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Education and Physical Health Trajectories in
Later Life. Evidence from the Survey of
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Abstract

The model of cumulative inequality predicts that health differences between educational levels increase with age. The empirical evidence, however, is inconclusive. Using a variety of analytical approaches and measures of health, studies have reported increasing as well as decreasing and constant patterns of educational health inequality. The aim of this study is to provide comparable and more generalizable results on the health trajectories across educational levels for different measures of physical health.

We used longitudinal data from two waves (2004/05 and 2006/07) of Survey of Health, Ageing and Retirement in Europe (SHARE). The sample consisted of respondents aged 50 to 80 (n=14,818). Using standardized OLS-regression models, we analyzed trajectories of health inequality in self-reported (ADL, IADL, mobility, chronic diseases, and self-rated health) as well as non-invasive objective (grip strength) measures of physical health.

Inequality between higher and lower educated individuals increased significantly in limitations of physical functioning and grip strength. In chronic diseases and self-rated health, the gap between these two groups remained constant.

Overall, our results mainly supported the model of cumulative inequality.

Key words Cumulative advantage; Education and health; Old age.

Introduction

The positive relationship between education and health is well-established and has been shown to be remarkably consistent across a variety of health outcomes (Chandola et al. 2006; Ross and Wu 1996; Lynch 2003). However, we understand less about the way in which this relationship changes with age. The empirical evidence on the extent of health decline across different levels of education is heterogeneous, and it remains unclear whether the health gap between individuals with high and low levels of education increases in old age (divergence), whether it decreases (convergence), or whether it remains constant (continuity).

Three opposing theoretical perspectives currently shape the epidemiological and sociological literature: the *cumulative advantage/disadvantage hypothesis*, the *age-as-leveler hypothesis*, and the *status maintenance hypothesis*. According to the cumulative advantage/disadvantage hypothesis, the positive effect of education on health increases over the life course (Blane et al. 2007; Dannefer 1987, 2003; Ferraro et al. 2009). From this perspective, education is seen as a resource that structures the distribution of health-related advantages and disadvantages as well as the onset and duration of exposure to environmental and social risks. Highly educated individuals accumulate advantages such as higher income, wealth, psychosocial resources, and healthy behaviors during adulthood, whereas the less-educated are subject to chronic stress (resulting, for example, from occupational uncertainty), lack of both financial and emotional support in their social networks, and risky health behaviors (Ross and Wu 1996). From biological research, we also know that compensatory mechanisms of the human organism may inhibit health decline until the age of 30 or 40, even if individuals experience unfavorable health-related conditions (Power and Hertzman 1997; Power et al. 1999). Therefore, it appears likely educational health inequality will increase markedly at older ages, after a considerable amount of advantages or disadvantages have been accumulated over the life course (e.g., Blane et al. 1997).

In contrast, the *status maintenance hypothesis* posits that the health gradient remains constant across different levels of education (Henretta and Campbell 1976). The main idea behind this hypothesis is that social positions which individuals attain in early adulthood do not change considerably in later life. Accordingly, the health gap between different social groups is expected to remain constant across their lives. Finally, the *age-as-leveler hypothesis* states that health inequality decreases at older ages (House et al. 1990). This pattern is mainly

attributed to selective attrition of less-educated participants in panel surveys and higher mortality in lower social strata. This changes the composition of the surviving population towards a selection of more “robust” individuals which, in turn, may weaken the observed relationship between education and health in old age (Lynch 2003).

Although extant research mostly reported diverging patterns of health inequality after middle adulthood, supporting the cumulative advantage/disadvantage hypothesis (e.g., Ross and Wu 1996; Willson et al. 2007), a considerable number of studies found the opposite pattern of decreasing educational health inequality in old age (e.g., House et al. 2005; Herd 2006). Still others concluded that the health gap between educational levels remains constant (Schöllgen et al. 2010; Knesebeck 2005).

A major reason for this conflicting evidence is that some studies were based on cross-sectional data that were not well suited for testing the age-varying relationship between education and health. Further, studies that used longitudinal data are too diverse in their research designs to be comparable in their results. They vary not only with respect to the countries and age groups studied, but also in their statistical methods and, particularly, in the health indicators that were used. In sum, previous research differed substantially with respect to theories, data, methods, and health measures.

In view of these shortcomings, our study is aimed at producing more generalizable results on educational health trajectories in old age. To accomplish this, we apply the same method to the analysis of multiple measures of physical health. Our data from SHARE comprise panel information on multiple indicators of physical health including limitations of physical functioning, chronic conditions, self-rated health, and a non-invasive objective measure of grip strength. We use data from two waves (2004/05 and 2006/07) to measure *change* in physical health across educational levels in older persons from 11 European countries.

Methods

The SHARE collects individual data on employment, health, and various socio-economic variables for persons aged 50+ in 14 European countries. More than 18,000 persons in 11 countries (Belgium, Denmark, Germany, France, Greece, Italy, the Netherlands, Austria,

Switzerland, Sweden, and Spain) participated in both waves. The average response rate in these countries at the first wave was 61.8 % (Börsch-Supan et al. 2008).¹

To reduce selectivity due to mortality and morbidity, we remove respondents who were older than 80 years at the time of their first interview, restricting the study population to individuals aged 50 to 80. Because migrants represent a selected population with respect to health and health trajectories (e.g., migrants are, on average, healthier than natives (Williams and Collins 1995)), we exclude all respondents who were born abroad. Moreover, we remove individuals with missing information on education (2.3 % of the original sample) and on the various health indicators (6.4 % of the remaining sample). Grip strength is an exception because of its relatively high proportion of missing values (11.7%). Therefore, the analysis of grip strength is based on a sample of 13,666 individuals, whereas the analysis of the other health indicators is based on a sample of 14,818 individuals. To cover different aspects of physical health, we draw both on self-reported data on physical conditions (the ADLs pertaining to the need for bodily care; the IADLs representing instrumental activities of daily life; mobility difficulties; the number of diagnosed chronic diseases; and the self-rated general health status), as well as on the objective measure of grip strength. Figure 1 presents descriptive information on these six indicators.

Figure 1 about here

The first measure of physical limitations counts the number of limitations in activities of daily living (ADL), including dressing, walking across a room, bathing or showering, eating, getting in or out of bed, and using the toilet, including getting up or down (Börsch-Supan et al. 2008). For ease of interpretation, we recoded the original variable so that high values represent good health. Therefore, the value 6 is assigned to respondents who reported no limitations in ADL (best health) whereas 0 indicates the maximum of six limitations in ADL (worst health). Accordingly, the dependent variable indicating the individual *change in ADL* between the two waves ranges from -6 (maximal health decline) to +6 (maximal health increase). This variable has a mean of -0.02, reflecting a slight health decline in ADL across

¹ This paper uses data from SHARE release 2.5.0, as of May 24th 2011. SHARE data collection in 2004-2007 was primarily funded by the European Commission through its 5th and 6th framework programmes (project numbers QLK6-CT-2001-00360; RII-CT- 2006-062193; CIT5-CT-2005-028857). Additional funding by the US National Institute on Aging (grant numbers U01 AG09740-13S2; P01 AG005842; P01 AG08291; P30 AG12815; Y1-AG-4553-01; OGHA 04-064; R21 AG025169) as well as by various national sources is gratefully acknowledged (see <http://www.share-project.org> for a full list of funding institutions).

the waves. For interpretation of our results, note that the higher this negative value, the greater the extent of health decline between the two waves. The same kind of recoding was applied to all health indicators. Detailed descriptive information on the variables used is presented in Table 1.

Table 1 about here

The second measure of physical functioning is the number of limitations in instrumental activities of daily living (IADL). These activities are considered more complex than the basic ADL and therefore better suited for assessing the functional status of older adults. There are seven IADLs: preparing a hot meal, shopping for groceries, making telephone calls, using a map to figure out how to get around in a strange place, taking medications, doing work around the house or garden, and managing money, such as paying bills and keeping track of expenses. The third measure of physical functioning is the number of limitations in mobility that respondents expected to last for more than three months at the time of the interview. These limitations included difficulties in walking 100 meters, sitting for about two hours, getting up from a chair after sitting for long periods, climbing several flights of stairs without resting, climbing one flight of stairs without resting, stooping, kneeling, or crouching, reaching or extending the arms above shoulder level (either arm), pulling or pushing large objects like a living room chair, lifting or carrying weights over 10 pounds, like a heavy bag of groceries, and picking up a small coin from a table. The fourth measure is the number of chronic diseases, which has been shown to be a good predictor of mortality in older persons (Dupre 2007; Schöllgen et al. 2010). The list of chronic diseases included heart attack, high blood pressure, elevated cholesterol, stroke, diabetes, lung disease, asthma, arthritis, osteoporosis, cancer, ulcer, Parkinson's disease, cataracts, and hip complaint. The fifth indicator, self-rated health, measures how individuals evaluate their own health status. This measure has been shown to contain information on the general health status which is not covered by other indicators (Willson et al. 2007). This variable is measured using a five-point scale (very poor, poor, good, very good, excellent), whereby higher values indicate better health. In addition to these self-reported measures, we draw on grip strength as a non-invasive objective indicator. Using a dynamometer, grip strength was measured four times – twice for each hand (Hank et al. 2006). We used a generated variable indicating the highest of these four values for each respondent.

To analyze change in health related to education, we use the approach proposed by Ross and Wu (1996), estimating the following OLS regression model for each of our health measures:

$$(health_{w2} - health_{w1}) = \hat{\beta}_0 + \hat{\beta}_1 age_{w1} + \hat{\beta}_2 education + \hat{\beta}_3 age_{w1} * education + \hat{\beta}_4 health_{w1} + \hat{\beta}_5 male + \sum_{j=6}^J X_j \hat{\beta}_j$$

The dependent variable ($health_{w2} - health_{w1}$) is the change in a health indicator between the first and the second wave of SHARE. We standardized these scores with the mean of zero and a standard deviation of one to allow for comparison between the indicators. The key predictor variables are age_{w1} , $education$ and the interaction term $age_{w1} * education$. The variable age_{w1} estimates the effect of age, measured in years, at the first wave on the change of each health indicator respectively. We expect this effect to be linear and negative, indicating an increasing health decline with age. The variable $education$, measured in years of both school and professional education, shows the main effect of education on health. This effect is expected to be positive, pointing to a slower average health decline in persons with higher education. For easing the interpretation of the estimation results, we centered the variables age_{w1} and $education$ at their means.

The interaction term $age_{w1} * education$ is the most important independent variable in this analysis. A positive effect of this variable indicates divergence, that is, the effect of education on the change in health increases with age. A negative effect suggests convergence, that is, the effect of education on the change in health declines with increasing age. An effect not significantly different from zero is consistent with the model of continuity, that is, the effect of education on the change in health decline remains constant with increasing age.

To account for a possible non-linear effect of age, a number of studies included additional interactions between education and squared or cubic age (Lynch 2003). Other studies showed that a linear specification of the age effect is better suited for some health indicators (Ross and Wu 1996; Willson et al. 2007). Thus we additionally tested for non-linear trajectories of change in health. Using the Bayesian Information Criterion (BIC), we compared different model specifications which included interactions between (a) age and education, (b) age^2 and education, and (c) age^3 and education. The third model specification was not a good fit for

any health indicator. For ADL and IADL, the fit of the model with the interaction between age² and education was slightly better compared to the linear model. For the other four health indicators (limitations in mobility, chronic diseases, self-rated health, and grip strength), the linear model turned out to be preferable. Because the differences in BIC were very small, we estimated the linear model for all indicators.

Finally, all models include the original levels of each health indicator respectively ($health_{w1}$). This control variable is also standardized with the mean of zero and a standard deviation of one. We introduce gender (*male*) and country dummies because there are well-known gender and cross-country differences in health which could bias the individual change in health if not controlled (Read and Gorman 2010; Knesebeck et al. 2006).

Results

Table 2 shows the estimated coefficients for the models of change in six indicators of physical health. First, note that health at the time of the first interview has a significant negative effect on the change of all health indicators, pointing to a ceiling effect: The better health was at the time of the first measurement, the larger was the possible margin for subsequent health decline. Results also show that males' health declines less in IADL, mobility, the number of chronic diseases, and grip strength. In ADL, there is no statistically significant difference in the decline between males and females.

Of central interest are the effects of age and education. The main effect of age indicates that those who were older at the first interview experienced a steeper health decline in all outcome measures. In contrast, education has a significant positive effect on all indicators, revealing a less pronounced health decline of more educated persons compared to those with lower levels of education.

Table 2 about here

The interaction effect between age and education identifies the age trajectory of educational health inequality, indicating whether the age effect on health decline varies across educational levels. Although the models do not show one consistent pattern across all six indicators, they reveal a predominantly divergent pattern. This applies to the indicators of physical limitations (M1, M2, and M3) and to grip strength (M6). Here the interaction effect

is positive and significant, implying an increase in educational health inequality with age. In the models for chronic diseases (M4) and self-rated health (M5), the interaction between age and education is not significantly different from zero.

Figure 2 facilitates the interpretation of these interaction effects between age and years of education by providing a graphical illustration of the results. For these graphical analyses, we simulated two scenarios based on the estimated coefficients from Table 2. The first scenario presents the estimated values for the change in health for a low level of education (five years of education below average, which is about one standard deviation). The second scenario estimates the change in health for a high level of education (five years of education above average). The initial level of health is fixed at the value of the 75th percentile of the total sample. The gender is set to males, and all other covariates are fixed at their means or shares. This procedure allows illustrating the change of health for high and low levels of education as well as plotting the confidence intervals for the estimated values which yield additional information on the age at which the estimated educational health differences become statistically significant.

Figure 2 about here

As Figure 2 shows, those with less education experienced a steeper health decline compared to highly educated individuals in all measures of physical health. The findings from Table 2 translate into clearly diverging curves in ADL, IADL, mobility, and grip strength. The continuous pattern of health decline in the number of chronic diseases and self-rated health corresponds to a similar decline for the high and low educated. The educational differences in health are significantly different from zero for almost the entire age range under study.

Discussion

Although the relationship between education and health is well-established, less is known about the way in which this relationship varies with age. The literature is divided over whether the health gap between individuals with high and low education increases, decreases, or remains constant in older age. Previous research varied considerably with regard to age groups and countries studied as well as the health indicators and statistical methods used. This heterogeneity precluded any clear and generalizable statements about educational health

trajectories in old age. The present study aimed to address this deficit using a cross-national sample, multidimensional measures of physical health, and a standardized research design. This analytical strategy enabled us to provide comprehensive results on the trajectories of physical health inequality both in self-reported and in objective health measures.

Overall, we found that educational health inequality shows a mainly divergent trajectory: The health gap between high and low educated individuals increases with age. This result applies both to self-reported measures and to an objective measure of grip strength. To the best of our knowledge, the present analysis is the first to report this pattern using an objective measure of physical health. For two indicators (number of chronic diseases and self-rated health), we observed continuous patterns of health decline. These findings may be attributable to different reasons. With regard to self-rated health, this indicator could be considered a personal attitude and attitudes are known to be relatively stable over time (Sturgis et al. 2009). Therefore, this indicator may not sufficiently capture health changes which occur during the rather short time span studied in the present analysis. Moreover, self-rated health has been argued to be more appropriate in measuring the health of younger persons who have less comparable and less pronounced limitations and illnesses (Willson et al. 2007). Concerning the number of chronic diseases, the illnesses which are subsumed under this indicator are very heterogeneous. However, it would be conceptually desirable to measure their duration and severity as well. Including these aspects may change the results: For instance, Schöllgen et al. (2010) found a constant educational health gap in the number of chronic diseases, whereas Dupre (2007) analyzed the duration of chronic diseases and the chances for healing to report a diverging pattern. Moreover, the gradients of specific illnesses may differ. For example, Goldman and Smith (2002) showed that less-educated persons faced more problems in regulating their blood sugar. Thus, diverging patterns may depend on the ability to follow complex treatment regimes. For other chronic diseases, educational health trajectories may depend less on cognitive abilities and self-control of a person, suggesting constant or even convergent patterns of the education health gradient.

Some limitations of the present study should be noted. First, the three hypotheses guiding our study refer to change in health over the entire life course. Our analysis, however, was restricted to changes in health among individuals over the age of 50. Therefore, our results only represent a truncated test of the underlying theoretical considerations. Second, only two waves of data covering a time span of approximately three years were available. For a more

comprehensive test, it would be desirable to analyze long-term panel data. This would not only allow analyzing more extensive health trajectories, but also separating age and cohort effects. Moreover, longitudinal data on factors that are likely to mediate the relationship between education and health would provide insights into the underlying mechanisms from a life course perspective. The results presented in this study only describe the age-dependent change in health related to education. How these trajectories are produced is still a largely open question.

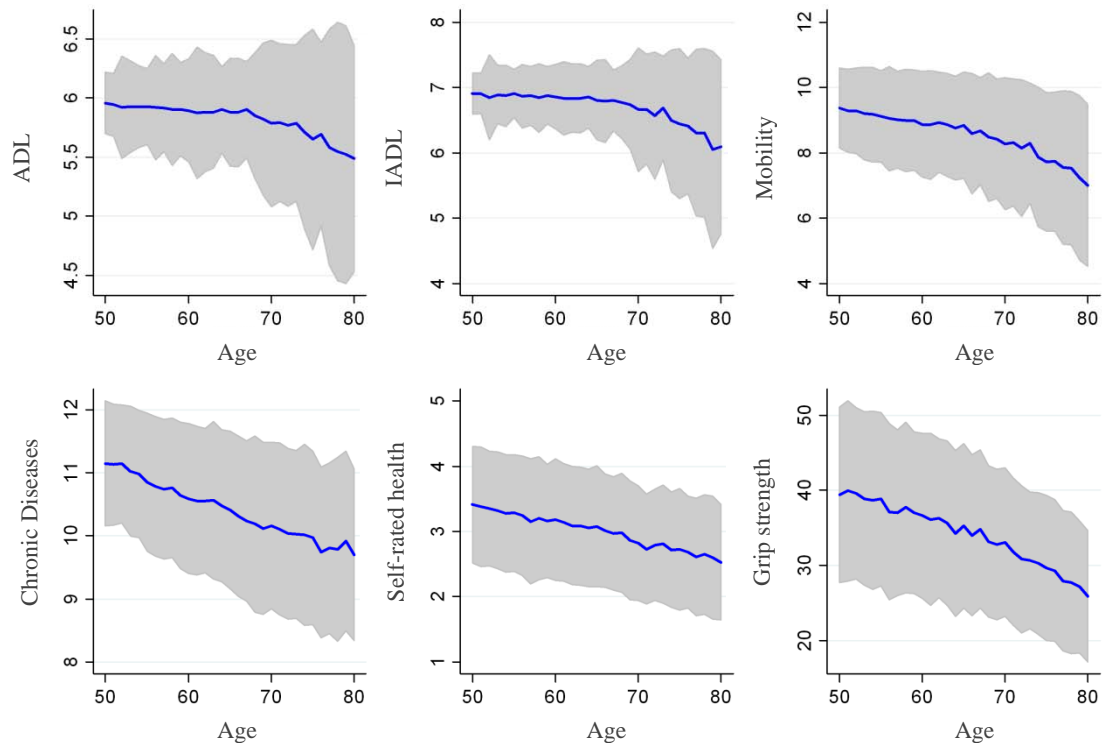
In this respect, future research should address the mechanisms behind the education health gradient over the life course both theoretically and empirically. As indicated by previous research, the correlation between education and health varies across countries (Kneesebeck et al. 2006; Avendano et al. 2009). Studies that reported a constant health gap between educational levels speculated that a strong welfare state may reduce health inequality (Schöllgen et al. 2010). However, a sound theoretical framework that allows to deriving specific hypotheses about different trajectories of health inequality has not been developed yet. In view of that, we consider it worthwhile for future research to conduct theoretically informed longitudinal analyses on health inequality from a cross-national comparative perspective.

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Figure 1: Means and standard deviations of six physical limitations by age at the Wave 1



Source: SHARE 2004/05; Release 2.5.0; own calculations

Table 1: Means and standard deviations of the variables used in the pooled sample

	Mean	Standard deviation	Minimum	Maximum
Age	62.71	8.26	50	80
Years of education	10.40	4.32	0	25
Male	0.46	0.49	0	1

ADL 2004	5.88	0.52	0	6
Change in ADL	-0.02	0.57	-6	6
IADL 2004	6-82	0.61	0	7
Change in IADL	-0-05	0.67	-7	7
Mobility 2004	8.81	1.82	0	10
Change in Mobility	-0.14	1.6 2	-10	10
Chronic diseases 2004	10.54	1.37	0	12
Change in chronic diseases	-0.06	1.18	-7	12
Self-rated health 2004	3.16	1.03	1	5
Change in self-rated health	-0.16	0.94	-4	4
Grip strength 2004	35.6	12.12	2	85
Change in grip strength	-0.70	7.26	-53	53

Source: SHARE 2004/05-2006/07; Release 2.5.0; own calculations.

Table 2: OLS regression models for the change in physical health between Wave 1 (2004/05) and Wave 2 (2006/07)

	M1	M2	M3	M4	M5	M6
	ADL	IADL	Mobility	Chronic diseases	Self-rated health	Grip strength
Male	0.01 (0.69)	0.03** (2.92)	0.08*** (6.82)	0.07*** (5.66)	0.03* (2.49)	0.45*** (30.81)
Age	-0.01*** (-11.30)	-0.01*** (-16.52)	-0.01*** (-18.20)	-0.01*** (-16.42)	-0.01*** (-12.08)	-0.02*** (-27.31)
Years of education	0.01*** (5.07)	0.01*** (6.12)	0.01*** (8.18)	0.01*** (6.40)	0.02*** (10.53)	0.01*** (4.28)
Age*education / 10	0.08*** (4.85)	0.11*** (6.80)	0.08*** (4.83)	0.00 (0.17)	0.01 (0.41)	0.03* (2.09)
Health 2004	-0.55*** (-80.27)	-0.53*** (-75.30)	-0.42*** (-63.87)	-0.41*** (-62.87)	-0.47*** (-66.56)	-0.40*** (-50.74)
R^2	0.305	0.280	0.223	0.214	0.237	0.181
Observations	14818	14818	14818	14818	14818	13666

Note: All models additionally control for country heterogeneity using 10 country dummies; |t|-values in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Source: SHARE 2004/05-2006/07; Release 2.5.0; own calculations.

Figure 2: Model-based change in physical health

