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Older mother's health and adult children's education: Conceptualization of adult children's education and mother-child relationships

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ABSTRACT

This study joins and extends an emerging body of work examining the association between adult children's education and their parents' health by (1) providing a conceptual treatment of adult children's education, (2) examining the link between adult children's education and older mothers' physical and mental health, and (3) investigating whether mother-child relationships moderate the association between children's education and mothers' health. Data on 541 older mothers in the U.S. who reported on all of their adult children collected as part of the Within-Family Differences Study. Results indicate the best performing measure of adult children's education, the proportion with a college degree or higher, reflects a cumulative, credential-based approach. In addition, the proportion of adult children with a college degree or higher maintains a negative association with mother's depressive symptoms and activity limitations net of mother's own education as well as a number of sociodemographic factors and adult children's measures. There was no evidence that various aspects of mother-child relationships (geographic proximity, frequency of contact, and quality of relationships) moderated these negative associations.

1. Introduction

An emerging body of research extends the well-documented education-health gradient to examine associations between adult children's education and parents' health, also known as upward spillover effects (see De Neve & Kawachi, 2017 for review). Studies find a robust inverse association between adult children's levels of education and parent mortality, as well as parents' activity limitations (De Neve & Harling, 2017; Friedman & Mare, 2014; Torssander, 2014, 2013; Yahirun, Sheehan, & Mossakowski, 2018, 2017, 2016; Yang, Martikainen, & Silventoinen, 2016; Zimmer, Hanson, & Smith, 2016, 2002). These associations have been documented among older populations in a diverse group of countries including China (Yang et al., 2016), Finland (Elo, Martikainen, & Aaltonen, 2018), Mexico (Yahirun, Sheehan, & Hayward, 2017, 2016), South Africa (De Neve & Harling, 2017), Sweden (Torssander, 2014, 2013), Taiwan (Lee, Gleib, Goldman, & Weinstein, 2017; Zimmer, Martin, Ofstedal, & Chuang, 2007, 2002), and the United States (Friedman & Mare, 2014; Wolfe, Bauldry, Hardy, & Pavalko, 2018b, 2018a; Yahirun et al., 2018), that capture a range of levels of economic development and extents of social welfare policies.

These past studies, however, are limited in three respects. First, previous studies have adopted a variety of approaches to

conceptualizing and measuring adult children's education with minimal theoretical consideration. The differences in conceptualization and measurement in part reflect differing distributions of and returns to educational attainment around the world (Beckfield, Olafsdottir, & Bakhtiari, 2013; Fink & Peet, 2016; Peet, Fink, & Fawzi, 2015). Second, although most past studies have investigated physical health or mortality, only a couple studies have analyzed whether adult children's education support the mental health of their aging parents (Lee et al., 2017; Yahirun et al., 2018). Third, past studies have not explored whether different aspects of parent-child relationships (e.g., the extent of contact and quality of the relationships) moderate the association between adult children's education and parents' health.

This study addresses these gaps through a theoretical treatment of how to conceptualize and measure adult children's education and an analysis of a uniquely suited source of data, the Within-Family Differences Study, which includes detailed information on mothers' relationships with each of their adult children. The analysis assesses both mental and physical health outcomes (depressive symptoms and activity limitations) and draws on a rich array of measures of mother-child relationships that capture how frequently mothers interact with their children as well as how close or strained mother's relationships are with their children.

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2. Conceptualizing adult children's education

Past studies have used a variety of different measures of adult children's education to investigate the association with parents' health. Some studies measure adult children's education as the highest degree completed among a set of children (e.g., [Torssander, 2014](#); [Wolfe, Bauldry, Hardy, & Pavalko, 2018a, 2018b](#)), other studies measure adult children's education as the education level of the first-born (e.g., [Torssander, 2013](#)), and yet other studies adopt more complex measurements that capture proportions of adult children with different years of schooling or degree levels (e.g., [Friedman & Mare, 2014](#); [Yahirun et al., 2017, 2016](#)). Although most studies report that different measures of adult children's education were explored in preliminary analyses and led to similar results, the preliminary analyses are not reported and there is little substantive discussion to guide the measurement decisions. The limited conceptual consideration and differences in measurement of adult children's education across studies provide little guidance for future research and make it difficult to compare results across studies.

For families with multiple children, there are two dimensions to consider when conceptualizing and ultimately constructing a measure of adult children's education: (1) the extent to which education is treated as reflecting human capital (typically measured in years of education completed) or as a credential (typically measured in attained degree) and (2) how to aggregate the education levels of multiple children to construct a family-level measure (see [Fig. 1](#)). For the first dimension, the distinction between a human capital perspective and a credential perspective lies in whether each additional year (or unit) of education leads to better health or whether achieving specific thresholds of education (e.g., a postsecondary degree) leads to better health. Research on the education-health gradient typically links human capital to knowledge and psychosocial-based mechanisms and credentials to income and occupation-based mechanisms ([Liu et al., 2013](#); [Mirowsky & Ross, 2003](#)). The human capital approach theorizes that each additional year (or unit) of education translates into greater awareness of health-promoting behaviors and an orientation towards making the most of that knowledge. In contrast, a credential approach emphasizes the fact that obtaining higher educational degrees leads to higher paying and more prestigious jobs, which in turn provide resources to support health and a healthier work environment.

The most systematic empirical study to date found evidence for both human capital and credential processes in an analysis of the functional form of education and the association with risk of mortality ([Montez, Hummer, & Hayward, 2012](#)), which is consistent with studies finding multiple mechanisms linking education and health ([Cutler & Lleras-Muney, 2008](#)). [Montez et al. \(2012\)](#) suggested that an optimal operationalization of education when analyzing the education-health gradient would account for both human capital and credential processes, but the hybrid functional form identified by them is difficult to translate into a summary measure when considering the attainment of multiple adult children. Although it is likely that both human capital and credential processes are intertwined and difficult to isolate using standard measures of adult children's educational attainment, it is possible that in some contexts either human capital or credential mechanisms will carry more weight.

The second dimension concerns how best to aggregate the levels of

education in families with multiple children in order to capture the resources or knowledge available in the family unit as a whole. There are numerous options for aggregation, but in practice two stand out as having clear links with substantive considerations. The first option involves identifying the maximum level of education among the set of adult children. This approach, which can be thought of as a threshold or non-cumulative approach, is based on the idea that adult children's education represents a non-cumulative resource such that having at least one child with high levels of education provides benefits and additional children with equivalently high levels of education do not provide additional benefits. Studies that measure adult children's education as the highest level among all of the children or the level of education of the eldest child implicitly adopt this approach ([Torssander, 2013, 2014](#); [Wolfe et al., 2018a](#); [Zimmer, Hermalin, & Lin, 2002, 2007](#)). The second option involves constructing a measure that captures the average level of education among the adult children. This approach, which can be thought of as a cumulative approach, is based on either the idea that adult children's education provides a cumulative resource or that family dynamics may be such that having a higher proportion of children with high levels of education increases the odds of realizing any benefits. In general, one would expect that conceptualizing adult children's education as an average (the cumulative approach) will be preferred in the presence of multiple mechanisms and potential family dynamics that could involve strained relationships, but there may be some social contexts in which the threshold approach would be sufficient (e.g., in social contexts in which filial piety is a strong cultural norm).

3. Adult children's education and parents' health

Despite the lack of conceptual clarity and consistency of measurement, research has shown a consistent association between adult children's education (or more broadly, adult children's socioeconomic position) and parents' mortality. Specifically, this body of work has found sizable negative associations between adult children's education and parents' mortality net of several measures of parent socioeconomic resources and other sociodemographic characteristics ([Friedman & Mare, 2014](#); [Torssander, 2013, 2014](#); [Wolfe et al., 2018a, 2018b](#); [Yahirun et al., 2017](#); [Yang et al., 2016](#); [Zimmer et al., 2007, 2016](#)). Studies examining activity limitations also typically find sizable negative associations net of a number of sociodemographic and socioeconomic covariates ([Yahirun, Sheehan, & Hayward, 2016, 2017](#); [Zimmer et al., 2002](#)).

Several mechanisms have been proposed as potential explanations for why adult children's education could be beneficial for parents' physical health. In broad strokes, the different mechanisms can be divided into three classes: (1) financial resources, (2) direct care, and (3) knowledge. The most commonly discussed mechanism, particularly among studies focusing on lower income countries, concerns the transfer of financial resources ([De Neve & Harling, 2017](#); [Friedman & Mare, 2014](#); [Yahirun et al., 2016, 2017](#); [Yang et al., 2016](#)). More educated children, on average, have access to better jobs and thus likely have more financial resources that could be used to support their aging parents' health, especially in the absence of health insurance or other state-sponsored health care programs, than less educated children. Alternatively, children with lower levels of education may draw on

		Mechanism	
		Human Capital	Credential
Aggregation Across Multiple Children	Cumulative	Mean years of schooling	Proportion attained a selected degree
	Threshold	Maximum years of schooling	At least one child attained a selected degree

Fig. 1. Conceptualization of adult children's education along two dimensions.

financial resources from their parents, thus diverting parents' resources that could be used to support their own health and potentially representing a significant source of social stress that could also undermine parents' health.

Another mechanism linking adult children's education and parents' health involves the provision of direct care (Friedman & Mare, 2014; Torssander, 2014; Yang et al., 2016). It is possible that adult children with higher levels of education are in a better position to provide care for parents in poor health than are children with lower levels of education; however, evidence from studies of adult children and caregiving suggests that the opportunities for direct care may be limited as more educated children are more likely to live further away from their parents and to face higher opportunity costs of providing care (Laditka & Laditka, 2001; Machin, Salvanes, & Pelkonen, 2012).

In addition to these mechanisms, past studies have also proposed two knowledge-based mechanisms that could link adult children's education and parents' health. The first involves knowledge about how to navigate the health care system that comes with higher education (Friedman & Mare, 2014; Torssander, 2014, 2013). The second stems from knowledge of health promoting behaviors and the transmission of healthier lifestyles or behaviors from adult children to their parents (Friedman & Mare, 2014). Higher levels of education are known to be associated with healthier lifestyles or more broadly engaging in a healthier profile of behaviors (e.g., lower rates of smoking, moderate drinking, and more frequent exercise) (Cockerham, Bauldry, Hamby, Shikany, & Bae, 2017; Lawrence, 2017). It is possible that more educated adult children pass on or encourage their parents to adopt the health promoting behaviors or general healthy lifestyles they have developed.

These mechanisms provide plausible explanations for the relatively strong associations between adult children's education and parent's physical health observed in past studies. Most of these same mechanisms have the potential to be applicable with respect to parents' psychological health as well as their physical health. For instance, financial resources that come with higher levels of adult children's education could help alleviate some of the stresses of older age that could undermine parents' mental health. In addition, greater knowledge of mental health concerns and mental health care that could come from higher educated adult children may also support parents' mental health. Finally, if more highly educated adult children are able to pass on healthier lifestyles to their parents, then this could also help improve parents' quality of life and general mental well-being.

4. Parent-child relationship as potential moderator

The various proposed mechanisms linking adult children's education and parents' health generally require parent-child contact to transmit resources, knowledge, health promoting behaviors, and social support. As such, one would expect that both the amount of contact parents have with their children and the degree of emotional closeness or conflict would moderate the association between adult children's education and parents' health. The quality of parent-child relationships is associated with intergenerational contact, and, in particular, older parents are likely to interact more with adult children with whom they have closer relationships (Gilligan, Suitor, & Pillemer, 2015; Silverstein, Parrott, & Bengtson, 1995). A higher frequency of contact and better relationships with adult children should help facilitate any transmission of knowledge or resources from adult children to their parents, thus strengthening the association between adult children's education and parents' health.

The mechanisms discussed above provide pathways through which adult children's education can have a causal effect on parents' health. It is also possible, however, that the observed associations are due to confounding. A few studies using quasi-experiments based on changes in policies concerning minimum years of schooling have found evidence of causal effects in less developed regions (e.g., Tanzania) but not in

welfare states (e.g., Sweden) (De Neve & Harling, 2017; Lundborg & Majlesi, 2018). These studies speculate that adult children's socioeconomic resources may play a relatively minor role in places with more comprehensive welfare systems. Although our study is unable to leverage a quasi-experimental design, the tests of parent-child relationships as moderators provide indirect evidence of causal effects in that the absence of expected moderation is consistent with the possibility that these mechanisms do not underlie the link between adult children's education and parent health. We return to this possibility in our discussion.

5. Research aims

In sum, this study aims to (1) provide a conceptual treatment of adult children's education, (2) examine the link between adult children's education and older mothers' physical and mental health, and (3) investigate whether mother-child relationships moderate the association between children's education and mothers' health.

6. Data and methods

6.1. Data

The data for this study were collected as part of the first wave of the Within-Family Differences Study, which includes a sample of mothers 65–75 years of age with at least two living adult children (A more detailed description of the design can be found at <https://web.ics.purdue.edu/~jsuitor/within-family-differences-study/index.html>).

Massachusetts city and town lists provided a sampling frame for the mothers. Massachusetts requires communities to keep city/town lists of all residents by address. Town lists also provide the age and gender of residents. The investigators drew a systematic sample of women aged 65–75 from the town lists from 20 communities in the greater Boston area. The interviewers completed interviews with 566 mothers between 2001 and 2003, which represented 61% of those who were eligible for participation, a rate comparable to that of similar surveys in the 2000s (Wright & Marsden, 2010). In the interviews mothers provided extensive information about each of their adult children, including details about their relationships.

Of the 566 mothers in the original sample, 6 mothers (1 percent) were excluded who had never been married and 19 mothers (3 percent) were excluded due to missing data on the covariates. The exclusions leave an analysis sample of 541 mothers who provided information on an average of 3.8 children.

6.2. Measures

6.2.1. Outcomes

The analysis focuses on two outcomes, one measure of mental health and one measure of physical health. The measure of mental health, depressive symptoms, comes from the Center for Epidemiological Studies Depression (CES-D-SF) Short Form Scale (Ross & Mirowsky, 1984). The CES-D-SF includes 7 items asking respondents how often in the past week they have felt a certain way with a range from 0 = rarely or none of the time (less than 1 day) to 3 = most or all of the time (5–7 days). The items include: (1) everything I did was an effort, (2) I had trouble getting to sleep or staying asleep, (3) I felt lonely, (4) I felt sad, (5) I could not get going, (6) I felt I could not shake off the blues, and (7) I had trouble keeping my mind on what I was doing. The scale was created by taking the average of the 7 items (Cronbach's alpha = 0.78). The measure of physical health, activity limitations, is based on a question asking respondents: "Do you have any health conditions or difficulties that limit your activities or things you can do?" with responses 0 = no activity limitation and 1 = at least one activity limitation.

6.2.2. Adult children's education

As discussed above, there are multiple ways to conceptualize adult children's education and all mothers in this study had at least two children. Mother's reported on their adult children's education with one question asking about the highest grade completed with responses (1) eighth grade or less, (2) 1–3 years of high school, (3) high school graduate, (4) vocational/non-college post high school, (5) 1–3 years of college, (6) college degree, and (7) graduate work. Preliminary analyses indicated that a college degree is the most significant credential with respect to the outcomes in this analysis, which is consistent with numerous studies identifying the salience of higher education in the contemporary US (Montez & Barnes, 2016; Yahirun et al., 2018). In our preliminary analysis, for instance, measures based on a college degree had a better fit relative to an alternative measure based on a high school degree with differences in BICs ranging from 3.57 to 13.52. Therefore, an indicator was created for a college degree or higher for each child as a measure of the credential perspective. To approximate the human capital perspective, the highest grades completed for each adult child were recoded into years of schooling as follows: (1) eighth grade or less = 8 years, (2) 1–3 years of high school = 10 years, (3) high school graduate = 12 years, (4) vocational/non-college post high school = 14 years, (5) 1–3 years of college = 14 years, (6) college degree = 16 years, and (7) graduate work = 19 years. To reflect the cumulative perspective, the mean level of education across all of the adult children for each mother was calculated. In contrast, to reflect the threshold perspective, the maximum level of education across all of the adult children for each mother was determined. Taken together, there are four measures of adult children's education that correspond with the different cells in Fig. 1: (1) the average years of schooling across adult children, (2) the proportion of adult children who attained a college degree or higher, (3) the maximum years of schooling across adult children, and (4) an indicator for whether at least one adult child had a college degree or higher.

It is important to note that the correlations between the four measures of adult children's education range from 0.72 to 0.91 (see Table A1 in Appendix for correlation matrix). Such high correlations are expected because all four measures reflect different dimensions of adult children's education and are derived from the same raw variables. These correlations are high, but not so high that it is impossible to distinguish among some of the measures and their corresponding conceptualization as we demonstrate below.

6.2.3. Mother-child relationships

The analysis explores five measures of mother-child relationships surrounding the average frequency of contact and quality of relationships between mothers and their adult children. The first measure, the proportion of adult children living within 2-hour driving radius of their mother, captures a geographic dimension that could dictate the frequency of in-person contact. The next two measures capture the average frequency of face-to-face and phone contact between mothers and their adult children with a range from seeing each other or speaking on the phone 0 = never to 6 = every day. The final two measures capture the average relationship quality between mothers and their adult children along two dimensions. The first dimension, closeness, is based on a question asking each mother on a scale from 1 "very distant" to 7 "very close" how she would describe the relationship between her and each child nowadays. The second dimension, strain, is based on a question asking each mother on a scale from 1 "not at all tense and strained" to 7 "very tense and strained" how she would describe how tense and strained the relationship is between her and each child nowadays.

6.2.4. Additional covariates

The analysis also adjusts for a number of mothers' characteristics that the literature has shown predict adult children's educational attainment and mother's health (Friedman & Mare, 2014; Wolfe et al.,

2018a; Yahirun et al., 2016, 2017). These include mother's age, race (1 = white, 0 = non-white), marital history (0 = married, 1 = divorced, 2 = widowed), and level of education (0 = less than high school, 1 = high school graduate or vocational school, 2 = some college, 3 = a college degree or higher). In addition, the models also adjust for three aggregate characteristics of adult children in the family: the number of living adult children, the proportion of daughters among the adult children, and the proportion of adult children who are married. Preliminary analyses also explored adjusting for mother's income and mother's self-rated health. The inclusion of these covariates did not alter the results. Due to missing data for mother's income and conceptual concerns around endogeneity with mother's self-rated health, these covariates are not included in the main analysis.

6.3. Analytic strategy

The analysis proceeds with three steps. The first step involves identifying the best of the four measures of adult children's education with respect to the association with mother's health. Following a strategy used by Montez et al. (2012), the analysis relies on model fit statistics (R^2 /pseudo- R^2 and BIC) from bivariate models regressing depressive symptoms and activity limitations on the four different measures of adult children's education. The second step involves fitting a series of regression models that include the best performing measure of adult children's education (model 1) and adjust for characteristics of the mothers and children (model 2) and then mother-child relationship measures (model 3). This second step provides estimates of the net associations between adult children's education and mother's depressive symptoms and activity limitations. The final step of the analysis involves introducing interaction terms between adult children's education and each of the measures of mother-child relationships to the fully adjusted models. Logit models are used for activity limitations and the interactions are tested via second differences using Stata's margins command (Ai & Norton, 2003; StataCorp, 2017). Analyses were completed using Stata 15 and all of the code is maintained at a publicly available website to facilitate replication and extensions (<https://github.com/PengSiyun/Kidedu-and-Mom-health-SSM-PH>).

7. Results

7.1. Descriptive statistics

On average, mothers experienced depressive moods less than one day per week, which is similar to other national representative sample (Levine, 2013), and a little under 40 percent reported having some activity limitation (see Table 1). Across mothers, the average proportion of their children with a bachelor's degree or higher ranged from 0 to 1 with an average of 0.47. Similarly, across mothers the average years of their children's schooling ranged from 8 to 19 years with a mean of 14.6 years of schooling. If one considers the maximum rather than the average level of educational attainment among adult children, then 69 percent of mothers had at least one child with a bachelor's degree or higher and across mothers the maximum years of schooling among their children ranges from 8 to 19 years with a mean of 16 years. Only 21 percent of the mothers in the sample have a bachelor's degree or higher, so, as one would expect given the expansion of higher education in the latter half of the twentieth century, mother's adult children have, on average, higher levels of education than they themselves do.

7.2. Four measures of adult children's education

Table 2 reports unstandardized estimates (linear regression coefficients for depressive symptoms and average marginal effects for activity limitations) and fit statistics from bivariate regressions for each of the four measures of adult children's education. Beginning with depressive symptoms, the best performing measure with respect to the BIC is the

Table 1
Descriptive statistics.

	Mean	Std Dev	Range
Outcomes			
Depressive symptoms	0.61	0.60	0–3
Any activity limitations	0.39		0,1
Children's Education			
Proportion of children with BA +	0.47	0.40	0–1
Average years of children's education	14.57	2.37	8–19
At least one child with BA +	0.69		0,1
Max years of children's education	16.02	2.66	8–19
Mother Characteristics			
Mother's age	70.92	3.10	66–76
Mother white	0.71		0,1
Mother's marital status			
married	0.49		0,1
divorced	0.16		0,1
widowed	0.35		0,1
Mother's education			
less than high school	0.22		0,1
high school degree	0.35		0,1
some college	0.22		0,1
college degree or higher	0.21		0,1
Children's Characteristics			
Number of children	3.81	1.82	2–13
Proportion female children	0.50	0.28	0–1
Proportion married children	0.64	0.31	0–1
Mother-Child Relations			
Proportion children live within 2 h	0.76	0.28	0–1
Average frequency of visits	3.19	1.26	0–6
Average frequency of talk on phone	4.39	1.07	0–6
Average closeness to children	6.09	0.96	2–7
Average strain with children	2.07	1.14	1–7

Table 2
Parameter estimates and model fit statistics for models predicting depressive symptoms and activity limitations using different measures of adult children's education; N = 541.

	Model 1	Model 2	Model 3	Model 4
Depressive Symptoms				
<i>Cumulative</i>				
Proportion children with BA +	−0.30*** (0.06)			
Mean years of schooling		−0.05*** (0.01)		
<i>Threshold</i>				
At least one child with BA +			−0.20*** (0.06)	
Maximum years of schooling				−0.04*** (0.01)
R2	0.04	0.04	0.03	0.03
BIC	964.29	965.26	972.88	969.20
Activity Limitations				
<i>Cumulative</i>				
Proportion children with BA +	−0.20*** (0.05)			
Mean years of schooling		−0.03*** (0.01)		
<i>Threshold</i>				
At least one child with BA +			−0.10* (0.04)	
Maximum years of schooling				−0.01 (0.01)
pseudo-R2	0.02	0.01	0.01	0.00
BIC	722.55	726.25	731.70	733.76

Notes: *p < 0.05, **p < 0.01, ***p < 0.001. Unstandardized estimates with robust standard errors in parentheses. Depressive symptoms estimates obtained from linear regression models. Activity limitation estimates are average marginal effects obtained from logit regression models.

proportion of children with a bachelor's degree or higher. The model with this measure has a BIC between 4.91 and 8.59 lower than the threshold-based measures, which provides “positive” to “strong” evidence in Raftery's (1995) scheme in support of the model with percent of children with a bachelor's degree or higher. The evidence from the BIC is much weaker in distinguishing the two cumulative-based measures with a difference of less than 1 between models with proportion of children with a bachelor's degree or higher and mean years of schooling. This is likely in part a reflection of not having a standard measure of years of schooling available in the data and the high correlation of 0.91 between the two measures. Finally, for the bivariate association we find that a shift from having no adult children (0%) with a bachelor's degree or higher to having all adult children (100%) with a bachelor's degree or higher is associated with 0.30 lower depressive symptoms and similarly a shift from an average of 12 years of schooling to 16 years of schooling among adult children is associated with 0.20 lower depressive symptoms.

A similar pattern emerges in the models for activity limitations, though the evidence from the BIC provides stronger support for the model with proportion of adult children with a bachelor's degree or higher. The BIC for the model with proportion of adult children with a bachelor's degree or higher ranges from 3.70 to 11.21 or between “positive” and “very strong” support for the model adopting the cumulative/credential-based measure. The same pattern of support for the best fitting model emerges from examining areas under the ROC curve. The average marginal effect indicates that a shift from having no adult children with a bachelor's degree or higher to have all adult children with a bachelor's degree or higher is associated with a 0.20 lower probability of having an activity limitation.

The bivariate models for the two health outcomes in combination provide clear support for the cumulative conceptualization of adult children's education over the threshold conceptualization. The evidence is less clear in distinguishing the human capital and the credential perspectives, but there is some indication that the measure based on the credential perspective performs a bit better and thus the analysis proceeds with proportion of adult children with a bachelor's degree or higher as the preferred measure of adult children's education.

7.3. Adult children's education and older mother's health

Table 3 reports the changes in the unstandardized estimates for proportion of adult children with a bachelor's degree or higher as additional covariates are added to the model. Model 1 is the bivariate model, model 2 adds mothers' and children's characteristics, and model 3 adds mother-child relationships measures. Although there is some attenuation in the size of the associations with the inclusion of additional covariates, the proportion of adult children with a bachelor's degree or higher maintains a significant association even after adjusting for mothers' and children's characteristics such as mother's education, the number of children, and the proportion of female children as well as aspects of mother-child relationships such as the average level of strain in the relationships. In the final models, a shift from having no adult children with a bachelor's degree or higher to have all adult children with a bachelor's degree or higher is associated 0.17 lower depressive symptoms and a 0.15 lower probability of having an activity limitation.

To gain a sense of the substantive magnitude of the association between children's education and mothers' health, predicted values for depressive symptoms and predicted probabilities for having any activity limitation were calculated based on the respective final models. Fig. 2 illustrates the predicted values and probabilities with 95 percent confidence intervals in addition to the marginal distribution of the proportion of adult children with a bachelor's degree or higher along the x-axis. The figure indicates that mothers who have no children with a bachelor's degree are predicted to score approximately 0.7 on depressive symptoms and have a 46 percent chance to have an activity limitation. In contrast, mothers who have all children with a bachelor's

Table 3
Parameter estimates from models regressing depressive symptoms and activity limitations on adult children's education and covariates; N = 541.

	Depressive Symptoms			Activity Limitations		
	M1	M2	M3	M1	M2	M3
Prop. children with BA +	-0.30*** (0.06)	-0.20* (0.08)	-0.17* (0.08)	-0.20*** (0.05)	-0.16* (0.06)	-0.15* (0.06)
Mothers' and Children's Characteristics						
Age		0.01 (0.01)	0.02 (0.01)		0.01* (0.01)	0.02* (0.01)
White		-0.07 (0.07)	-0.08 (0.07)		-0.15** (0.05)	-0.15** (0.05)
Marital status (ref. = married)						
divorced		0.03 (0.08)	-0.01 (0.08)		0.17* (0.07)	0.16* (0.07)
widowed		0.09 (0.06)	0.07 (0.06)		0.06 (0.05)	0.05 (0.05)
Education (ref. = less than high school)						
high school degree		-0.16* (0.08)	-0.15 (0.08)		-0.05 (0.06)	-0.04 (0.05)
some college		-0.22* (0.09)	-0.21* (0.09)		0.01 (0.06)	0.02 (0.06)
college degree or higher		-0.13 (0.10)	-0.12 (0.10)		0.11 (0.07)	0.14 (0.08)
Number of children		-0.01 (0.01)	-0.01 (0.01)		-0.01 (0.01)	-0.00 (0.01)
Prop. female children		-0.03 (0.09)	-0.02 (0.09)		-0.09 (0.07)	-0.09 (0.07)
Prop. married children		0.03 (0.09)	0.06 (0.09)		-0.03 (0.07)	0.02 (0.07)
Mother-Child Relationships						
Prop. children live within 2 h			0.10 (0.11)			-0.02 (0.10)
Average frequency of visits			-0.01 (0.04)			0.03 (0.03)
Average frequency of phone calls			-0.01 (0.05)			0.01 (0.03)
Average closeness with mother			0.03 (0.04)			-0.03 (0.03)
Average strain with mother			0.11** (0.03)			0.03 (0.02)
R2	0.04	0.07	0.10	0.02	0.07	0.08

Notes: *p < 0.05, **p < 0.01, ***p < 0.001. Unstandardized estimates with robust standard errors in parentheses. Depressive symptoms estimates obtained from linear regression models. Activity limitation estimates are average marginal effects obtained from logit regression models.

degree or higher are predicted to score approximately 0.5 on depressive symptoms and have a 31 percent chance to have any activity limitation. Although the 0.2 difference in depressive symptoms may seem small, it is roughly equivalent to the association of mothers' own education and depressive symptoms.

7.4. Mother-child relationships

As shown in Table 3, including the measures of mother-child relationships has minimal impact on the association between adult children's education and mothers' health net of mother's and children's characteristics. Among the measures of mother-child relationships, only

the average level of strain in the relationships has a net positive association with depressive symptoms (b = 0.12). No net associations for the aggregate measures of mother-child relationships are evident with activity limitations.

Despite the lack of main effects, it is possible that the mother-child relationship quality could moderate the observed associations between adult children's education and mother's health. A series of models, however, that introduced interaction terms between the proportion of children with a bachelor's degree or higher and each of the mother-child relationship measures one at a time revealed no evidence of moderation (see Table 4). Thus, the net associations between adult children's education and both mother's physical and mental health do not vary systematically by average quality of mother-child relationships.

8. Conclusion

In this study we join and extend an emerging body of work examining the association between adult children's education and their mothers' health. In particular, we offer a conceptual treatment of adult children's education that has been lacking in past work, an examination of a mental health outcome, depressive symptoms, alongside a physical health outcome, and an assessment of mother-child relationships as moderators of the link between adult children's education and mothers' health.

Past studies have adopted several different approaches to operationalizing adult children's education with limited theoretical consideration. Measures of adult children's education range from whether the first-born child had a tertiary education (Torssander, 2014), the highest degree attained of all children (Wolfe et al., 2018a; 2018b), the proportion of children holding different degrees (Friedman & Mare, 2014), and the percent of children reaching different thresholds of years of schooling (Zimmer et al., 2007) among other approaches. This lack of consistency in the measurement of adult children's education limits generalizability and makes it difficult to compare results across studies. This analysis of a US sample finds that an approach that captures levels of education among all of the adult children, the cumulative approach, is preferred over one that only considers the education levels of the most educated child, the threshold approach. The better performance of the proportion of children with a college degree or higher relative to the maximum level of education among adult children is consistent with two theoretical possibilities: (1) adult children's education represents a cumulative resource and/or (2) having multiple children with higher levels of education may increase the odds of the beneficial transfer of resources or knowledge in the potential presence of family conflicts.

The better performance of the cumulative measures of adult children's education may also in part reflect the social context of the Within-Family Differences Study mothers – i.e., a relatively recent cohort (as compared with some other studies in this area) with adult children who may have benefited from the expansion of higher education in the United States during the second half of the twentieth century. In other social contexts with more limited opportunities for higher education or in contexts with a greater cultural emphasis on filial piety it is possible that the education levels of the most educated child would perform equally as well. Nonetheless, it is difficult to imagine a context in which the education levels of the most educated child would *outperform* a measure that takes into account the education levels of all adult children.

We found weak support for a measurement based on the credential approach (degree) as opposed to the human capital approach (years of schooling). The inability to clearly distinguish between the two approaches likely in part reflects a limitation of the measure of adult children's education in the Within-Family Differences Study (i.e., the need to assign years of schooling to various thresholds for grades completed). Although these assignments did not have a perfect overlap with educational degrees, they still missed the full range of years of

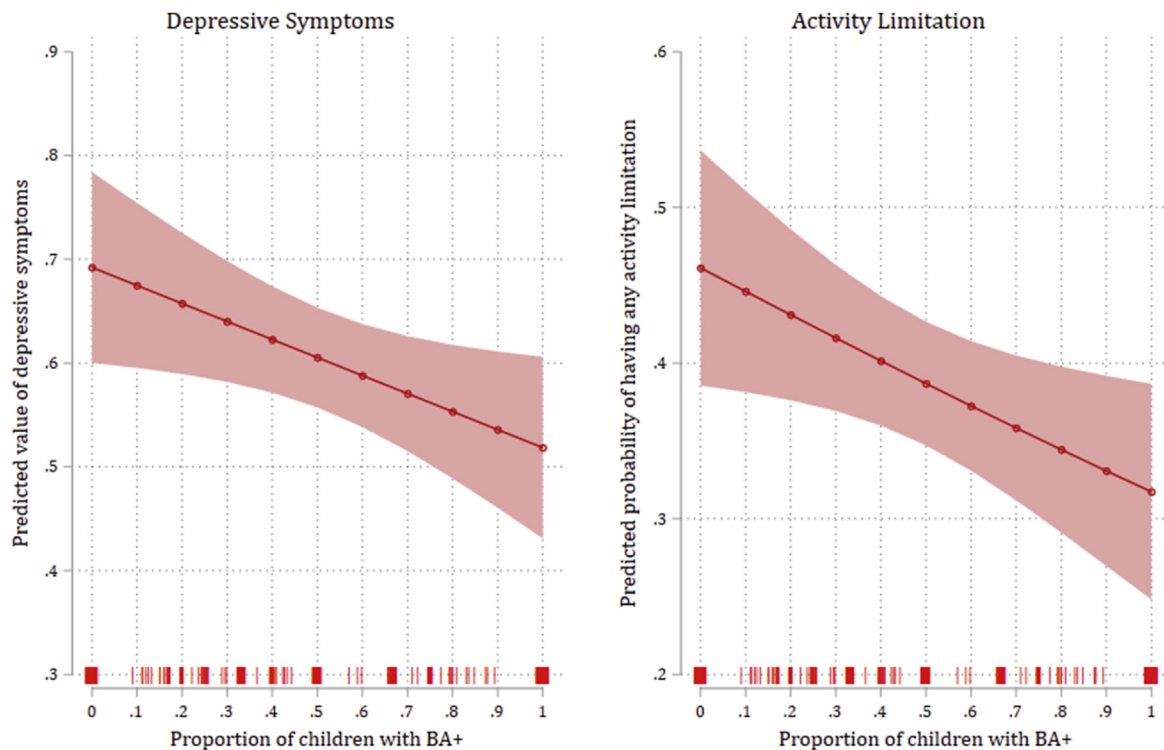


Fig. 2. Predicted values for depressive symptoms and predicted probabilities for activity limitations based on fully adjusted models (Model 3) across the range of proportion of adult children with a bachelor's degree or higher. Marginal distribution of proportion of children with a bachelor's degree or higher indicated in red on the x-axis. The shaded regions indicate 95% confidence intervals.

Table 4
Selected parameter estimates for models including interactions; N = 541.

	Depressive Symptoms					Activity Limitations				
	M1	M2	M3	M4	M5	M1	M2	M3	M4	M5
Prop. children with BA +	-0.08 (0.21)	-0.46* (0.19)	-0.64* (0.32)	-0.66 (0.47)	-0.10 (0.13)	-1.05 (0.78)	-1.56* (0.71)	-2.24* (1.06)	-0.91 (1.46)	-0.71 (0.50)
Mother-Child Relationships										
Prop. children live within 2 h	0.16 (0.18)	0.06 (0.11)	0.08 (0.11)	0.09 (0.11)	0.09 (0.11)	-0.33 (0.68)	-0.19 (0.49)	-0.12 (0.48)	-0.09 (0.47)	-0.09 (0.47)
Avg. frequency of visits	-0.01 (0.04)	-0.05 (0.05)	-0.01 (0.04)	-0.01 (0.04)	-0.01 (0.04)	0.15 (0.12)	0.05 (0.15)	0.16 (0.12)	0.16 (0.12)	0.16 (0.12)
Avg. frequency of phone calls	-0.01 (0.05)	-0.01 (0.05)	-0.06 (0.06)	-0.01 (0.05)	-0.01 (0.05)	0.03 (0.12)	0.03 (0.12)	-0.12 (0.16)	0.02 (0.12)	0.02 (0.12)
Avg. closeness with mother	0.03 (0.04)	0.03 (0.04)	0.03 (0.04)	-0.00 (0.06)	0.03 (0.04)	-0.12 (0.13)	-0.11 (0.13)	-0.12 (0.13)	-0.13 (0.17)	-0.12 (0.13)
Avg. strain with mother	0.11*** (0.03)	0.11*** (0.03)	0.11*** (0.03)	0.11*** (0.03)	0.12** (0.04)	0.14 (0.11)	0.15 (0.11)	0.14 (0.11)	0.14 (0.11)	0.14 (0.13)
Interactions with Proportion Children with BA +										
Prop. children live within 2 h	-0.11 (0.23)					0.43 (0.88)				
Avg. frequency of visits		0.09 (0.05)					0.25 (0.19)			
Avg. frequency of phone calls			0.10 (0.07)					0.34 (0.22)		
Avg. closeness with mother				0.08 (0.07)					0.03 (0.23)	
Avg. strain with mother					-0.04 (0.06)					0.00 (0.19)

Notes: *p < 0.05, **p < 0.01, ***p < 0.001. Unstandardized estimates with robust standard errors in parentheses. Depressive symptoms estimates obtained from linear regression models. Activity limitation estimates are log odds obtained from logit regression models. All models also adjust for mothers' and children's characteristics.

schooling. The inability to clearly distinguish between the two approaches may also reflect the possibility that both credential- and human capital-based processes are operant in the links between adult children's education and mothers' health as has been found with the education-mortality gradient (Montez et al., 2012). Additional research

is needed to determine whether one or another approach is generally preferred and to determine whether the preferred approach varies across social contexts. For instance, it is possible that a different measure of adult children's education would perform better in areas of the world where the distribution of educational attainment and the returns

to education are different than in the US.

In this paper, we confirmed past findings regarding the association between adult children's education and mother's physical health (activity limitations) and as well as relatively new findings regarding the association between adult children's education and mother's mental health (depressive symptoms). In addition, we found both associations to remain after adjusting for a broader array of measures of mother-child relationships than have previously been examined in past studies (Friedman & Mare, 2014; Torssander, 2013, 2014; Wolfe et al., 2018a). The analysis thus contributes to the growing body of work documenting an association between adult children's education and parents' health. As with earlier work, an important limitation stems from our reliance on cross-sectional data and our inability to address all potential confounders (e.g., mothers' genetic endowments and/or psychosocial resources that may impact both their health and their children's levels of education) and therefore the association should not be interpreted as a causal effect. More work is needed using alternative research designs, such as the quasi-experimental designs discussed above, to establish causal effects and to elucidate potential mechanisms underlying the relationship between adult children's education and parents' health.

Finally, we tested whether various aspects of mother-child relationships – the average of adult children's geographic proximity, frequency of contact, and quality of relationships with their mothers – moderated the association between adult children's education and mother's health and found no evidence of moderation. This is surprising given the likely importance of these factors for many of the mechanisms proposed to account for the association between adult children's education and parents' health. The lack of evidence of moderation may reflect three possibilities. First, it is possible that the average relationships mothers have with their adult children misses important one-on-one relationship dynamics that could impact the transfer of resources from any given child. It is also possible that alternative measures of the relationship mothers have with their children, such as the variance in contact and closeness, could affect the transfer of resources. Second,

consistent with other studies of older adults (Fingerman, Pillemer, Silverstein, & Suito, 2012; Polenick, DePasquale, Eggebeen, Zarit, & Fingerman, 2018), this study found relatively limited variability in the average frequency of contact and the average quality of relationships with mothers. This limited variability, itself, makes it difficult to detect moderation. Third, it is possible that the absence of moderation is an indication that the children's education-parental health association is largely endogenous and driven by unobserved confounders, at least in the context of the contemporary US. Additional conceptual and empirical work is needed to assess these possibilities.

In addition to the limitations noted above, it is also important to acknowledge that this study relies on a sample that does not include fathers and only includes mothers with at least two children. Past studies, however, have found similar associations between adult children's education and mothers' and fathers' health and the associations are not shaped by the number of children (Wolfe et al., 2018a; 2018b). Despite the limitations, these findings contribute to a broader understanding of the social determinants of health that takes into consideration the potential importance of multiple generations and in particular possible flows of resources from adult children back to their parents. This study joins an emerging literature investigating the effects of socioeconomic resources of various family members on individuals' health (Lee et al., 2017). In particular, the better fit of cumulative approach over the threshold approach implies that education levels of all children may matter for aging parents' health.

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Appendix

Table A1

Correlation matrix for four measures of adult children's education; N = 541.

	[1]	[2]	[3]	[4]
[1] Proportion children with BA +	1			
[2] Mean years of schooling	0.91	1		
[3] At least one child with BA +	0.79	0.72	1	
[4] Maximum years of schooling	0.78	0.87	0.84	1

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