in stressful life events ($b = -0.16$). Similar links appear with some of the health-related behaviors, such as a reduced risk of being a former smoker ($b = -0.44$) or a current smoker ($b = -0.61$) and an elevated likelihood of having a healthy diet ($b = 0.39$). The gender interaction terms (Model 4) indicate that as children's years of schooling increase, mothers are more likely than fathers have physical check-ups ($b = 0.44$, $p < .01$).

Finally, Table 4 displays the percentage of the association between children's schooling and inflammation explained by mediators and the significance of indirect effects. We tested five psychosocial and behavioral factors that were significantly associated with children's education in Model 3 of Table 3 (subjective social status, life satisfaction, stressful life events, healthy diet, and smoking) as potential mediators. To investigate specific pathways, we included each mediator separately. The effect of children's education remained significant after adjusting for confounding variables ($b = -0.10$, $p < .05$). After including the mediators, the percentage explained by each mediator ranged from 3% to 27%. Smoking independently explained 27% of the association between children's education and inflammation. The indirect effect was statistically significant (95% CI = −0.044, −0.009). However, psychological factors explained much less of the variation in inflammation (<10%) and the association was not statistically significant.

Discussion

Across various mental and physical health outcomes, individuals who have lower levels of schooling are at greater risk for poor health than those who have higher levels of

Table 3. Association Between Children's Education and Psychosocial and Behavioral Factors of Older Parents

	Subjective social status (OLS)	Life satisfaction (OLS)	Stressful events (P)	Healthy diet(Logit)	Regular exercise(Logit)	Physical exam (Logit)	Smoking (mlogit) Formerly smoked	Smoking (mlogit) Current smoking	Drinking (mlogit) Infrequent drinker	Drinking (mlogit) Frequent drinker
Model (M)1:										
Children's education	0.235***	0.230***	−0.203***	0.589***	0.335***	0.186*	−0.115	−0.353***	0.024	−0.059
	(0.036)	(0.036)	(0.050)	(0.084)	(0.080)	(0.079)	(0.107)	(0.090)	(0.119)	(0.112)
M2: M1 + Respondent's & Spouse's SES										
Children's education	0.102*	0.170***	−0.177**	0.400***	0.093	0.157	−0.412*	−0.610***	0.196	−0.124
	(0.042)	(0.042)	(0.059)	(0.095)	(0.093)	(0.092)	(0.158)	(0.137)	(0.145)	(0.142)
M3: M2 + Respondent's health										
Children's education	0.098*	0.149***	−0.163**	0.387***	0.068	0.140	−0.440**	−0.607***	0.194	0.117
	(0.042)	(0.041)	(0.059)	(0.096)	(0.094)	(0.093)	(0.160)	(0.138)	(0.146)	(0.143)
M4: M3 + Gender interaction term										
Children's education	0.060	0.154**	−0.133	0.340**	0.031	−0.058	−0.516**	−0.710***	−0.267	−0.114
	(0.051)	(0.051)	(0.076)	(0.120)	(0.115)	(0.114)	(0.171)	(0.154)	(0.153)	(0.149)
Female	−0.063	−0.013	0.202	0.436	−0.297	0.072	−4.834***	−3.755***	−2.196***	−2.688***
	(0.095)	(.093)	(0.140)	(0.227)	(0.215)	(0.212)	(0.762)	(0.404)	(0.401)	(0.485)
Children's education × Female	0.079	−0.010	−0.057	0.102	0.084	0.441**	−0.334	0.411	0.554	−0.157
	(0.066)	(0.064)	(0.093)	(0.159)	(0.150)	(0.149)	(0.539)	(0.295)	(0.338)	(0.353)

Notes: Logit = logistic regression model; mlogit = logistic regression model; OLS = ordinary least squares regression model; P = Poisson regression model. Model 1 (baseline) controls for all confounding variables. The measures of children's education, subjective social status, and life satisfaction are standardized (mean = 0, *SD* = 1). Never smoked and Abstainer are the reference groups for mlogit.

$^*p < .05$, $^{**}p < .01$, $^{***}p < .001$.

Table 4. Test of Mediation in Association Between Children's Education and Inflammation Through Psychosocial and Behavioral Factors

	Model 1 (baseline)	Model 2: Baseline + Subjective social status	Model 3: Baseline + Life satisfaction	Model 4: Baseline + Stressful events	Model 5: Baseline + Healthy diet	Model 6: Baseline + Smoking
Estimate of children's education (standard error)	−0.096* (0.042)	−0.100* (0.042)	−0.088* (0.042)	−0.093* (0.042)	−0.090* (0.042)	−0.070 (0.042)
Percentage explained by mediators		5.58	8.56	2.65	6.41	27.05
Estimate of indirect effect (95% confidence interval)		0.005 (−0.002, 0.013)	−0.008 (−0.019, 0.002)	−0.003 (−0.012, 0.005)	−0.005 (−0.017, 0.006)	−0.026 (−0.044, −0.009)

Notes: P = Poisson regression model. Percentage of total effect of children's education explained by mediators was calculated with the KHB-module in Stata 14.0. Model 1 (baseline) controls for all confounding variables in 1996.

$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$.

schooling (Hummer & Lariscy, 2011; Mirowsky & Ross, 2003). Although most studies have focused mainly on the health benefits of individuals' education (Montez & Friedman, 2015), recent studies have indicated that aging parents also benefit from their children's education (Friedman & Mare, 2014; C. Lee et al., 2017; Torssander, 2013; Zimmer et al., 2007), yet the underlying biological mechanisms through which well-educated children promote the health of older parents are poorly understood. Using a nationally representative longitudinal study of aging in Taiwan, the present study identified the mechanisms that link adult children's schooling and the health of aging parents.

Several key contributions emerge from our findings. First, motivated by theories of social support and control, as well as life-course perspectives, we expected that parents who have well-educated children would tend to have better biological profiles than those who have poorly-educated children (H1). We found an inverse association between children's schooling and inflammation—an association that remains robust and statistically significant even after considering other family members' SES and respondent's health status at baseline. Given that systemic inflammatory biomarkers, for example, CRP and IL-6, are well-known contributors to elevated risk of chronic diseases and mortality (Ershler & Keller, 2000; Volpato et al., 2001), our findings broaden prior work by uncovering biological mechanisms that explain the associations between children's schooling and parental mortality (Friedman et al., 2014; Torssander, 2013; Zimmer et al., 2007). However, fewer significant associations were evident when looking at the other body systems. Given the physiological interconnections between inflammation and CV/metabolic function, the non-significant effect of children's schooling was unexpected. Thus, we performed sensitivity analyses with three alternate constructions: (a) using different cutoff-values for "high risk," (b) controlling for the use of medication, and (c) reclassifying individuals taking certain medications (for hypertension, high cholesterol, and diabetes) as being at risk. Yet our results were consistent. Given the positive associations in low or middle-income countries between SES and preventable diseases, such as obesity, diabetes, and hypertension (Dinsa, Goryakin, Fumagalli, & Suhrcke, 2012; McEniry et al., 2015), we speculate that a unique feature of the sample—older adults who were born before 1947 and experienced dramatic changes in socioeconomic development and health-related behaviors (e.g., diet and smoking)—may contribute to our findings.

We also expected that older parents who have well-educated children would be more likely to experience psychological wellbeing and engage in health-enhancing behaviors, thus resulting in better biological profiles (H2 and H3). Our findings show that parents who have well-educated children report higher social standing and life satisfaction and are less likely to experience stressful events. They are also more actively engaged in healthy behaviors, for example, eating fruits and vegetables every day and not smoking. Such patterns may appear because poorly-educated children tend to have less job security, lower income, and a greater risk of experiencing psychosocial stressors. Through intergenerational transmission of stress, older parents who have poorly-educated children may have greater risk of experiencing subsequent stressors, such as financial strain and residential instability, but they may receive little social support from their children and frequently come into conflict with them. Such taxing experiences in later years may result in accumulated psychological distress and mood disorders, as well as health-harming behaviors to cope with stress. Consonant with prior work (Friedman & Mare, 2014), our findings indicate that unhealthy behaviors like smoking are a potential pathway linking children's education and parental inflammation. Given that smoking is highly concentrated among poorly-educated individuals, particularly for younger generations (Boardman, Blalock, & Pampel, 2010), we speculate that well-educated children may be more likely to inform their parents about the hazards of smoking and encourage them to quit.

Based on theories of resource substitution and gender inequality, we anticipated that mothers may benefit more than fathers from children's schooling (H4). We provided some evidence that supports this hypothesis. Specifically, as children's educational levels increase mothers tend to exhibit lower levels of cardiovascular and metabolic risk than fathers. Mothers are more likely to have physical examinations. However, we did not find significant interaction terms between children's education and parent's gender for other domains of PD and psychosocial and behavioral mediators. Prior work on parental mortality based on data from the United States and Sweden has found no significant gender differences in the effect of children's education (Friedman & Mare, 2014; Torssander, 2013). Similarly, no gender differences have been observed in the association between children's education and depressive symptoms of older parents in Taiwan (C. Lee et al., 2017). These findings suggest that the health benefits from having well-educated children may not differ for mothers and fathers or that the effect of gender (men vs. women) may be negligible. Since only a few studies have explicitly investigated gender differences, more work on various domains of health outcomes would be needed to establish firm conclusions.

There are some limitations to this study. First, there could be problems of endogeneity; for example, if parents have health problems, this can affect the educational attainment of their children. To reduce this possibility, we fully utilized the longitudinal nature of this data by controlling for major mental and physical health problems of parents at baseline. However, at baseline the average age of living children was 37, and for 80% of respondents, their youngest child was already older than 25, indicating that most children had reached the age of college graduation. Thus, our analytic approach could not fully rule out reverse causality. In addition, since some of the mediators were measured contemporaneously with outcomes or only 1 year apart, we could not establish clear causal ordering or capture effects with longer latency periods. Third, although our analysis reduced potential bias by including an extensive set of confounding variables, we can't exclude bias due to omitted variables or unobserved factors (e.g., parental intelligence and aspirations toward children's education). Thus, our findings may not be causal. Fourth, high mortality attrition (e.g., 24% of respondents by the 1999 TLSA) may have affected our results, particularly if individuals who have poorly educated children have greater attrition rates. In the sensitivity analysis, we found that the average educational attainment of all living children was lower for respondents who died before the 1999 TLSA, compared with those who participated in the 1999 survey (9 years vs. 11 years of schooling, $p < .001$). Given the well-established positive association between PD and mortality risk (Goldman et al., 2006), our estimates of children's schooling may be attenuated by attrition due to mortality. Fifth, our measure of children's schooling was based on reports from respondents beyond midlife, so cognitive decline among aging parents or recall bias more generally may have affected the accuracy of their reports. However, compared with occupation and income, education is a more reliable and less subjective measure of SES (Elo, 2009). Finally, we did not directly measure whether adult children promote parental health behaviors, for example, by assisting their parents with selecting health care providers. Thus, whereas plausible, our results on underlying mechanisms are only speculative and should be interpreted cautiously.

Despite these limitations, our central findings contribute to literature on the upward intergenerational transfer of educational benefits by revealing potential physiological, psychosocial, and behavioral mechanisms by which adult children can play a central role in the health of their older parents. Traditionally, the people of Taiwan have emphasized family integration, intergenerational support, and education. There were large generational gaps in educational attainments between older parents and adult children (Hsu & Wu, 2015; Y-J. Lee et al., 1994); our findings may thus be uniquely situated to the cultural contexts of Taiwan. Yet cumulative evidence indicates that aging parents in Western societies, such as the United States and Sweden, also benefit from raising well-educated children. Future studies should investigate whether our findings can be replicated using longitudinal studies of aging in Western societies and whether the way in which well-educated children influence the health of their parents differs across societies.

Supplementary Material

Supplementary data is available at *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences* online.

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Conflict of Interest

The author declares no conflicts of interest.

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