



Increased adult child schooling and older parents' health behaviors in Europe: A quasi-experimental study

Jacqueline M. Torres^{a,*}, Yulin Yang^a, Kara E. Rudolph^b, Emilie Courtin^c

^a Department of Epidemiology & Biostatistics, UC San Francisco, San Francisco, CA, USA

^b Department of Epidemiology, Mailman School of Public Health, Columbia University, New York City, NY, USA

^c Department of Public Health, Environments and Society, London School of Hygiene & Tropical Medicine, London, UK

ARTICLE INFO

Keywords:

Lifecourse epidemiology
Intergenerational influences
Socio-economic status
Health behaviors
Quasi-experimental methods

ABSTRACT

There is growing evidence that adult child educational attainment is associated with older parents' physical health and longevity. Scholars have hypothesized that these associations may be driven by health-behavior pathways, whereby adult children with more education may share information about healthy lifestyles, role-model healthier behaviors, and/or have more economic resources to support leisure-based physical activity or the purchase of healthy foods for older parents. However, this relationship has not been comprehensively evaluated with methods capable of addressing the confounding bias expected for observational studies on this topic. We estimated the association between increased adult child schooling and older parents' health behaviors using data from the Survey for Health, Aging and Retirement in Europe (SHARE) (n = 8195). We leveraged changes to compulsory schooling laws that would have impacted respondents' adult children as quasi-experiments and estimated the association between increased schooling among oldest adult children and respondents' (parents') body mass index, obesity, physical inactivity, excessive drinking, and current smoking using two-stage least squares regression. Each year of increased schooling among oldest adult children was associated with a lower risk of current smoking (β : -0.029, 95% CI: -0.056, -0.003), physical inactivity (β : -0.034, 95% confidence interval [CI]: -0.077, 0.009), obesity (β : -0.038, 95% CI: -0.065, -0.011) and lower body mass index (β : -0.37, 95% CI: -0.73, -0.02). The direction of associations with excessive drinking varied by parent gender (β : -0.027, 95% CI: -0.046, -0.007 for mothers; β : 0.068, 95% CI: -0.011, 0.148 for fathers). Increases in adult child schooling may have upward influences on parents' late-life health behaviors, although there may be some differences by parent gender. Findings should be replicated across other global settings and studies should directly evaluate parent health behaviors as mediators of the relationship between increased adult child schooling and older parents' longevity.

1. Introduction

A growing body of research across global settings considers the impact of adult child educational attainment on older parents' health (De Neve & Kawachi, 2017), showing that higher adult child educational attainment is associated with better physical functioning and cognition as well as reduced mortality risk for older parents (De Neve & Harling, 2017; Yahirun et al., 2017; Zimmer et al., 2002, 2007). Much of this work hypothesizes that higher adult child educational attainment influences older parents' health outcomes via financial (e.g. direct financial transfers) and psychosocial mechanisms (e.g. lower stress, more

social engagement) (De Neve & Kawachi, 2017; Y. Lee, 2018). These factors may in turn lead to reduced stress, depression, and anxiety (Thoma et al., 2020; Yahirun, Sheehan, & Mossakowski, 2020), which could have positive consequences for late-life health and mortality.

A smaller set of studies have proposed that there might also be health behavior-related pathways that underlie associations between adult child education and parental health (Friedman & Mare, 2014; Torssander, 2014). For example, children with higher education may have more knowledge about health behaviors that they may transmit to older parents directly or indirectly (e.g. via role-modeling) (Berniell et al., 2013). Adult children with greater socio-economic resources

Abbreviations: CSL, Compulsory Schooling Law; BMI, Body Mass Index; 2SLS, Two-Stage Least Squares Regression; SES, Socio-economic Status.

* Corresponding author. 550 16th Street, San Francisco, CA, 94143, USA.

E-mail address: Jacqueline.Torres@ucsf.edu (J.M. Torres).

<https://doi.org/10.1016/j.ssmph.2022.101162>

Received 18 April 2022; Received in revised form 27 June 2022; Accepted 1 July 2022

Available online 6 July 2022

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resulting from higher education may also be better able to support healthier lifestyles among older parents, including by purchasing healthier foods and freeing up more resources for their parents' leisure-time physical activity (Böhme et al., 2015; Friedman & Mare, 2014).

Nevertheless, very few studies have actually evaluated the association between adult child education and parents' health behaviors. A small number have done so indirectly, by evaluating whether adult child education was linked to causes of death more likely to be driven by adverse health behaviors (e.g. lung cancer) (Friedman & Mare, 2014; Lundborg & Majlesi, 2018; Torssander, 2014). Of the two studies that have directly examined associations between adult child education and older parents' health behavior-related outcomes (Friedman & Mare, 2014; Ma, 2019), only one, based in China, used a quasi-experimental approach to address potential confounding bias. However, this study focused only on older parents' body mass index (BMI); other health behavior-related outcomes such as smoking or drinking were not examined.

In the present study, we used data on older adults in Europe collected at the beginning of the 21st century (2004–2005) to evaluate the impact of increased adult child educational attainment on older parents' BMI, obesity, physical inactivity, smoking, and excessive drinking. We follow prior quasi-experimental studies focused on parents' cognition and mortality (De Neve & Harling, 2017; Lundborg & Majlesi, 2018; Ma, 2019), using adult child exposure to changes in compulsory schooling laws passed in the latter half of the 20th century (between 1962 and 1983) as instrumental variables. We additionally examine differences in the associations between adult child schooling and older parents' health behaviors by parent gender, given prior evidence of heterogeneity in the effects of adult child educational attainment on the late-life health and mortality for older mothers and older fathers (Lundborg & Majlesi, 2018; Ma et al., 2021).

2. Background

2.1. Adult child education and parents' health and longevity

A nascent but growing set of studies from across global settings shows that higher adult child educational attainment is associated with better health among older parents (De Neve & Harling, 2017; Yahirun et al., 2017; Zimmer et al., 2002, 2007). The most rigorous and generally consistent set of findings pertain to parental mortality. Scholars have used both observational and quasi-experimental studies – the latter typically leveraging exposure to changes in compulsory schooling laws as instrumental variables – to show that more years of adult child schooling are associated with increased longevity among older parents across low, middle, and high-income settings (De Neve & Harling, 2017; Friedman & Mare, 2014; Lundborg & Majlesi, 2018; Zimmer et al., 2007, 2016). There are limited exceptions, for example, with Lundborg and Majlesi (2018) finding no overall evidence of association between adult child schooling and older parents' mortality in Sweden. However, even in this study there was evidence of association within some subgroups (e.g. for older fathers from lower socio-economic backgrounds).

Other studies – more commonly using strictly observational methods – have found that higher adult child education is associated with a range of other aspects of parental health, including overall (self-rated) health, physical functioning, mental health, and biomarkers of chronic disease risk (C. Lee, 2018; Thoma et al., 2020; Yahirun et al., 2017; Zimmer et al., 2002). Once again, these studies have been conducted across varied global settings and have shown extremely consistent evidence of association between higher adult child education and older parents' health outcomes. More recently, studies have also shown associations between adult child schooling and older parents' cognitive performance using observational and quasi-experimental methods (Y. Lee, 2018; Ma, 2019; Ma et al., 2021; Torres et al., 2021; Yahirun, Vasireddy, & Hayward, 2020), with large quasi-experimental effect estimates reported for

studies of older adults in China and Mexico (Ma, 2019; Ma et al., 2021).

2.2. Potential mechanisms linking adult child education to older parents' health

Fundamental cause theory (Link & Phelan, 1995, 1996) suggests that individuals with higher socio-economic status (SES) can use their resources flexibly to both prevent adverse health outcomes and to protect against the most dire consequences of poor health. Education is typically considered a fundamental cause, given that higher levels of education are associated with greater socio-economic resources that may be used flexibly to support health, including higher income and wealth and greater occupational prestige. For many older adults, children may be their most important economic resource (Kim & Cook, 2011; Pan et al., 2017). Adult children with higher education and higher subsequent average incomes and/or wealth in middle-age may contribute critical economic resources via direct financial transfers to their older parents (Chou, 2010; Deindl & Brandt, 2011; Quashie, 2016; Silverstein et al., 2006). Receipt of financial transfers from adult children have in turn been linked to older parents' mental health outcomes (Wu et al., 2018) and health care use patterns (Behrman & Parker, 2013). Even in settings such as Europe, where financial transfers flow more commonly from parent to child (Deindl & Brandt, 2011), adult children with higher SES may require fewer financial resources (McGarry & Schoeni, 1995), freeing up more of parents' economic resources.

There may also be overlapping non-economic mechanisms at play. For example, higher education (and higher subsequent SES) among adult children may contribute to improved psychosocial outcomes among older parents via reduced financial strain as well as higher perceived relationship quality and familial support (Y. Lee, 2018). Scholars have found that increased adult child education is associated with higher ratings on measures of life satisfaction and fewer depressive symptoms among parents across varied global settings, potentially also driven by feelings of increased social status and/or parental pride in children's achievements (Lee et al., 2017; Ma, 2019; Yahirun et al., 2020). These potential economic and psychosocial mechanisms are most cited as the set of factors that might underlie associations between adult child education and older parents' health and longevity.

2.3. Adult child education and parents' health behaviors

A less commonly considered set of pathways linking adult child education to parents' health pertain to health behavior-related mechanisms. For example, scholars have proposed that adult children with higher SES may offer parents informational resources that may be used to increase health-related knowledge, including about the benefits and risks associated with various lifestyle choices (Jiang & Kaushal, 2020). Adult children with higher SES may additionally influence their parents' health behaviors via role-modeling (Berniell et al., 2013) or paying for health-related resources (e.g. healthy foods) (Friedman & Mare, 2014). More socio-economic resources among adult children may enable older parents to retire at the age of their choosing, thereby freeing up time for leisure-related physical activity. Finally, reduced family-level economic strain may reduce the likelihood that older parents engage in unhealthy coping behaviors such as excessive drinking or smoking.

Despite these hypothesized pathways, there has been relatively limited empirical attention to the relationship between adult child education and older parents' health behaviors. In one foundational exception, Friedman and Mare (2014) found that in the U.S., increased education among adult children was associated with lower parental mortality, and that this appeared to be driven by mortality causes closely linked to adverse health behaviors (e.g. lung cancer). In the same study, the authors found an observational association between higher adult child educational attainment and a lower odds of reporting no vigorous physical activity or being a current smoker and a greater odds of having quit smoking among older parents.

Two other studies (Lundborg & Majlesi, 2018; Torssander, 2014) have also indirectly evaluated the relationship between adult child education and older parents' health behaviors, finding that higher adult child education was linked to a lower risk of specific causes of death likely to be driven by poor health behaviors. To our knowledge, the only other study to directly examine the impact of adult child educational attainment on parents' health behavior-related outcomes used a quasi-experimental approach and found that increased adult child educational attainment resulting from a change in compulsory schooling was associated with *higher* BMI and a lower risk of underweight among older parents in China (Ma, 2019). The study did not look at smoking, drinking, or physical activity outcomes.

2.4. Potential differences by gender

Within the growing landscape of research on adult child education and older parents' health, there is mixed evidence that associations may differ by parent gender. For example, some scholars have found that higher adult child educational attainment has greater returns for the health of older mothers (Ma et al., 2021). Scholars have hypothesized that these findings may be driven the fact that across global settings, women – and particularly women in current older adult cohorts – have lower levels of own education, lower average income, and less wealth (World Economic Forum, 2021). Resource substitution theory (Ross & Mirowsky, 2011) suggests that those with fewer socio-economic resources may stand to benefit more from the resources of the subsequent generation, which may fill in critical gaps in basic needs and/or alleviate economic stressors. Adult child socio-economic resources may be less impactful for older men who are more likely to have basic needs met and/or less likely to experience financial strain than their older women counterparts.

However, at least one other quasi-experimental study showed greater returns of adult child education to mortality among older fathers in Sweden (Lundborg & Majlesi, 2018). The authors of this study suggested that older men were likely frailer than their women counterparts, given gendered differences in life expectancy, and that adult child socio-economic resources could be more critical for supporting older fathers in poorer health. In addition, counter to resource substitution theory, resource multiplication theory suggests that socio-economic resources may compound or multiply across generations (Ross & Mirowsky, 2006). Resource multiplication theory would generally predict that older fathers, who typically have more socio-economic resources than older mothers in the same birth cohort, might accrue more benefits from higher education and related SES resources among adult children. Finally, many other studies using a range of approaches have found no parent gender differences in associations between adult child education and parent health (e.g. C. Lee, 2018), suggesting that adult child resources may benefit the health of older parents regardless of gender. Nevertheless, studies have yet to consider heterogeneity by parent gender in the association between adult child education and parents' health behavior outcomes specifically.

2.5. Potential confounding bias in studies of adult child education and parents' health

A core methodological concern in observational research on adult child education and parents' health is residual confounding bias. This is because myriad dimensions of parents' own earlier and mid-life SES and health conditions are strong determinants of the SES of their children (Case et al., 2005; Hertz et al., 2008) and many of these same earlier life SES and health conditions are well-established determinants of parents' late-life health behaviors (Pudrovska et al., 2014; Puolakka et al., 2018). To the extent that many of these dimensions of parents' earlier life characteristics (e.g. SES prior to beginning one's educational trajectory, educational quality, childhood health) go unmeasured in large population based surveys, observational estimates may face substantial

confounding bias. More specifically, there could be reverse causation at play, whereby parents who have poorer health behaviors and, consequently, poorer health in midlife have fewer resources to invest in their child's education; these same mid-life health behaviors may persist into later-life.

Much as with studies of own education and health (Hamad et al., 2019), scholars have taken quasi-experimental approaches to evaluate the impact of increased adult child schooling on parents' health by leveraging exposure to national or sub-national changes to compulsory schooling laws as instrumental variables. The intuition behind this approach is that changes in school-leaving policies at the regional or national level should not be influenced by the individual, parent-level factors (e.g. early-life socio-economic and/or health status) – whether measured or unmeasured – that would be of central concern as confounders in an associational study. That is, parents' individual-level factors, including early-life SES and educational experiences, should have no impact on whether and when a given country decides to pass a law to change compulsory schooling. This means that exposure to a country-level compulsory schooling laws should be unconfounded by individual-level factors that may serve as common causes of both adult child educational attainment and older parents' health behaviors.

This quasi-experimental approach has been applied to several studies of the relationship between adult child education and older parents' mortality and a smaller set of studies evaluating impacts on older parents' cognitive performance and psychosocial outcomes. As previously mentioned, only one study, to our knowledge has applied this approach to evaluate older parents' body mass index using population-based data from China (Ma, 2019). No such studies have evaluated associations with a broader set of older parents' health behaviors and related outcomes.

2.6. The present study

We filled the gap in research on the influence of adult child education on older parents' health behaviors and related outcomes with a cross-sectional quasi-experimental analysis of population-based data collected on older European adults in 2004–2005. We evaluated the contribution of increases in adult child schooling to a wide range of health behaviors and health behavior-related outcomes among older parents, including body mass index, obesity, physical inactivity, current smoking and excessive drinking. To address the potential for confounding bias, we followed an approach applied in prior studies by leveraging changes in compulsory schooling laws that were enacted through the latter half of the 20th century in Europe (between 1962 and 1983) as instrumental variables.

We hypothesized that increased adult child educational attainment would contribute to better health behaviors and related outcomes among older parents overall. We further expected that there might have been differences in the magnitude of these associations by parent gender. We expected that the returns to increased adult child schooling would be greater for older mothers vs. older fathers. While prior evidence of heterogeneity by parent gender has been mixed, the majority of studies finding differences have found stronger association for older mothers, potentially driven by the fact that adult children's socio-economic resources may substitute for gaps in socio-economic resources held by older women (vs. older men) in current aging cohorts.

3. Data and methods

Data come from the Survey of Health and Retirement in Europe (SHARE) study. The SHARE data have been described in detail elsewhere (Börsch-Supan et al., 2013). Briefly, at baseline (2004–2005) the SHARE surveyed community-dwelling adults 50 years and older and their spouses of any age from 11 European countries plus Israel. The overall household response rate at the baseline study was 61.8% (n = 30421).

We first limited the analytic sample for our observational analysis to 22963 respondents 50 years and older in the 9 countries that passed national-level compulsory schooling laws (CSLs) in years that would have plausibly affected the schooling of respondents' adult children (see eTable 1 for a summary of CSLs and eFig. 1 for the derivation of the analytic sample).

We further limited the analytic sample to respondents who had at least one living child and whose oldest child was born in the first 10 birth cohorts to be affected by the CSL, which we considered to be the "treated" group, or in the 10 birth cohorts that would have just missed being influenced by the CSL, which we considered to be our "control" group ($n = 8539$). Finally, we excluded those missing on health behavior variables measures or on either adult child education or confounder variables, for a final analytic sample of 8195 (4718 women, 3477 men).

3.1. Health behavior measures

We considered a range of respondent health behaviors measured at the SHARE study baseline. Current smoking was measured with questions asking respondents if they had ever smoked cigarettes, cigars, cigarillos, or a pipe daily for a period of at least one year and, if so, whether they were smoking at the present time. We contrasted current smokers with those who never or ever smoked. Following Friedman and Mare (2014), we also conducted a sensitivity analysis contrasting those who quit smoking with those who were current smokers, excluding those who never smoked ($n = 1325$ women and 2376 men). This sensitivity analysis was intended to shed light on whether increases in adult child education might have led older adults to change their smoking behavior.

Excessive drinking was measured via a series of questions asking respondents about whether they consumed any alcohol in the previous six months and, if so, how often they had more than two glasses of beer, cider, or wine, or more than two cocktails or hard liquor drinks. Response options were "almost every day", "five or six days a week", "three or four days a week", "once or twice a week", "once or twice a month", "less than once a month", or "not at all in the last 6 months". Those who reported drinking >2 glasses/drinks almost every day or 5–6 days/week were classified as excessive drinkers vs. those who reported drinking less.

Physical inactivity was measured with two questions that asked respondents how often they engaged in 1) vigorous activity (e.g. sports, heavy housework, or a job that involves physical labor) and 2) moderate activity (e.g. gardening, cleaning the car, or going for a walk); response options for each question were "more than once a week", "once a week", "one to three times a month", or "hardly ever/never". Those who reported engaging in one type of physical activity more than once a week or both types of activities once a week were classified as 'active', with the remaining classified as physically inactive. In sensitivity analyses, we separately evaluated outcomes of a) hardly ever/never engaging in moderate physical activity and b) hardly ever/never engaging in vigorous physical inactivity.

Body mass index (BMI) was calculated by converting respondents' self-reported height and weight to a continuous measure of kilograms per squared meters. We evaluated a continuous measure of BMI as well as a categorical indicator of obesity ($BMI >30$) vs. overweight or normal/underweight ($BMI \leq 30$).

3.2. Adult child educational attainment

At baseline, SHARE respondents reported on the highest degree attained for up to four living children (94.3% of respondents had four or fewer children) ≥ 16 years of age. This information was reclassified into levels and then into years of education attained following the UNESCO international standard classification of education (ISCED) (UNESCO Institute for Statistics, 2012).

We considered our primary exposure as the years of education

attained by oldest child. If oldest children benefitted from a given CSL, the remaining children should have also benefitted from the same CSL, so our analyses approximate a contrast of outcomes for older adults for whom all children benefitted from a CSL change vs. some or no children benefitted. We also considered the educational attainment of oldest daughters and oldest sons separately, given prior evidence of child gender-specific pathways of impact (Y. Lee, 2018).

We also present sensitivity analyses with the highest educated adult child as an alternative index child. When there were multiple children with equally high levels of education, we selected the oldest highest educated child as the index child.

3.3. Instrumental variable

We generated a binary instrumental variable that indicated whether respondents' oldest child was in one of the first birth cohorts exposed to compulsory schooling laws (CSL) in their country (eTable 1). More specifically, our binary variable indicated whether the respondents' oldest child was born in the 10 birth cohorts first affected by the CSL vs. the 10 birth cohorts that would have just missed being impacted by the same law. These birth cohort bounds help ensure that exposed and unexposed respondents were otherwise exposed to similar social policies beyond the CSL changes (Brunello et al., 2009; Gathmann et al., 2015).

3.4. Covariates

All covariates were collected at study baseline. These included respondents' demographic characteristics including age in years, gender, nativity (i.e. born in country of residence at baseline vs. born in a different country), current marital status, and their total number of living children.

Lifecourse socio-economic status (SES) measures included continuous indicators of respondents' mother's and father's occupational prestige measured with the Standard International Occupational Prestige Scale (SIOPS) (Ganzeboom & Treiman, 1996) (as well as binary variables indicating whether mother's and father's occupational prestige score was missing), respondents' own level of educational attainment, a binary measure of whether or not they ever worked for pay, and the occupational prestige score (using the SIOPS) corresponding to respondents' current job, if employed, or to their last job, if currently not employed/retired (including a category indicating missingness on the occupational prestige score).

If respondents were married, we controlled for their spouses' baseline age and level of educational attainment. For currently or ever married respondents, we also included the SIOPS score corresponding to their primary lifetime occupation (as well as an indicator of missingness on this variable).

3.5. Statistical analyses

We used two-stage least squares (2SLS) estimation (Angrist & Krueger, 1992) to evaluate the effects of increased years of adult child schooling on parents' health behaviors. We compared these estimates to those generated via conventional Ordinary Least Squares for continuous outcomes or via linear probability models for binary outcome (both unadjusted and adjusted for covariates), as well as nonparametric estimates.

For the instrumental variables (IV) analysis, we adopted the monotonicity assumption, i.e. that increases in mandatory schooling would not lead any children to have less schooling than they otherwise would have completed. We also adopted the exclusion restriction assumption i.e. that these particular changes to compulsory schooling laws would have only influenced older parents' health behavior outcomes via the impacts of the CSL on adult child schooling. Under these assumptions and additional conventional IV assumptions of relevance and independence, the IV estimate is interpretable as the effect of additional

schooling completed by the oldest child due to the change in a compulsory schooling law among compliers – i.e. among those for whom the compulsory schooling law change would cause them to complete more schooling.

For the 2SLS approach, our first-stage estimates were generated with a linear model regressing the years of educational attainment of the oldest child on the birth cohort-based instrumental variable and covariates, specified as follows:

$$Yrs\ of\ Schooling_{ic} = \alpha_0 + \alpha_1 CSL_{ic} + \alpha_2 X_{ic} + \alpha_4 Country_c + \alpha_5 Country_c * Birth\ Year_{ic} + \varepsilon_{ihc} \tag{1}$$

Where *Yrs of Schooling_{ic}* indicates the years of schooling reported for the oldest child for respondent, *i*, living in country, *c*; *CSL_{ic}* is whether the respondents' oldest child was in one of the first 10 birth cohorts to be impacted by a compulsory schooling law change in country, *c*, vs. in one of the 10 birth cohorts who just missed benefitting from the change; *X_{ic}* is a vector of covariates; *Country_c* indicates country fixed effects; and *Country * Birth Year_{ic}* is the interaction between country and respondents' birth year; and *ε_{ihc}* is the error term clustered at the household and country levels.

We evaluated the strength of our instrument via the Kleibergen-Paap Wald F-test (Kleibergen, 2006); all analyses had a first-stage F-statistic above the conventional cut-off of 10. F-statistics, first-stage coefficients, as well as graphs showing the discontinuity of oldest children's years of educational attainment around the CSL changes are presented in the eAppendix (eTable 2; eTable 3; eFig. 2A and 2B).

Our second stage model regressed respondents' health behavior measures on the predicted value of schooling years for their oldest child, generated with the first-stage regression, and the same set of covariates as the first-stage model:

$$Health\ Behaviors_{ic} = \beta_0 + \beta_1 \widehat{Yrs\ of\ Schooling}_{ic} + \beta_2 X_{ic} + \beta_4 Country_c + \beta_5 Country_c * Birth\ Year_{ic} + \varepsilon_{ihc} \tag{2}$$

Where *Health Behaviors_{ic}* indicates respondents' value on a given health behavior measure and *Yrs of Schooling_{ic}* is the predicted value of the years of schooling attained by respondents' oldest children. In the models for the overall sample, we clustered standard errors at the household and country levels; given our interest in gender differences, we also estimated models stratified by parent gender.

4. Results

4.1. Descriptive characteristics

On average, respondents were just under 69 years old at the time of the survey and had an average of 2.6 living children (±1.38) (Table 1). Respondents reported that they had completed an average of 8.6 years of education (±4.39) and that their oldest children had completed an average of 12.3 years of schooling (±3.55). While there were many similarities in descriptive characteristics by respondent gender (eTable 4), women in the survey reported lower life-course socio-economic status, including fewer years of education and lower occupational prestige scores than their male counterparts.

Sixteen percent of respondents overall (14% of women, 20% of men) reported being current smokers, 14% (7% of women, 23% of men) reported drinking >2 alcoholic drinks 5–7 days/week, and 12% (13% of women, 10% of men) reported no moderate or vigorous physical activity. Respondents reported an average BMI of 26.6 kg/m² (±4.29), and 18% overall (20% of women, 16% of men) reported having obesity (BMI >30).

Table 1

Descriptive characteristics, older European adults 50+ years whose oldest child was in the first birth cohorts to just benefit from or just miss benefitting from a change in compulsory schooling laws (n = 8195).

Respondent Demographic Characteristics, Baseline		
Age, mean (SD)	68.81	(8.73)
Female, n (prop.)	4718	(0.58)
Born in country of current residence, n (prop.)	7752	(0.95)
Marital status, n (prop.)		
Married	5900	(0.72)
Never Married	98	(0.01)
Divorced	459	(0.06)
Widowed	1746	(0.21)
Spouse age, mean (SD)a	67.52	(8.97)
Total number of living children, mean (SD)	2.59	(1.38)
Respondent and Family Life-course Socio-Economic Status		
Respondent years of education, mean (SD)	8.55	(4.39)
Spouse years of education, mean (SD)a	8.70	(4.37)
Maternal occupational prestige score, mean (SD)	9.28	(16.52)
Maternal occupational prestige score missing, n (prop.)	6048	(0.74)
Paternal occupational prestige score, mean (SD)	32.89	(16.29)
Paternal occupational prestige score missing, n (prop.)	1057	(0.13)
Respondent ever worked, n (prop.)	7187	(0.88)
Respondents' occupational prestige score for current/last job, mean (SD)	31.39	(20.16)
Respondents' occupational prestige score for first job missing, n (prop.)	1696	(0.21)
Spouses' occupational prestige score, mean (SD)	28.39	(21.21)
Spouses' occupational prestige score missing, n (prop.)	2360	(0.29)
Adult Child Educational Attainment		
Years of educational attainment, oldest child, mean (SD)	12.30	(3.55)
Years of educational attainment, oldest daughter, mean (SD)b	12.23	(3.53)
Years of educational attainment, oldest son, mean (SD)c	12.28	(3.55)
Respondent Health Behaviors		
Current smoker, n (prop.)	1270	(0.16)
Drink >2 alcoholic drinks 5–7 days/weeks, n (prop.)	1115	(0.14)
No moderate or vigorous physical activity, n (prop.)	975	(0.12)
Body mass index, kg/m ² , mean (SD)	26.54	(4.28)
Obesity (BMI ≥30), n (prop.)	1500	(0.18)

Source: Survey on Health, Aging and Retirement in Europe, 2004. Notes: a. Limited to those who were married at baseline; b. Limited to n = 6237 with at least one adult daughter; c. Limited to n = 6255 with at least one adult son.

4.2. Adult child education and parents' health behaviors

Estimates from unadjusted (eTable 5) and adjusted (Table 2) OLS and linear probability models without the instrumental variable suggested

Table 2

Comparison of Beta Coefficients and 95% Confidence Intervals from Ordinary Least Squares/Linear Probability Models and Two-Stage Least Squares Regression Evaluating the Association between Oldest Adult Child Educational Attainment and Health Behaviors for Older Parents aged 50+ in Europe (n = 8195).

	OLS		2SLS	
	β	[95% CI]	β	[95% CI]
Current smoker	−0.005	(−0.008, −0.003)	−0.029	(−0.056, −0.003)
Drink 2+ drinks/day	0.001	(−0.002, 0.004)	0.013	(−0.022, 0.009)
Physical inactivity	−0.005	(−0.008, −0.003)	−0.034	(−0.077, 0.009)
Body Mass Index, kg/m ²	−0.077	(−0.110, −0.044)	−0.372	(−0.728, −0.016)
Obesity	−0.006	(−0.009, −0.003)	−0.038	(−0.065, −0.011)

Source: Survey on Health, Aging and Retirement in Europe, 2004/2005. Controls: Age, gender, marital status, own education, spouse age (if married), spouse education (if married), total number of kids, whether or not the respondent was born in country of current residence, paternal and maternal occupational prestige, spouse occupational prestige, respondent occupational prestige, whether or not respondent ever worked outside the home, country of residence; models cluster standard errors at the household level.

that more years of schooling among oldest adult children was associated with better health behaviors across outcomes with the following exceptions: unadjusted (but not adjusted) associations with current smoking were null and unadjusted associations with excessive drinking were in the adverse direction (adjusted associations were null).

Estimates from instrumental variables analysis suggested that increased years of schooling among oldest children were associated with a lower risk of current smoking (β : -0.029 , 95% CI: -0.056 , -0.003) as well as lower continuous body mass index (β : -0.37 , 95% CI: -0.728 , -0.016) and a lower risk of obesity (β : -0.038 , 95% CI: -0.065 , -0.011) among older parents (Table 2, Figs. 1 and 2). Increased years of schooling among oldest children was also associated with a lower risk of physical inactivity (β : -0.034 , 95% CI: -0.077 , 0.009), but the 95% confidence interval crossed the null. The association with risk of excessive drinking (i.e. 2 or more drinks for 5 or more days per week) was in the opposite of the hypothesized direction (β : 0.013 , 95% CI: -0.022 , 0.009), but the 95% confidence interval crossed the null.

Results were similar when focusing on increased education among oldest daughters and oldest sons (eTable 6a and eTable 6b) or on the highest educated adult child as the index child (eTable 7), or when using a nonparametric estimator (eTable 8).

4.3. Heterogeneity by respondent (parent) gender

There were differences in the magnitude of associations between increased adult child educational attainment and older parents' current smoking (β : -0.048 , 95% CI: -0.084 , -0.012 for older mothers; β : -0.005 , 95% CI: -0.048 , 0.038 for older fathers) and physical inactivity risk (β : -0.011 , 95% CI: -0.055 , 0.034 for older mothers; β : -0.059 , 95% CI: -0.129 , 0.012 for older fathers), although the 95% confidence intervals for these parent gender-specific estimates were highly overlapping (eTable 9, Fig. 1).

Increased adult child education was associated with a lower risk of

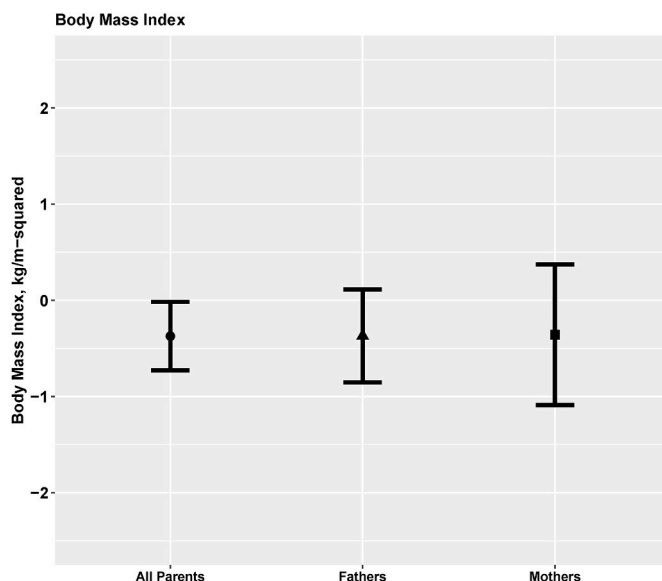


Fig. 2. Two-stage least squares estimates of the association between increased oldest child education on and older parents' continuous body mass index, overall and by parent gender, in the Survey of Health, Aging and Retirement in Europe (2004/2005).

excessive drinking (β : -0.027 , 95% CI: -0.046 , -0.007) among older mothers, but a greater risk of excessive drinking for older fathers (β : 0.068 , 95% CI: -0.011 , 0.148). There were no differences in the magnitude or direction of estimates by parent gender for obesity or continuous BMI outcomes (eTable 9, Figs. 1 and 2).

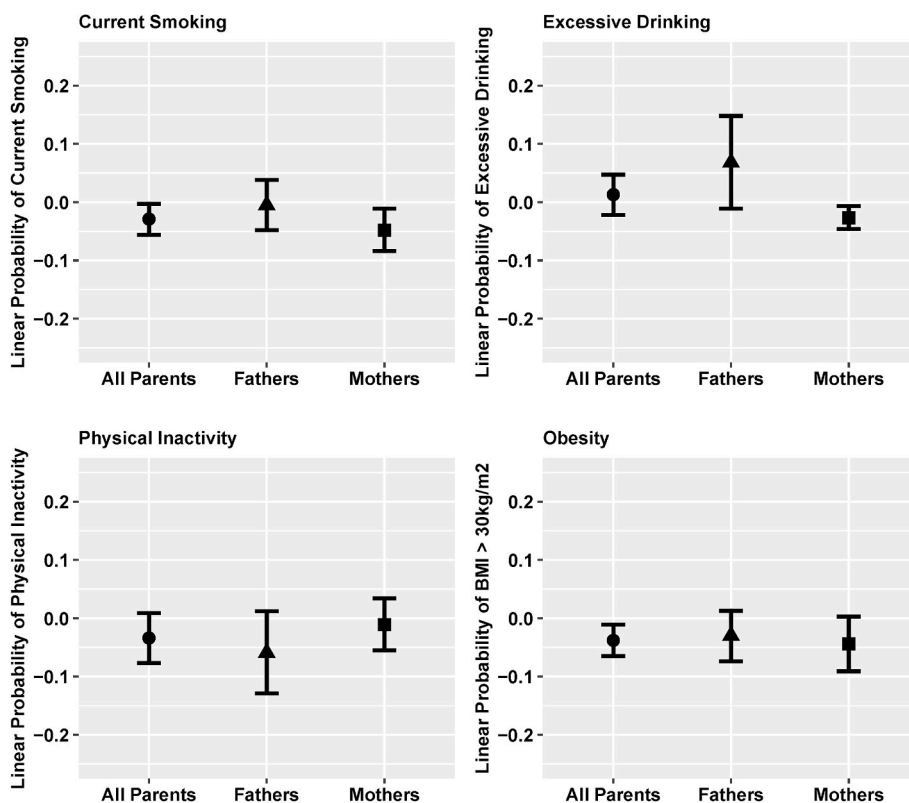


Fig. 1. Two-stage least squares estimates of the association between increased oldest child education on and older parents' health behavior-related outcomes, overall and by parent gender, in the Survey of Health, Aging and Retirement in Europe (2004/2005).

4.4. Sensitivity analyses

In sensitivity analyses, we found in OLS estimates that more years of schooling among oldest children were associated with an increased probability of older parents' having quit smoking (vs. continued smoking) for both older mothers and fathers (eTable 10) but our quasi-experimental estimates suggested an association between increased adult child education and smoking cessation for older mothers only. However, quasi-experimental estimates were highly imprecise, likely driven by the fact that the sample size for these sensitivity analyses was much smaller than for our primary analyses. In additional sensitivity analyses, we observed generally similar estimates as found in our primary analyses when we separately evaluated outcomes of hardly ever/never engaging in a) moderate and b) vigorous physical activity (eTable 11). For older fathers, the magnitude of the quasi-experimental associations was larger for moderate vs. vigorous physical inactivity, although in both cases the 95% confidence intervals crossed the null.

5. Discussion

We used population-based data from older adults in Europe collected at the start of the 21st century and employed compulsory schooling laws that would have impacted the children of these older participants' as quasi-experiments. We found that increased years of education among respondents' oldest children was associated with an overall reduction of the risk of physical inactivity, obesity, and smoking, as well as lower continuous body mass index. This study adds to growing evidence that the socio-economic resources of adult children may shape the health and longevity of their older parents (De Neve & Harling, 2017; Yahirun et al., 2017; Zimmer et al., 2002, 2007). While scholars have suggested that this relationship may be partially explained by health behavior-related mechanisms (De Neve & Kawachi, 2017; Torssander, 2014) very few studies have directly tested the relationship between adult child education (or other dimensions of SES) and older parents' health behaviors and quasi-experimental evidence on this topic has been almost non-existent (Friedman & Mare, 2014; Ma, 2019).

One prior study (Ma, 2019) evaluated the effects of increased years of education among adult children on health and financial outcomes for older parents in China, finding that increased offspring education was associated with higher BMI among older parents. In this context, higher BMI may have been likely reflective of the improved financial and material resources that older adults experienced as the result of children with improved socio-economic status, and could be seen as a positive indicator (e.g. reflecting reduced food insecurity and undernutrition). In the European context, where obesity is much more prevalent in late life (Peralta et al., 2018), lower BMI and reduced risk of obesity would also be reflective of a protective effect of increased adult child education.

The only other study (Friedman & Mare, 2014), to our knowledge, to directly examine the associations between adult child education and parents' health behaviors – in this case using an observational approach and population-level data from the U.S. – reported findings similar to our quasi-experimental estimates: higher educational attainment among adult children was associated with a lower odds that parents reported physical inactivity and current smoking. In addition, both ours and Friedman and Mare's studies reported observational associations between greater adult child schooling and smoking cessation among older parents who ever smoked. These findings suggest that higher education among adult children may have contributed to behavior change even among parents who had already adopted adverse health behaviors. Scholars have suggested that such associations may be driven by the fact that more highly educated adult children may transmit information about chronic disease prevention and management and healthy lifestyles to their older parents (Friedman & Mare, 2014). Nevertheless, we found evidence of some differences in associations by parent gender; differences by gender were not explored in the prior studies on this topic (De Neve & Harling, 2017; Lundborg & Majlesi, 2018; Ma et al., 2021).

Most notably, we found that the direction of the associations between increased adult child schooling and parents' risk of excessive drinking differed by parents' gender – findings suggested a protective association for older mothers but an adverse association for older fathers. There was also variation in the magnitude of associations with smoking and physical inactivity by parent gender, although confidence intervals overlapped such that we could not conclude that these associations differed for older mothers vs. older fathers.

These mixed findings by gender and outcome do not necessarily lend support to the competing theories of resource substitution and resource multiplication (Ross & Mirowsky, 2006, 2011) commonly invoked to explain greater health returns to adult child education for older mothers or older fathers. Specifically, scholars have suggested that greater health returns to adult child education for older mothers might be explained by the fact that older mothers tend to be of lower socio-economic status than their male counterparts and are more likely to be widowed. Older mothers may therefore rely on the resources of their adult children to a greater extent than older fathers to substitute for gaps in basic needs (i.e. resource substitution). Alternatively, older fathers may accrue benefit from increased adult child education via the accumulation of socio-economic advantages across generations (i.e. resource multiplication), which could contribute to improved health outcomes.

However, neither of these commonly cited theoretical perspectives have given sufficient attention to the possibility of adverse associations between increased adult child SES and the health of older mothers and fathers. Moreover, these theories have not sufficiently addressed the potentially nuanced pathways of influence linked to health behaviors. For example, increased adult child educational attainment may have had unintended adverse consequences for older parents' excess drinking by allowing for more family-level economic resources that could be spent on alcohol. Even though direct financial transfers from adult children to parents are relatively rare in European countries (Deindl & Brandt, 2011), more highly educated adult children may require fewer resources from their older parents, thereby freeing up funds for discretionary spending. The impacts of increased adult child education on parents' health behaviors could also intersect with gender-specific norms that shape societal health behavior patterns. For example, scholars have found that higher own SES is associated with greater alcohol consumption among men across global settings, while for women the relationships between own SES and alcohol consumption vary in complex ways cross-nationally (Grittner et al., 2013). These complex relationships may explain divergent associations between increased adult child schooling and alcohol consumption among older mothers and fathers.

Future research should help elucidate mechanisms underlying gendered differences in the relationship between adult child education and health behaviors by examining how patterns differ across global settings with varying gender-specific norms related to health behaviors such as smoking and alcohol use. In addition, future research might explore gender differences in the association between adult child education and older parents' financial outcomes (e.g. household income, financial stress), health literacy, beliefs and knowledge around health behaviors, and adult child co-residence patterns to help identify potential drivers of mixed findings by parent gender.

6. Limitations

We report several limitations. First, estimates generated from the instrumental variables approach are interpreted as the local average treatment effect and are not generalizable to respondents whose children whose educational attainment did not change as the result of compulsory schooling law changes. Second, there is the potential for exposure misclassification. Respondents classified as being in the "control" group in our analysis could have had younger children who were exposed to the CSLs, leading to exposure misclassification and potentially biasing our estimates to the null. Our estimates with an alternative

(i.e. the highest educated) index child were consistent with our primary results, albeit with reduced first-stage power. Third, we note potential information bias given that outcome variables were self-reported. Reporting of health behaviors such as smoking or drinking may have been subject to social desirability bias, which could have been differential with respect to respondents' (and adult child) socio-economic status. In addition, accurate reporting of weight, physical activity, or drinking may have been challenged by recall bias.

Finally, one of the common tradeoffs in instrumental variables analysis is that estimates can often have limited statistical precision; this issue is further exacerbated by our strategy to reduce the analytic sample based on the birth cohort of respondents' oldest children, which we felt was important for balancing demographic characteristics and exposure to other social policies across treatment and control groups, to the extent possible. As a result, we were not able to explore further heterogeneity in our estimates, including across individual countries or country clusters with similar characteristics. It is possible that adult child educational attainment may have different impacts on the health of older parents based on features of the social safety net (e.g. generosity, means-tested vs. universal, reliance on family members to provide late-life care) (Bambra, 2007). Evaluating these differences could be a fruitful area of future research.

7. Conclusion

This is the first quasi-experimental study that, to our knowledge, comprehensively evaluates the impact of increased adult child educational attainment on a wide range of parental health behaviors and health behavior-related outcomes. We found that in Europe, increased adult child educational attainment was associated with mostly improved health behaviors and related outcomes for older parents, including lower smoking and obesity risk. However, we also uncovered some important differences by respondent gender, including evidence that increased adult child educational attainment was protective for older mothers' excessive drinking but was adversely associated with excessive drinking for older fathers. This work, combined with the very few prior studies on this topic suggests that health behavior-related pathways may be plausible mechanisms by which higher adult child education influences older parents' health and longevity, but that the direction and magnitude of these pathways may vary to some extent by parents' gender. Future research should replicate these findings in other settings and formally evaluate the degree to which health behavior-related mechanisms mediate the effect of adult child educational attainment on older parents' mortality.

Funding

JMT reports funding from the National Institute on Aging (K01AG056602); JMT, EC, and KER acknowledge funding from the National Institute on Aging (R01AG072448); EC acknowledges funding from the UK Medical Research Council (MR/T032499/1).

Author contributions

Jacqueline Torres, Kara Rudolph and Emilie Courtin contributed to the study conception and design. Jacqueline Torres, Yulin Yang and Kara Rudolph analyzed the data. Yulin Yang performed code review. The first draft of the manuscript was written by Jacqueline Torres; all authors commented on previous versions of the manuscript. All authors read and approved the final version of the manuscript.

Ethics approval

This is a secondary data analysis of publicly available data; the Institutional Review Board at the University of California, San Francisco has determined it meets exempt status (#21-35802, January 02, 2022).

Ethical statement

This project is based on data that are deidentified and are publicly available. Analyses of these secondary data were approved as part of larger project by the Institutional Review Board at the University of California San Francisco (#21-35802).

Declaration of competing interest

The authors have no relevant financial or non-financial interests to disclose.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ssmph.2022.101162>.

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