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Socio-economic family background and adult children's health in Germany: The role of intergenerational transmission of education

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Abstract

The present study examines consequences of parental education for adult children's physical and mental health using panel data from the German Socio-economic panel study (GSOEP), waves 2002-2017. Based on random-effects growth curve models (N=5,564 individuals born between 1930 and 1990), we estimate gender-, age- and cohort-specific trajectories of physical and mental health components of the SF-12 questionnaire that were measured biennially. Findings suggest more persistent effects of parental education on physical than mental health; particularly daughters and sons of the least educated group of parents (with lower secondary or less education) exhibit markedly lower physical health scores than those of higher educated parents. Educational gradients regarding physical health tend to widen over the life course; among daughters, the health returns of parental education appear to increase in the youngest cohorts. Patterns for mental health are similar but weaker. As soon as children's educational attainment is held constant, effects of parental education on children's health mostly vanish. This suggests that in the strongly stratified German context with its rather low social mobility, intergenerational transmission of educational attainment, which, according to our analyses, has even grown slightly stronger among younger cohorts, contributes to cementing long-term health inequalities across the life course related to childhood family background.

1 Introduction

Health has been shown to be a critical determinant not only of mortality (Klein and Unger, 2001), but also of life chances such as unemployment (Paul and Moser, 2009) and social status (Case, Fertig and Paxson, 2005). Despite the fact that money cannot buy health directly, there is vast evidence of a sizable, persistent and roughly linear socio-economic health gradient, that is, with every step on the socio-economic ladder climbed up, health improves proportionately (Ross and Wu, 1996; Ross and Mirowsky, 2010). Life course theory posits that early childhood socio-economic conditions such as parental income and education lay an important foundation for children's later-life health and mortality throughout adulthood (Corna, 2013). Numerous studies, mainly from the U.S.A., have supported this assumption empirically, both for composite measures of socioeconomic status (SES) (Case, Fertig and Paxson, 2005; Hayward and Gorman, 2004; Hoffmann, Kröger and Pakpahan, 2018; Montez and Hayward, 2014) and for single family SES indicators such as parental education (Case, Fertig and Paxson, 2005; Laaksonen *et al.,* 2005; Montez and Hayward, 2011), parental occupational status and position (Hayward and Gorman, 2004; Huebener, 2019; Laaksonen *et al.,* 2005; Montez and Hayward, 2011), childhood economic hardship (Montez and Hayward, 2011; Shuey and Willson, 2014), and parental income (Case, Fertig and Paxson, 2005; Case, Lubotsky and Paxson, 2002; Laaksonen *et al.,* 2005), and for different health outcomes and mortality (Hayward and Gorman, 2004; Huebener, 2019; Montez and Hayward, 2014). However, research from Europe is still scarce (e.g., Hoffmann, Kröger and Pakpahan, 2018), and existing studies on Germany are mainly concerned with the econometric identification of an overall causal effect for parental education rather than following a sociological life course perspective (Kemptner and Marcus, 2013). In the present study, we consider life course variations in different health outcome gradients based on parental education background. As we will describe in more detail below, this endeavour requires longitudinal analyses that carefully distinguish between ageing and sociohistorical context (i.e., birth cohort) effects across time. To the best of our knowledge, this has not been studied previously.

In the present study, we focus on education as a critical mechanism of placement in the social hierarchy (Karhula *et al.,* 2019), thus constituting a prime health determinant from adolescence to old age. We argue that education is a central concept in this regard because it entails or leads to both cultural (e.g., health-related knowledge) and economic (i.e., human capital) resources that are highly relevant for health. As a methodological advantage, as

educational attainment is completed in early adulthood and hardly changes for most individuals later on, so issues of reverse causality typical for other SES dimensions (e.g., income) are less pervasive and easier to avoid.

2 Family background and health: theoretical considerations

In recent overviews, it has been pointed out that in light of the severe limitations of cross-sectional studies regarding the importance of timing and temporal dynamics for the emergence of health inequalities, the adoption of a consistent longitudinal perspective is a prerequisite to generating novel findings in this field (Corna, 2013). Hence, research on the education-health nexus needs to consider shifts over time in the form of life course dynamics and cohort differences. The life course paradigm (Mayer, 2009) seeks to understand any human development as a function a dynamic interplay of both previous individual (though socially connected and normatively regulated) biographies and their broader socio-historical contexts across time. Applied to socio-economic health differentials, this perspective has led to the development of explanatory frameworks such as cumulative inequality theory (CIT, Ferraro and Shippee, 2009). According to CIT, initially small socioeconomic health differences tend to grow over the life course (Willson, Shuey and Elder, 2007). As a theoretical rationale for this, health-relevant resources acquired relatively early in the life course, such as education, can be invested into other resources (e.g., health-related knowledge) and ultimately transformed into health benefits such as healthier lifestyles. At the same time, vulnerabilities in early life such as childhood poverty, being socially transmitted from parents to children, may increase the risk of children's poor educational and occupational success and ultimately impinge upon children's later life health. This two-fold process of cumulative advantages and disadvantages (Dannefer, 2003) has been called the Matthew effect (a term coined by sociologist Robert K. Merton, see Merton, 1968). The expected result is health-related divergence of educational attainment groups, i.e., an increasing health gradient, across the life course.

Several theoretical arguments have been made for the life course continuity of resource accumulation (Corna, 2013). According to the pathway framework, children raised under poor SES conditions often live under similar adverse circumstances in their own later lives (Montez and Hayward, 2011). Hence, the expected causal chain goes from childhood conditions

through children's health, lifestyles and adult children's SES to later health (Leopold, 2016: 258; Montez and Hayward, 2011). Regarding this "cascade of events" argument (Willson, Shuey and Elder, 2007), the actual degree of path dependency or sequential contingency is not yet fully understood. An opposing theoretical approach, called the biological imprint model, assumes that adverse childhood conditions inevitably and irreversibly lead to poorer health because of adverse biological processes set in motion, irrespective of subsequently accumulated resources (Montez and Hayward, 2014). It is likely that empirical support for either framework will depend on the national context (see below), so comparative, cross-national studies are required for a critical theory test. In sum, in order to understand the long-term health consequences of family socio-economic background, it is important to control for children's own socio-economic position during adulthood. Unfortunately, early life selection effects of child health on educational attainment cannot be incorporated in analyses of the education-health nexus with most available datasets because they usually do not cover the whole lifespan. Hence, we argue that family background is also required as a control when studying the educational health gradient in adulthood in order to minimize selection bias.

Although a number of studies has yielded evidence of cumulative education-based health inequalities across the life course, a second, competing age-as-leveler hypothesis assumes that education-based health inequalities will diminish in later age (Lynch, 2003; Willson, Shuey and Elder, 2007). This is mainly because of selective elevated mortality among the less educated, leaving an increasingly select subgroup of particularly resilient healthy, low-educated individuals in the population (Dupre, 2007).

As a complication raised by the life course framework, however, ageing across the life course can only be meaningfully understood if its embeddedness in different individual socio-historical contexts is taken into account (Dannefer, 1987). As different birth cohorts experience certain age-graded life course events at different points in historical time, in any study on cumulative inequalities and potential age-as-leveler effects it is indispensable to disentangle age and cohort effects and the interaction of both (Bell, 2014; Ferraro, Pylypiv Shippee and Schafer, 2009). Unfortunately, the two life course hypotheses outlined above (cumulative advantage and age-as-leveler) may even offset each other to some degree unless age and cohort effects are disentangled, which requires longitudinal data (Lynch, 2003). Previous studies suggest that life course (i.e., ageing) effects vary by cohorts in which individuals were born, and ignorance of cohort effects introduces bias into age effect

estimates (Willson, Shuey and Elder, 2007). Hence, modeling interaction effects between SES indicators, age, and birth cohort is critical, yet many studies fail to consider such interaction effects or comprise only few cohorts. As a consequence, many previous findings on life course development of the SES health gradient remain inconclusive. In terms of theorizing cohort interaction effects, the "rising importance hypothesis" posits increasing health-related returns of education in younger cohorts, mainly because health-related and preventive knowledge produced by medical advances has become more widespread among the population, particularly among the higher educated. This may have enhanced their relative health advantage compared to the low educated, a group that, in the course of educational expansion, has become smaller and increasingly composed of negatively selected individuals throughout the past decades.

Previous research supports this expectation for the U.S. (Goesling, 2007; Goldman and Smith, 2011), for Sweden (Leopold, 2016), and for men's self-rated health in Germany (Leopold and Leopold, 2018). Generally, cohort effects are likely to vary across country contexts, as decreasing education-based health gradients in China in younger cohorts suggest (Chen, Yang and Liu, 2010).

Most previous studies have examined health effects of adult children's own education. Regarding the shape of the educational health gradient was reported to be fairly linear (e.g., across years of schooling) for physical functioning (Ross and Wu, 1996; Ross and Mirowsky, 2010). With respect to the life course hypotheses, despite a large body of research showing diverging trends for the educational health gradient (Corna, 2013), relatively few studies have adequately separated age and cohort effects. However, findings from these methodologically more refined U.S. studies indeed corroborate the notion of cumulative health (dis)advantages related to education (Kim, 2008; Mirowsky and Ross, 2008; Willson, Shuey and Elder, 2007). At the same time, some (mostly U.S.) studies find decreasing health inequalities in older ages, as posited by the age-as-leveler hypothesis (Dupre, 2007; Herd, 2006; Leopold, 2018). A German panel study by Leopold and Leopold (2018), using self-rated health as the outcome, showed that starting from early adulthood, the educational health gradient increased among men, supporting the cumulative (dis)advantage hypothesis, but not among women. Furthermore, it proved to be increasing among younger male cohorts, thereby providing support for the rising importance hypothesis. Regarding gender differences, whereas women and men with high education exhibit very similar trajectories of physical impairments, it is the

low educated women who fare considerably worse than low educated men, pointing to "multiplication of disadvantage" (Ross and Mirowsky, 2010).

Previous studies on parental education effects (for a review of previous research, see Corna, 2013) on children's health generally indicate beneficial effects of parental education on adult children's self-rated health (Case, Lubotsky and Paxson, 2002; Case, Fertig and Paxson, 2005; Currie and Stabile, 2003) and physical impairment (Ross and Mirowsky, 2011). There is some evidence that these effects may vary across children's age. Specifically, Case et al. (2005) and Currie and Stabile (2003) report an increasing effect of maternal education throughout children's adulthood (but see Case, Lubotsky and Paxson, 2002). Another study (Chou *et al.,* 2010) finds declining effects across child's age. Regarding potential moderation by parental gender, there has been an increase in the variance in maternal education since the educational expansion in the 1960s, so intergenerational transmission from the mother to her children may have become more important over time. Previous studies have found comparable effects of both maternal and paternal education on children's health (Case, Lubotsky and Paxson, 2002). [moderation by child gender?]

The present study is concerned with the potential role of educational transmission as a mediator through which parental education affects children's health (Rathmann *et al.,* 2018). educational systems determine labor market outcomes, and thus socioeconomic positions, to different degrees (Allmendinger, 1989), the strength of intergenerational transmission of education can be considered a key mechanism for family background effects on adult children's health. International studies indicate substantial intergenerational transmission effects for maternal and paternal education in Europe, yielding roughly linear associations (Case, Fertig and Paxson, 2005). Intergenerational associations of educational attainment can be traced back theoretically either to selection (e.g., shared environment shaping both generations' educational careers) or causation (i.e., parental education increases perceived importance of children's education and promotion of children's educational aspirations) (Black, Devereux and Salvanes, 2005). Either way, previous studies have lent support to the mediation of background effects through educational transmission in the form of non-causal associations between parental education and child health that were attenuated when controlling for child SES (Lindeboom, Llena-Nozal and van der Klaauw, 2009). In sum, there seems to be a strong selection of children into educational tracks depending on family background, so some authors have argued that it is important to control for parental SES (e.g.,

education) when studying health effects of (adult) children's education (Conti, Heckman and Urzua, 2010).

[describe variations by outcomes?]

2.1.1 Peculiarities of the German context

Compared to other Western countries, Germany has a highly stratified schooling system with relatively early allocation to school tracks with modest permeability and strong links to the occupational system (DiPrete *et al.,* 2017). As a key result from the PISA study and other research, the educational mobility regime in Germany is characterised by high intergenerational continuity and little mobility (Heineck and Riphahn, 2009). The result is a generally strong link between parental educational background and children's own educational attainment (Waldhauer *et al.,* 2019). Consequently, we consider children's education as the primary channel through which family SES (e.g., parental education) affects children's adult health in the German context. This is because in Germany, the universal healthcare system should diminish the role of wealth and income on health, whereas parental education can be considered as a critical vantage point for offspring's placement in the social hierarchy (Karhula *et al.,* 2019). Moreover, both parental and children's education may be linked to the adoption of health-relevant lifestyles and to knowledge about illness, to healthcare usage, patient adherence etc. which, in turn, are key determinants of adult children's health. The only existing longitudinal life course study with German data we are aware of showed marked and rising educational health gradients (Leopold and Leopold, 2018), however based solely on adult children's (not parental) education and for a different outcome measure (self-rated health).

2.2 Aims of the present study

The present study aims to education-based health inequalities in a comprehensive life course framework, focusing on early-life health determinants arising from family educational background. We model indirect (and possibly health-related) selection into educational tracks by intergenerational transmission of education. Moreover, we go beyond existing research mostly based on SRH or specific illnesses by considering physical and mental health-related quality of life (Kim, 2008: 672). In order to test our hypotheses, we use panel data instead of repeated cross-sections (e.g., Lynch 2003) to account for selective mortality and potentially

health-related attrition and thus provide findings from a German national panel sample to be compared to previous research mainly coming from the U.S. To the best of our knowledge, this is the first European multicohort study to consider both effects of family background and adult children's education on health. Finally, we examine moderator effects of gender and differences by health outcomes.

To sum up our hypotheses based on theoretical premises of the life course framework and on previous research, we expect parental education to be clearly associated with adult children's health, increasingly over their life courses (cumulative inequality) and in younger cohorts (rising importance hypothesis). Because of the expected strong educational transmission of education in Germany (transmission hypothesis), we hypothesize that children's highest educational attainment mediates the associations between parental education and children's health. Because particularly women's education has benefited from educational expansion in Germany, the rising variance in women's education should have led to increasing mediation among younger cohorts of women (gendered mediation hypothesis). Regarding outcomes, we generally hypothesize larger educational health gradients for physical than for mental health (outcome differential hypothesis).

3 Method

3.1 Data and sample

We use longitudinal data (waves 2002-2017) from the German Socio-Economic Panel (SOEP, 2017), a national panel household survey that was initiated in West Germany in 1984 and in East Germany in 1990, with subsequent waves conducted annually. Because our outcomes of interest were collected biennually starting in 2002 and the last available measurement was in 2016, the observational period of our analysis included all even years from 2002 to 2016 (N=26,522 regular GSOEP respondents aged 16 and older). Because case numbers fell below n=30 men and women, respectively, for most birth years before 1930 and because we further set a minimum age of 25 years for assuming advanced participation or completion of tertiary education, we restricted our sample to respondents born from 1930 to 1990. We were thus left with a sample of N=20,935 individuals, of whom 75.6% (N=15,828 respondents) provided valid information on their own educational attainment. Of the latter group, 72.7% (N=11,514 individuals) provided information on at least one of their parents' educational attainment. Out

of these respondents, 51.9% (N=5,977) had complete information on all dependent variable indicators (listwise deletion). Finally, there were 1,8% listwise missing values on the remaining covariates, so the final sample comprised N=5,564 respondents (N=2,771 men and N=2,793 women).

3.2 Measures

Our dependent variables were the two subdimensions of the SF-12 health survey instrument, physical and mental health-related quality of life. The SF-12v2 is an adapted short version of the psychometrically validated and internationally used original SF36 scale (see Ware *et al.,* 1993). Good construct validity has been shown for the SF-12v2 across many countries, including a national German sample (Wirtz *et al.,* 2017). Convergent validity with respect to other established scales (Cheak-Zamora, Wyrwich and McBride, 2009) and predictive validity with regard to mortality (Tsai *et al.,* 2007) have been demonstrated empirically. Data on the SF-12v2 items have been collected in the GSOEP biennially since 2002 (Andersen *et al.,* 2007). When referring to perceived health-related quality of life, for the sake of brevity we will use the shorter terms “physical health” and “mental health”. The SF-12v2 physical and mental health composite scores were based on twelve health-related items pertaining to eight subscales (Andersen *et al.,* 2007):

- The physical health component is comprised of four subscales: physical functioning (two items on limitations: moderate activities, several flights of stairs), role physical (two items: accomplished less, limited in work), bodily pain (one item), and general self-perceived health (one item).
- The mental health component is conceptualised via four subscales: vitality (one item: energy level), social functioning (one item: limitation of social activities due to health), role emotional (two items: accomplished less due to emotional problems, less careful due to emotional problems) and mental health (two items: blue and downhearted, calm and peaceful).

The scores used in this study were also extracted via PCA with an oblique rotation method (oblimin), allowing the components to be non-orthogonal (the component correlation was 0.53). Our analysis yielded the expected two-component solution for the total estimation

sample (criterion: eigenvalues greater than 1) with standardized PCA loadings for mental health ranging from 0.57 to 0.90. Finally, we rescaled the PCA scores to the range 0 to 100. Higher values correspond to better physical or mental health, lower values to poorer health.

For both the respondents and their parents, information on highest educational attainment is collected and updated regularly in the GSOEP. In order to distinguish health-relevant educational groups while keeping with subsample size requirements for the analyses, we coded education as follows: lower secondary education (code 0) from no qualification up to Mittlere Reife, higher secondary education yielding entrance qualification for (technical or full) university (Abitur)(1), and tertiary education with a diploma obtained at technical or full universities (2). We always used the latest information available and coded education as time-invariant. Proxy information on parental education was collected from the main respondents where possible. We decided against the use of a continuous education measure (e.g., years of schooling) to avoid implicit proportionality constraints in the main and interaction effects of education. Also, a more fine-grained measure with more categories was not feasible because of limited case numbers in some subgroups.

As further covariates, we included linear and squared terms for age years, centred around the mean, and for birth cohort (centred around 1960). The age range for the analyses started at age 25 where information on completed schooling was deemed final. We conducted initial fixed-effects models to determine nonlinear period effects, although period effects did not seem very plausible because of the short observation window. The only exception that was also substantiated empirically was the financial crisis starting in 2008 which seemed to have a temporary negative impact, particularly on mental health. Hence, we included a dummy that was coded "1" for waves 2010 and 2012 (0 otherwise). Finally, we included two time-varying dummy indicators coded 1 in the last two episodes before attrition of the respective respondent and in the episode preceding death recorded in the "exit interviews" (code 0 otherwise). This procedure, a variant of which was used in previous studies (Chen, Yang and Liu, 2010; Kim and Durden, 2007; Leopold and Leopold, 2018), aims at reducing selection bias in the effects of education while retaining data from respondents who drop out of the study.

3.3 Analytical approach

Similar to previous longitudinal studies, we estimated growth curve models for panel data for revealing life course dynamics of health conditional on educational attainment. Regarding

growth trajectory parameters, we included individually varying random intercepts and random (linear) age slopes. Due to the clustering of timepoints in respondents in households, a three-level quadratic LGC model with random intercepts was used:

Level 1: $Health_{tih} = \pi_{0ih} + \pi_{1ih}age_{tih} + \pi_{2ih}age^2_{tih} + e_{tih}$

Level 2: $\pi_{0ij} = \beta_{00h} + \beta_{01}cohort_i + \beta_{01}education_i + \beta_{01}cohort_i \times education_i + \beta_{0k}\, controls_i + r_{0i}$

$\pi_{1i} = \beta_{10} + \beta_{11}cohort_i + \beta_{12}education_i + \beta_{13}cohort_i \times education_i + \beta_{0k}\, controls_i + r_{1i}$

Level 3: […] [adapt from similar equation in Willson et al. 2007]

Because linear[1] random age slopes were modeled as a function of education and cohort (and their interaction), we are able to disentangle age and cohort effects. Our specification thus allows for shifts in age effects across cohorts. Further advantages of the LGC approach include its capability of handling unbalanced data and to model incomplete trajectories in case of attrition or dropout as conditioned on survival (Rohwer, 2016). Because in our models, health trajectories are a complex, non-linear and non-additive function of age and cohort, we illustrate life course and cohort effects on the educational health gradient graphically using model-predicted growth curve trajectory plots with confidence bands instead of interpreting regression coefficients (for a full regression output, see Appendix).

In our analyses on intergenerational transmission of education, we computed rank-order correlations (Spearman's Rho) between each parent's and child's education for each birth year to infer trends in the strength of the potential transmission mechanism over time. Unlike most social mobility studies, we do not provide detailed mobility matrices (Breen, 2010) because our focus was not on distinguishing between upward and downward mobility but on overall intergenerational associations of educational attainment which is inversely related to intergenerational educational mobility.

[1] Additional analyses (not shown) yielded a trivial and nonsignificant amount of random variance in quadratic slopes, that is, only the linear shape of the trajectories varied substantially across individuals while their degree of concavity was similar across respondents, leading to convergence issues that are common when modelling quadratic slopes as random (Rabe-Hesketh and Skrondal, 2008: 348). Hence, the quadratic slope was modeled as fixed instead of random; covariance was assumed to be unstructured, allowing for correlations between random intercept and linear slope. Nonetheless, we consider it as substantively meaningful and thus necessary to include a quadratic trend to allow for within-cohort gradual convergence and/or divergence in mean slopes of the educational groups. Further auxiliary analyses (not shown) indicated that the inclusion of cubic and higher-order age terms did not improve model fit nor substantive interpretability of trajectories.

4 Results

In Table 1, we provide descriptive statistics of our sample, separately for men and women. The average age of respondents lies around 50 years. It can be seen that a higher share of men than women in the sample has obtained a tertiary degree, which can be considered as a result of the presence of older cohorts who finished their educational careers before educational expansion took place in Germany. Similar gender-specific proportions are found for parental education, albeit at a generally lower level of education. Whereas only seven to eight per cent of mothers have tertiary education, the corresponding share of fathers is considerably higher (17 to 18 per cent).

Table 1: Descriptive sample statistics, by gender (N= 5,564 respondents)

	Men		*Women*	
Time-invariant characteristics	*Proportion*	*SD*	*Proportion*	*SD*
Respondent's education				
up to lower secondary education	0.28	(0.45)	0.28	(0.45)
up to higher secondary education	0.29	(0.45)	0.40	(0.49)
tertiary education	0.44	(0.50)	0.32	(0.47)
Maternal education				
up to lower secondary education	0.66	(0.47)	0.67	(0.47)
up to higher secondary education	0.26	(0.44)	0.26	(0.44)
tertiary education	0.08	(0.27)	0.07	(0.26)
Paternal education				
up to lower secondary education	0.62	(0.49)	0.63	(0.48)
up to higher secondary education	0.20	(0.40)	0.20	(0.40)
tertiary education	0.18	(0.38)	0.17	(0.38)
Birth cohorts				
1930-40	0.13	(0.34)	0.11	(0.31)
1940-49	0.22	(0.41)	0.19	(0.39)
1950-59	0.22	(0.41)	0.25	(0.43)
1960-69	0.19	(0.40)	0.23	(0.42)
1970-79	0.15	(0.35)	0.13	(0.34)
1980-92	0.09	(0.29)	0.08	(0.27)
N (individuals)	2,771		2,793	
Time-varying characteristics	*Mean*	*SD*	*Mean*	*SD*
Age (years)	51.51	(14.56)	50.63	(14.46)
Physical health (SF-12)	67.32	(18.97)	64.95	(19.76)
Mental health (SF-12)	70.70	(15.15)	67.45	(16.18)
N (episodes)	54,211		60,080	

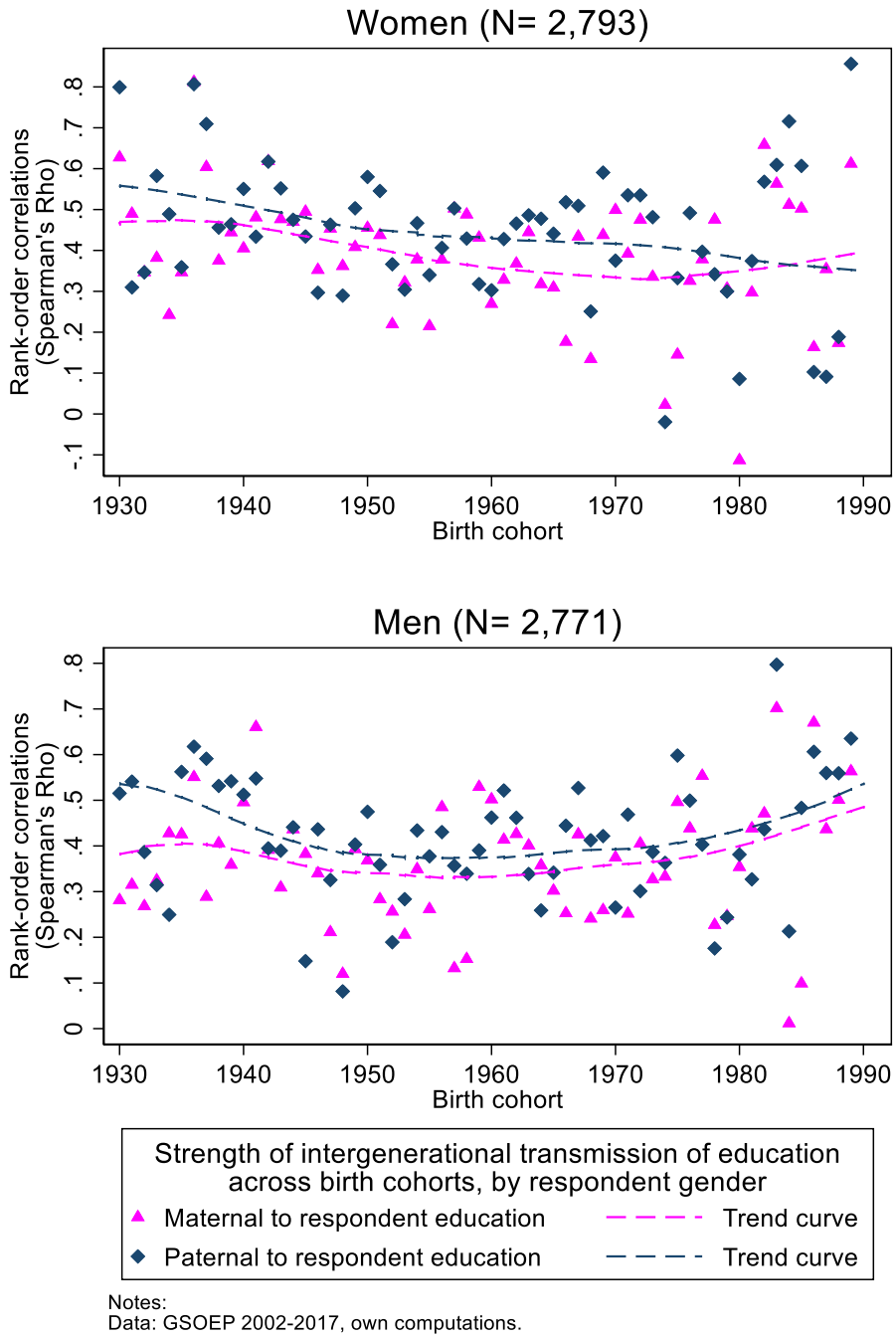
Data: GSOEP 2002-2017, own computations.

Next, we turn to the intergenerational transmission of education as a potential mechanism through which parental education affects adult children's health.

4.1 Intergenerational transmission of education

In the study sample, there is a sizable average rank-order correlation of Spearman's ρ=0.62 between maternal and paternal education. Figure 1 displays cohort-specific associations between parents' (i.e., maternal and paternal) and adult children's education across birth cohorts.

Figure 1: Intergenerational associations of parents' and children's educational attainment across children's birth cohorts (N=5,564 respondents)



Notes:
Data: GSOEP 2002-2017, own computations.

Generally, paternal education seems to be more predictive of children's educational attainment (overall Spearman's ρ=0.42) than maternal education (ρ=0.38). Furthermore, we find moderate educational transmission from mothers to respondents (sons: ρ=0.36; daughters: ρ=0.41) and, somewhat more pronounced, from fathers to respondents (sons: ρ=0.40; daughters: ρ=0.43). Hence, transmission tends to be stronger for daughters than for sons. The general cohort trend of the intergenerational associations , particularly for sons, is u-shaped, with declines in educational transmission from early to intermediate cohorts born in the 1960s, where educational expansion in Germany started. Subsequently, the rank-order associations rises in more recent cohorts, indicating an increasing effect of educational origin and declines in intergenerational educational mobility in young cohorts. For daughters, a similar u-shaped pattern is only found for maternal education, whereas the influence of paternal education tends to decline continuously across cohorts. This suggests that potential mediator effects through children's education may be strongest among youngest and oldest respondents in our sample. Very similar results were obtained when using a more fine-grained classification of education comprising six categories.

4.2 Effects of family background (parental education) on adult children's health

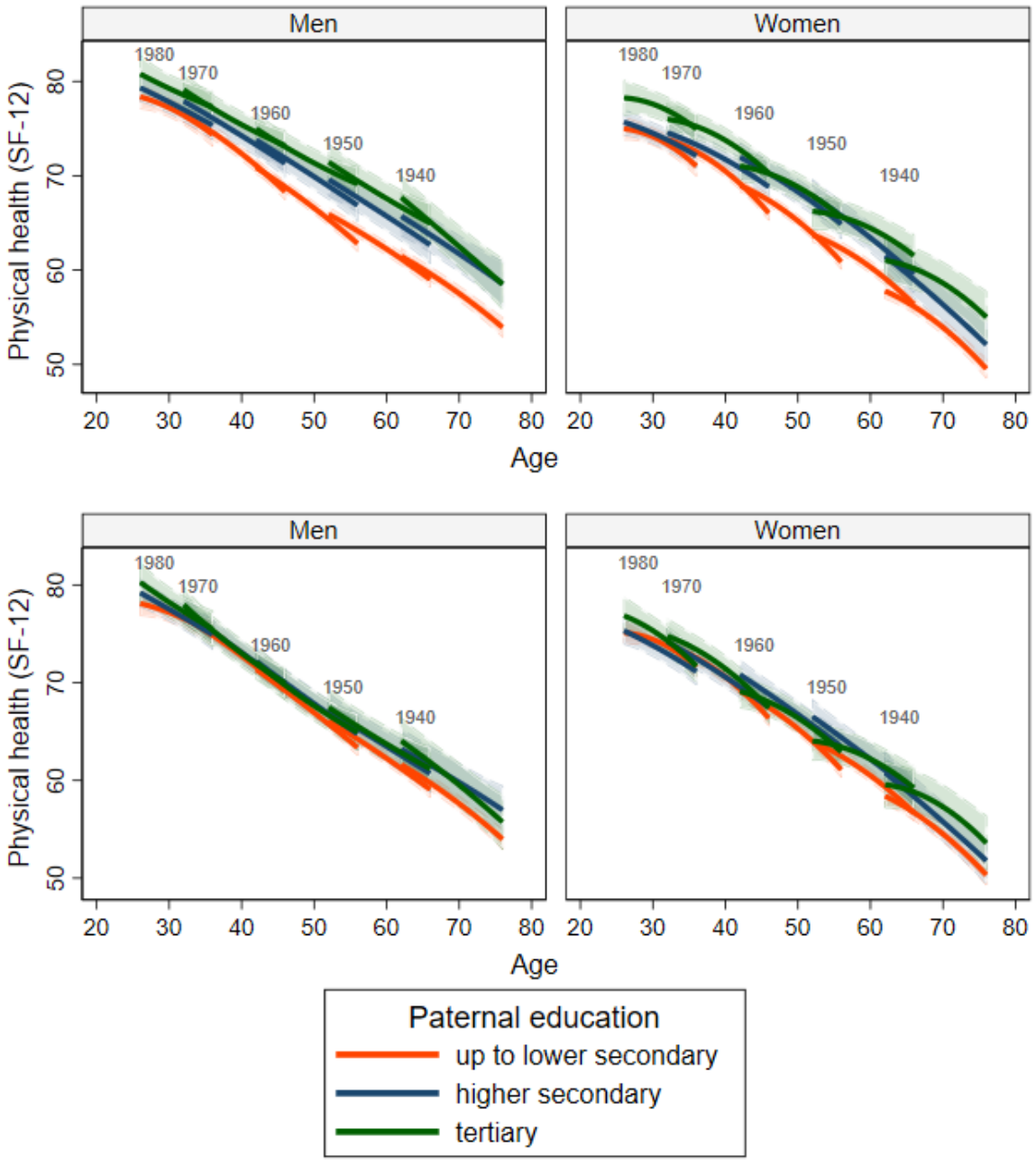
In the following subsection, we present results from our multivariate growth curve models. In the first step, we describe physical and mental health gradients by parental education. In the second step, we additionally control for respondents' education to see whether intergenerational transmission of education mediates the effects of parental education on adult children's health over time. We start with physical health and then proceed to mental health.

4.2.1 Physical health

Figure 2 displays predicted physical health trajectories across different levels of paternal education, by respondent gender. Several findings are revealed in the graphs. First, a declining overall trajectory is visible among men and women, in line with previous U.S. studies on physical health outcomes (Ross and Mirowsky, 2011). Second, women generally score somewhat lower than men on physical health (Ross and Mirowsky, 2010). Third, in the upper panel of the graph there is a clear educational gradient pattern, with higher paternal education being associated with higher adult children's physical health. Particularly the sons

and daughters of fathers with lowest (i.e., lower secondary) education generally exhibit a markedly lower average physical health, and particularly sons of low educated fathers also tend to display the steepest rates of health decline over time of all groups.

Figure 2: Predicted physical health trajectories in three groups of respondents with different paternal education in selected birth cohorts across the life course, unadjusted (upper panel) and controlling for respondent's own education (lower panel)



Note: 99% CI
Specification: i.fedu_edu##c.cgebj##c.cgebj##c.cage##c.cage
Controls: Birth cohort, Period dummy (2009-2012), indicators for dropout and death, Respondent's educatio

The fact that, among sons, the confidence bands of the low paternal education group (shaded areas) do not overlap with those of the remaining groups from roughly age 40 onwards suggests that the differences are substantial and statistically significant.[2] The educational gradient for daughters is equally large.Fourth, among men there is some evidence of cumulative health inequality, indicated by the slightly diverging trajectories over the life course. At the same time, in the oldest cohort of men plotted (birth year 1940) there appear to be age-as-leveler effects, indicated by slightly converging trajectories in old age. [comment on dropout dummies]

Interestingly, fifth, the seams between the different cohort-specific trajectories of the first three cohorts suggest a gendered cohort pattern. Whereas the youngest cohorts with high educated fathers (dark green line) tend to show better physical health than previous cohorts, daughters of low educated fathers (orange line) exhibit an adverse health cohort trend in the youngest cohorts in the overlapping age ranges.

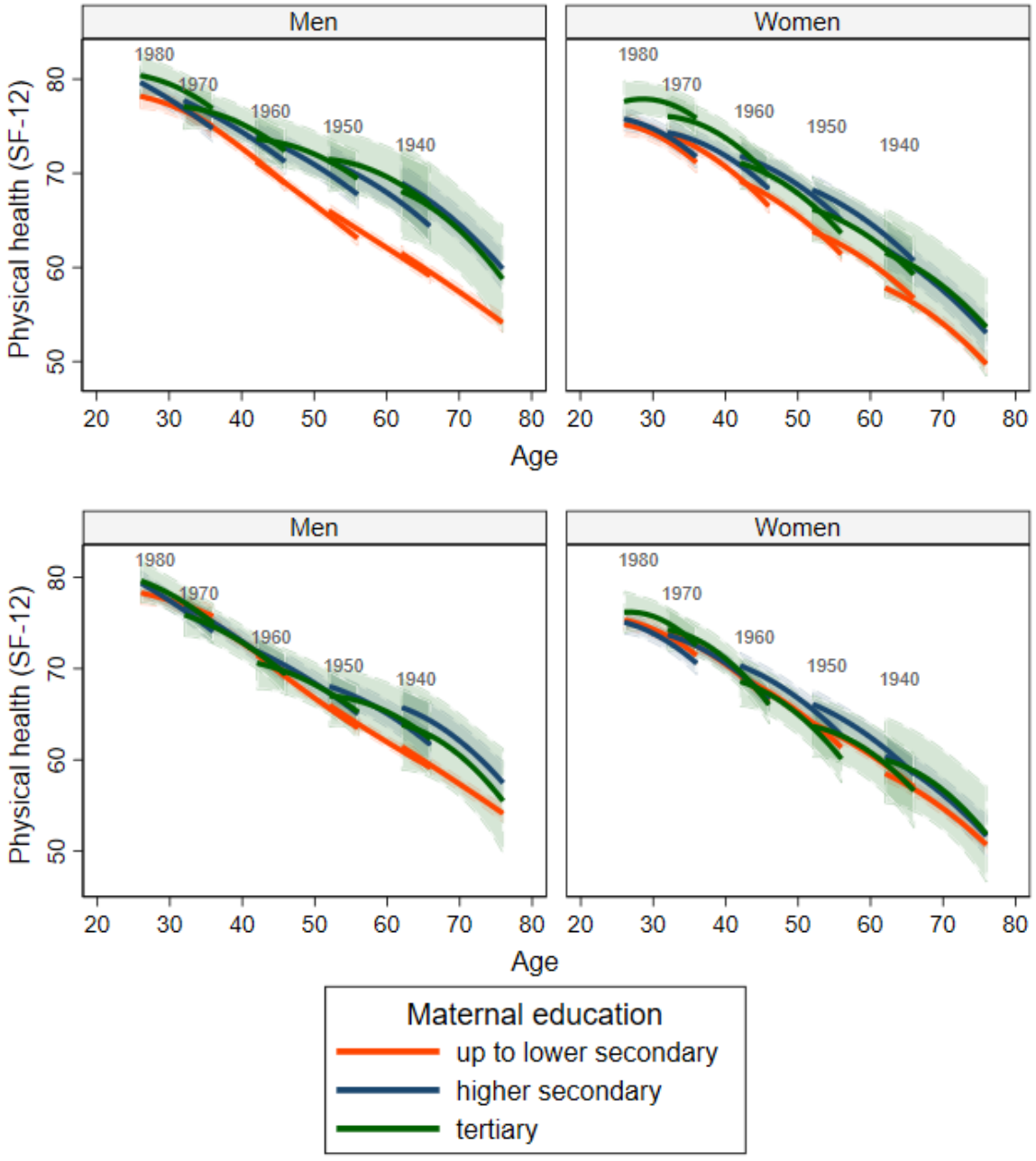
The lower panel of Figure 2 shows effects of paternal education when controlling for adult children's own education, that is, when taking into account intergenerational transmission of education. The graphs show that educational gradients are strongly reduced and mostly vanish. Hence, when respondents' own education is held constant statistically, their family background does not matter much for their physical health. In other words, parental education affects adult children's health largely through the transmission of human capital to their children. Conversely, if predicted health gradients are plotted based on respondents' own education (not shown), these gradients remain largely invariant when controlling for parental health.

Similar patterns emerge for effects of maternal education (see the upper panel of Figure 3). There is a clear educational health gradient that tends to grow across the life course, without any clear sign of convergence in old age. The adverse trend of declining physical health across successive cohorts among the low educated is more pronounced for women than for men, indicating a gendered rising importance of paternal educational background for women's health. Cumulative inequality in the form of widening health gradients, as well as convergence in older age, is evident among sons but not among daughters.

[2] Although differences between the groups may be significantly different despite overlapping confidence bands, as a rule of thumb, nonoverlapping confidence bands at some specific age can be safely interpreted as significant with the chosen significance level ($p<0.01$).

Apparently, these health implications of maternal education largely operate through educational transmission. As the lower panel of Figure 3 reveals, the health gradient virtually disappears across the whole life course after controlling for children's education. This means that high maternal education benefits children's health mainly because it leads to higher education among their children, which in turn affect physical health positively.

Figure 3: Predicted physical health trajectories in three groups of respondents with different maternal education in selected birth cohorts across the life course, unadjusted (upper panel) and controlling for respondent's own education (lower panel)

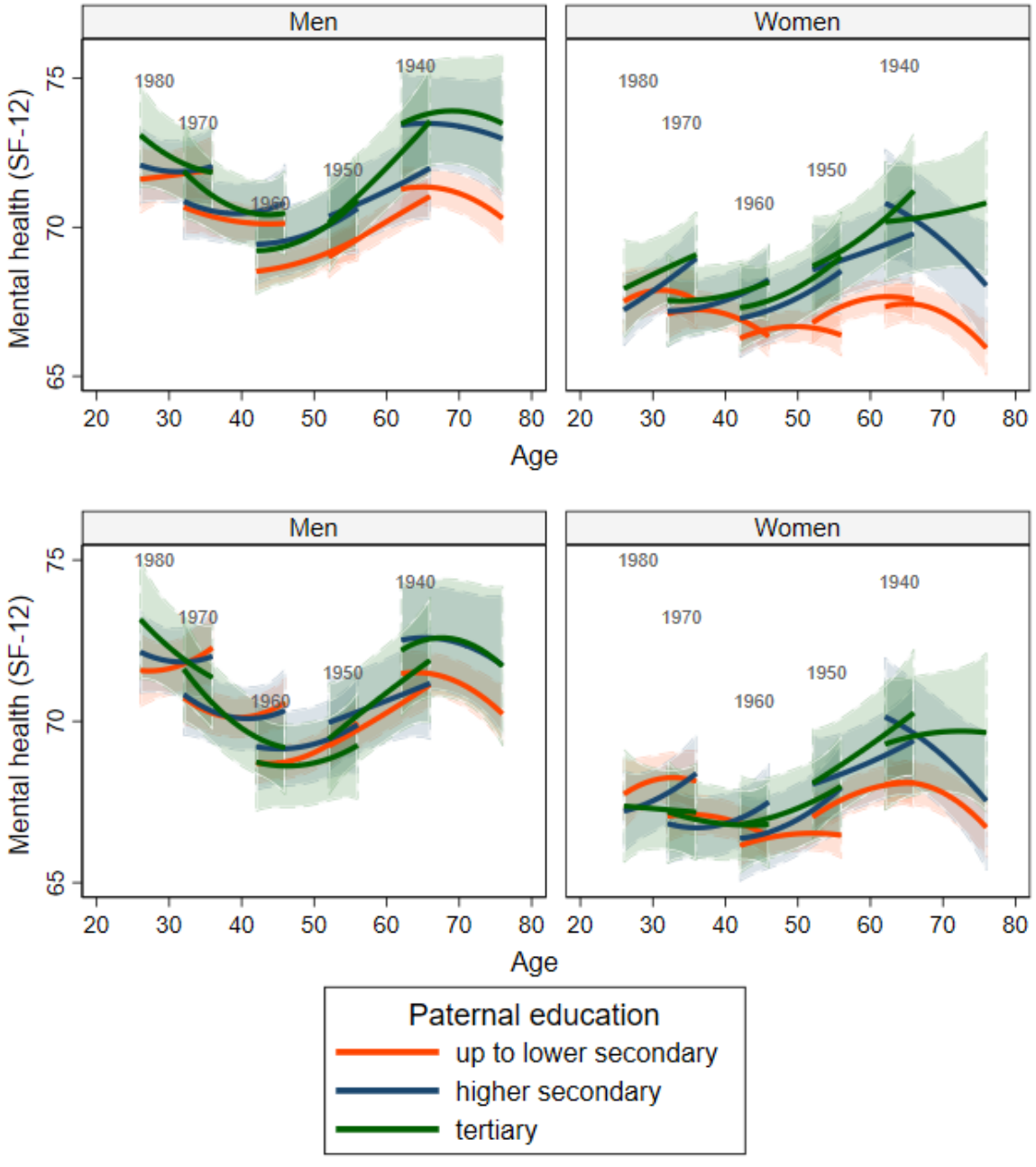


Note: 99% CI
Specification: i.medu_edu##c.cgebj##c.cgebj##c.cage##c.cage
Controls: Birth cohort, Period dummy (2009-2012), indicators for dropout and death, Respondent's educatio

4.2.2 Mental health

Next, we turn to our second outcome, mental health. Figure 4 (upper panel) displays predicted mental health trajectories by paternal education. In contrast to physical health, mental health does not decline steadily but roughly follows an s-shaped curve over the life course, something also found in previous studies (Bell, 2014).

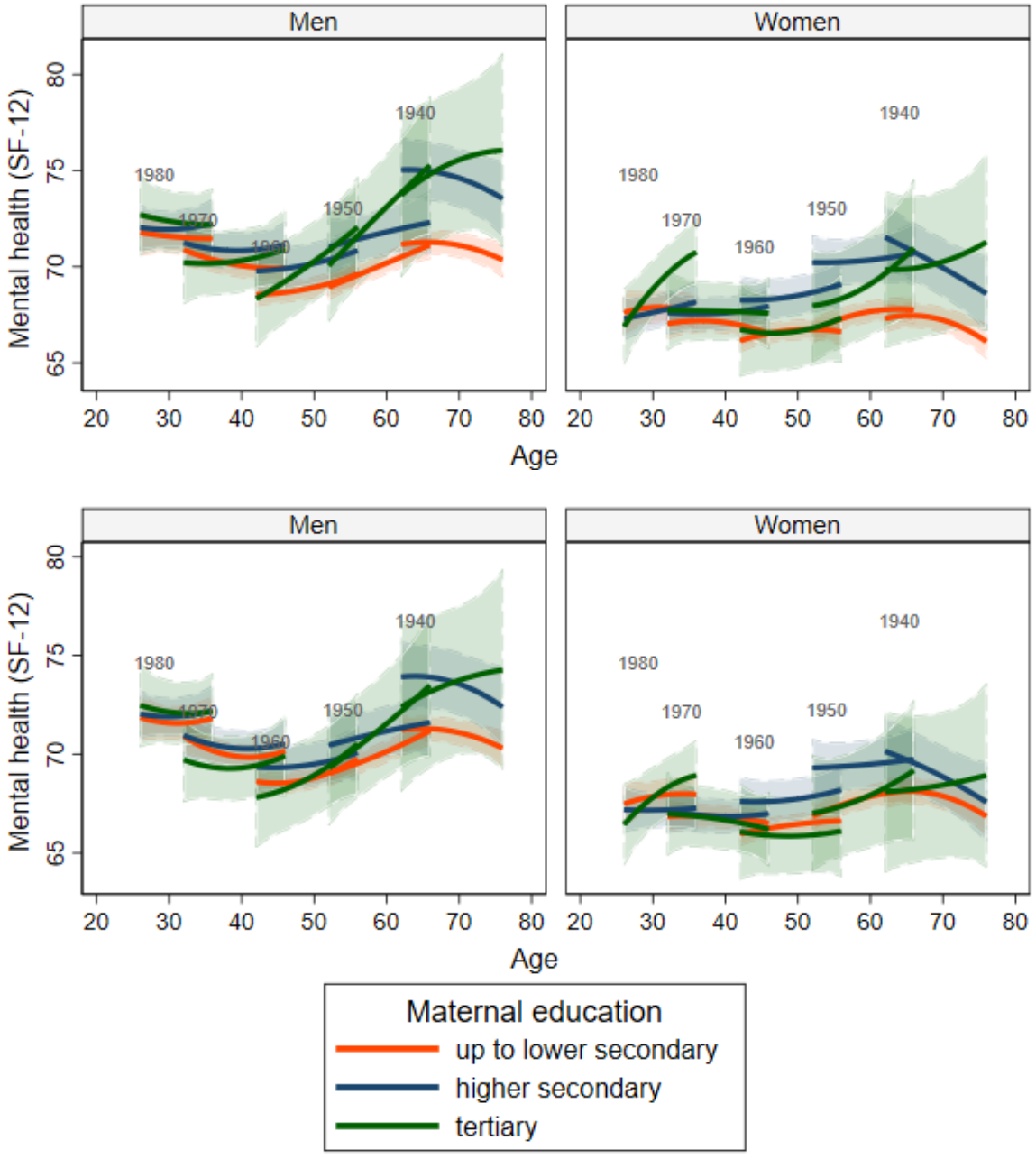
Figure 4: Predicted mental health trajectories in three groups of respondents with different paternal education in selected birth cohorts across the life course, unadjusted (upper panel) and controlling for respondent's own education (lower panel)



Note: 99% CI
Specification: i.fedu_edu##c.cgebj##c.cgebj##c.cage##c.cage
Controls: Birth cohort, Period dummy (2009-2012), indicators for dropout and death, Respondent's educatio

Moreover, the educational mental health gradient is less clear-cut than for physical health, except in the oldest cohort, where sons and daughters of low-educated fathers exhibit a pronounced disadvantage in terms of mental health.

Figure 5: Predicted mental health trajectories in three groups of respondents with different maternal education in selected birth cohorts across the life course, unadjusted (upper panel) and controlling for respondent's own education (lower panel)



Note: 99% CI
Specification: i.medu_edu##c.cgebj##c.cgebj##c.cage##c.cage
Controls: Birth cohort, Period dummy (2009-2012), indicators for dropout and death, Respondent's educatio

The adverse cohort trends seen for physical health are reversed, in that younger cohorts, irrespective of paternal education, tend to show better mental health than preceding older ones when inspecting the overlapping age ranges. Across cohorts, the gradients tend to increase. Within-cohort inspection of gradients, particularly among women, yields patterns most compatible with cumulative inequality, without any clear evidence of age-as-leveler effects; among men, there appears to be convergence over time in younger cohorts and constant gradients in older cohorts. Again, once respondent's own education is controlled for (Figure 4, lower panel), mental health gradients are slightly reduced, suggesting that family background impacts health partly by determining one's own educational attainment.

Finally, turning to maternal education effects on children's mental health (see upper panel of Figure 5) reveals mostly small educational gradients. The cohort-specific trajectories tend to diverge in older cohorts among men (indicating cumulative inequality), for women the patterns are less clear-cut. We find no uniform convergence of trajectories in old age for either women or men. Similar to what was observed for maternal education, the oldest World War II cohort (1940) stands out with a markedly larger health gradient than subsequent birth cohorts. Contrary to expectations, cohort effects are positive for all education groups, indicating increasing mental health among younger cohorts. When educational transmission across generations is taken into account (see lower panel of Figure 4), the size of the gradients shrinks considerably, except among the 1940 birth cohort. This suggests that in post-World War cohorts, the low educational mobility in Germany largely explains parental education effects on adult children's health.

5 Discussion

Our analyses show that, as expected, family educational background indeed matters for adult children's health in later life. In contrast to previous studies in the German context that were either cross-sectional or limited to the health of the first few years of children or both (Coneus and Spiess, 2012; Du Prel *et al.,* 2006; Kuntz and Lampert, 2013; Rathmann *et al.,* 2018), we took a longitudinal life course perspective, modelling education-specific average health trajectories contingent on parental education from early adulthood to old age. Generally, we found support for the tenets of the life course framework positing life-long consequences of early childhood socio-economic conditions on later health (Corna, 2013). To the best of our

knowledge, this study is the first to present evidence of growing health inequality over the life course (cumulative inequality) by parental education in Germany to date. We find cumulative health inequalities contingent on parental education particularly for the dimension of physical health. There is little evidence of converging trends in old age though, possibly because we control for selective dropout due to attrition or death (Leopold and Leopold, 2018). In any case, growth curves can be considered as conditional on survival so this selection is rather part of a natural ageing process than a bias (Rohwer, 2016). Apart from these ageing patterns, negative cohort effects provide some support for the rising importance of parental education among women. This finding is consistent with previous cross-country comparative research on adult children's own educational attainment (Leopold, 2018). Because we focus on parents' instead of adult children's education, the argument of adverse shifts in the composition of the lower educated during educational expansion raised by previous studies (Leopold and Leopold, 2018) is less plausible here.

Regarding mental health, life course patterns with respect to the educational gradient are less clear-cut. In line with previous research aiming to separate ageing and cohort effects, we generally find cubic, s-shaped age trajectories, consisting of a 'midlife crisis' and a subsequent increase from roughly age 50 onwards, part of which possibly reflect beneficial retirement effects (Bell, 2014). This peak is followed by a decline in late life, likely because of chronic conditions and loneliness (Wenger *et al.,* 1996). In contrast, we did not expect to find positive cohort effects (from older to younger cohorts), so the positive cohort effects for mental health for all educational groups were somewhat surprising, given that strains, for instance, from mass unemployment and precarious employment have likely been increasing throughout the last decades. Positive ageing (i.e., life course) effects and positive cohort effects appear to offset each other to some degree, particularly among daughters of higher educated parents. We also found strikingly large mental health gradients for World War II birth cohorts among both genders and also for physical health among men. It could be argued that the World War experience of economic hardship and stress may take its long-term toll here by amplifying education-based health differences.

In sum, the differential effect patterns for both health outcomes, characterised by clearer educational gradients for physical health, may indicate that mental health is more volatile and more sensitive to situational conditions rather than to early childhood socialisation factors. Regarding gender differences, the patterns are complex. On the one hand, we found more

negative cohort effects for physical health among younger daughters than sons of low educated parents. This implies that the rising importance of parental education for physical health in more recent cohorts represents a particular disadvantage for low educated women. On the other hand, the presented evidence of growing inequalities in physical health over the life course was stronger for men than for women, owing to both ageing and cohort effects. As a consequence of both processes, the educational gradient with respect to physical health is larger among older men, whereas rising health inequalities could be observed among young women, particularly to the disadvantage of daughters of low educated parents. Regarding parent gender differences, the patterns were generally very similar, paternal education gradients tended to be clearer (e.g., the two higher education groups were more readily distinguishable), suggesting that it may be sufficient to include paternal education if both parents' education is unavailable.

In the second part of our analyses, we additionally considered respondents' own education in the models in order to examine the mediating role of own education. As a clear finding, most family background effects disappeared once respondents' own education was held constant in the analyses, particularly for physical health. In substantive terms, this implies that offspring of higher educated parents are faring better in terms of health because they manage to attain higher degrees of education themselves. Theoretically, these findings speak for the "cascade of events" causal chain model (Willson, Shuey and Elder, 2007) rather than the biological imprint model, supporting social pathway models that posit "chains of risk" from childhood to adulthood, consistent with the life course framework (Corna, 2013). Unlike previous studies, we did not attempt to provide simple overall indirect effects because the degree of mediation varied across the life course. Be believe that resisting the temptation to quantify mediation always comes at the cost of neglecting the temporal dynamics of the modelled processes. In our view, this is especially important when introducing complex cohort interactions.

Regarding intergenerational transmission of education, a key finding was the u-shaped trend in the strength of transmission across cohorts. Specifically, after a decline of the correlation of parental and children's educational attainment up to the 1960s which is in line with previous studies in the German context (Breen, 2010), associations have started to rise again in younger cohorts. Despite a caveat due to rather small case numbers in the youngest cohorts, the latest increase in transmission of education we find seems to be a novel trend

mostly produced by the most recent cohorts that were not included in previous studies. On a more general level, the limited social mobility in the German context (Breen, 2010; DiPrete *et al.,* 2017) has the potential to not only reproduce socio-economic inequalities but also education-based health inequalities. As an extension to the presented findings, social mobility could be addressed more explicitly by directly measuring individual educational mobility effects on children's health. However, this was out of scope of the present study because it would require a different theoretical framework and a different analytical approach including interaction effects between parental and children's education (Ross and Mirowsky, 2011).

With respect to the country context, several conclusions can be drawn. First, in countries with a strongly stratified educational regime and little social mobility such as Germany, not only socio-economic positions but also other life chances are transmitted across generations. It would be important to replicate similar analyses for other countries with different degrees of social stratification and mobility to gain more insight about the moderating role of the broader context. Second,

This study has limitations. Despite the fact that we tried to account for early childhood selection into educational tracks by considering parental education background, our findings cannot be interpreted in a strictly causal sense. Because of sample limitations, e.g. with respect to the age range in which data were collected on the two health outcomes (i.e., starting from adulthood), we could not directly examine early childhood effects of health on education. Unfortunately, this issue is inherent to most published studies because there is no panel dataset with the necessary health measures spanning the whole lifespan for any country yet. We aimed at going beyond previous studies by controlling for parental education to control at least part of the indirect health-related selection (i.e., intergenerational transmission of education).

Furthermore, even when using panel data, age effects may still be partially confounded by potential period effects (Kim and Durden, 2007). Hence, we cannot be certain that our life course (ageing) trajectories are completely purged of period effects. However, preparatory analyses using fixed-effects regressions in which we implicitly controlled for all cohort differences yielded little evidence of systematic shifts across calendar time affecting all cohorts equally, independent of ageing. An important exception concerns negative effects of several years following financial crisis starting after 2008, which we controlled for in our models. Moreover, agree with previous study authors that there is little theoretical reason for

continued period effects, particularly for mental health (Bell, 2014). We believe that more important than disentangling age and period effects is to separate cohort and age effects, considering the cohort effects and cohort-specific health trajectories we found. Obviously, a complete separation of ageing and cohort effects is impossible unless panel data with very long time series (e.g., whole lifespan data for several cohorts) are available. This will not be the case any time soon though.

In sum, we add to the existing literature by showing long-term health consequences of early childhood family SES background (parental education) that is almost completely mediated through children's later own educational attainment. Future life course studies may explore similar and different chains of risk for other countries, where other potential mediating mechanisms could possibly be relevant.

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