Int J Public Health (2013) 58:23–31
DOI 10.1007/s00038-012-0399-0

ORIGINAL ARTICLE

Education and physical health trajectories in old age. Evidence from the Survey of Health, Ageing and Retirement in Europe (SHARE)

Liliya Leopold · Henriette Engelhartdt

Received: 31 October 2011 / Revised: 2 July 2012 / Accepted: 26 July 2012 / Published online: 24 August 2012

Abstract

Objectives The model of cumulative inequality predicts that health differences between educational levels increase with age. Using a variety of analytical approaches and measures of health, studies have, however, reported increasing as well as decreasing and constant patterns of educational health inequality. The aim of this study is use a standardized research design to compare different dimensions of health inequality trajectories across educational levels.

Methods We used data from two waves (2004/2005 and 2006/2007) of SHARE. The sample consisted of respondents aged 50–80 ($n = 14{,}818$). Using OLS regression models, we analyzed trajectories of health inequality in self-reported measures (ADL, IADL, mobility, chronic diseases, and self-rated health) as well as non-invasive objective measures (grip strength) of physical health.

Results 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.

Conclusion Although our results mainly supported the model of cumulative inequality, they also showed that the trajectory of the education-health gradient is not uniform but varies across different dimensions of physical health.

Keywords Cumulative advantage · Education and health · Old age

This article is part of the special issue "Life course influences on health and health inequalities: moving towards a Public Health perspective".

L. Leopold (✉)
European University Institute, Via dei Rustici 2/11, 50122 Florence, Italy
e-mail: liliya.leopold@eui.eu

H. Engelhartdt
Chair of Population Studies, University of Bamberg, Lichtenhaidestraße 11, 96045 Bamberg, Germany
e-mail: henriette.engelhardt-woelfler@uni-bamberg.de

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 and Shippee 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 or used measures that were not well suited for testing the age-varying relationship between education and health. Further, studies that used longitudinal data were 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, this study aims to examine different dimensions of physical health and to compare their trajectories across educational levels. To accomplish this, we apply the same method to the analysis of multiple measures of physical health. In previous research, these measures were only examined separately using a variety of operationalizations, analytical samples, and statistical methods. Our data from SHARE comprise panel information on multiple indicators of physical health including limitations of physical functioning, chronic conditions, self-rated health, and grip strength. Thus, these data allow investigating the education-health gradient not only in self-reported measures of health (representing the dominant approach of previous research in this field) but also in a non-invasive objective measure of grip strength.

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). We use data from two waves (2004/05 and 2006/07) to measure *change* in the physical health of older persons across educational levels.

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 50–80. 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. Since the scales of these measures differ substantially between the indicators, we standardized these scores with a mean of zero and a standard deviation of one to allow for comparison between the indicators. Figure 1 presents descriptive information on these six indicators

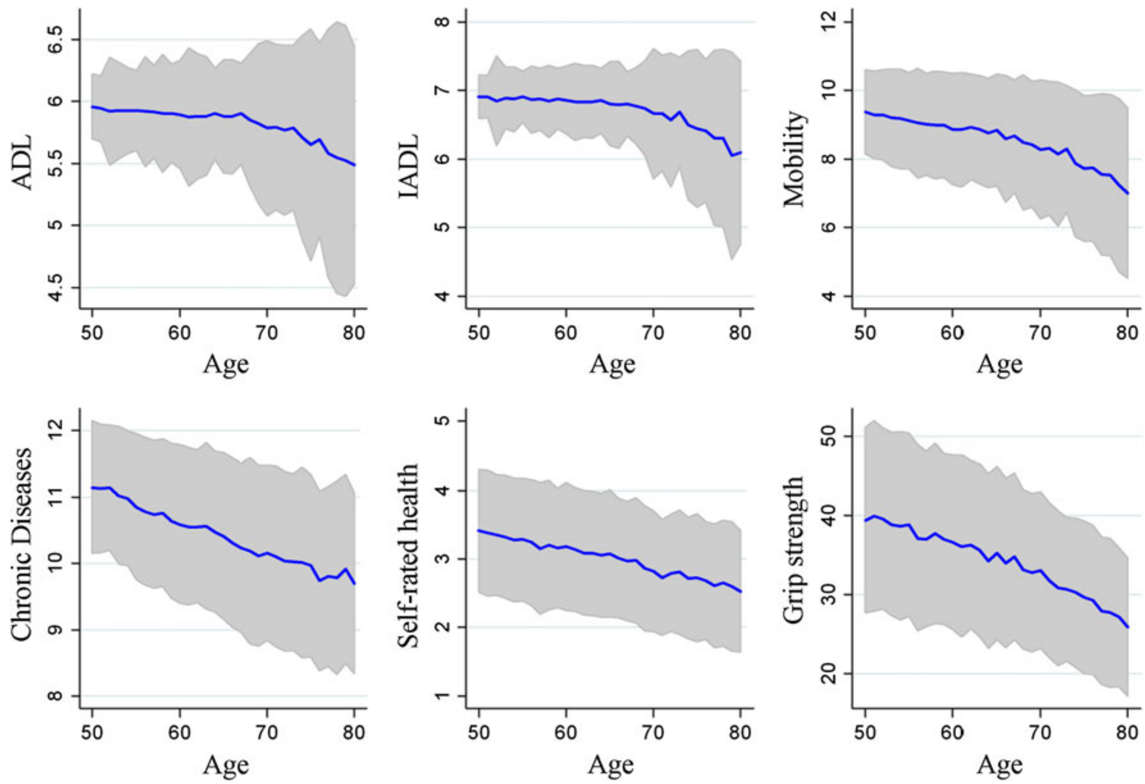

Fig. 1 Means and standard deviations of six physical limitations by age. Source: SHARE 2004–2007, Release 2.5.0, Countries: Belgium, Denmark, Germany, France, Greece, Italy, The Netherlands, Austria, Switzerland, Sweden, and Spain, Own calculations

with their original scales and Fig. 2 shows the standardized scores of these measures.

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 6 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 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 as well as on health outcomes from the second wave is presented in Table 1.

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 3 months at the time of the interview. These limitations included difficulties in walking 100 m, sitting for about 2 h, 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.

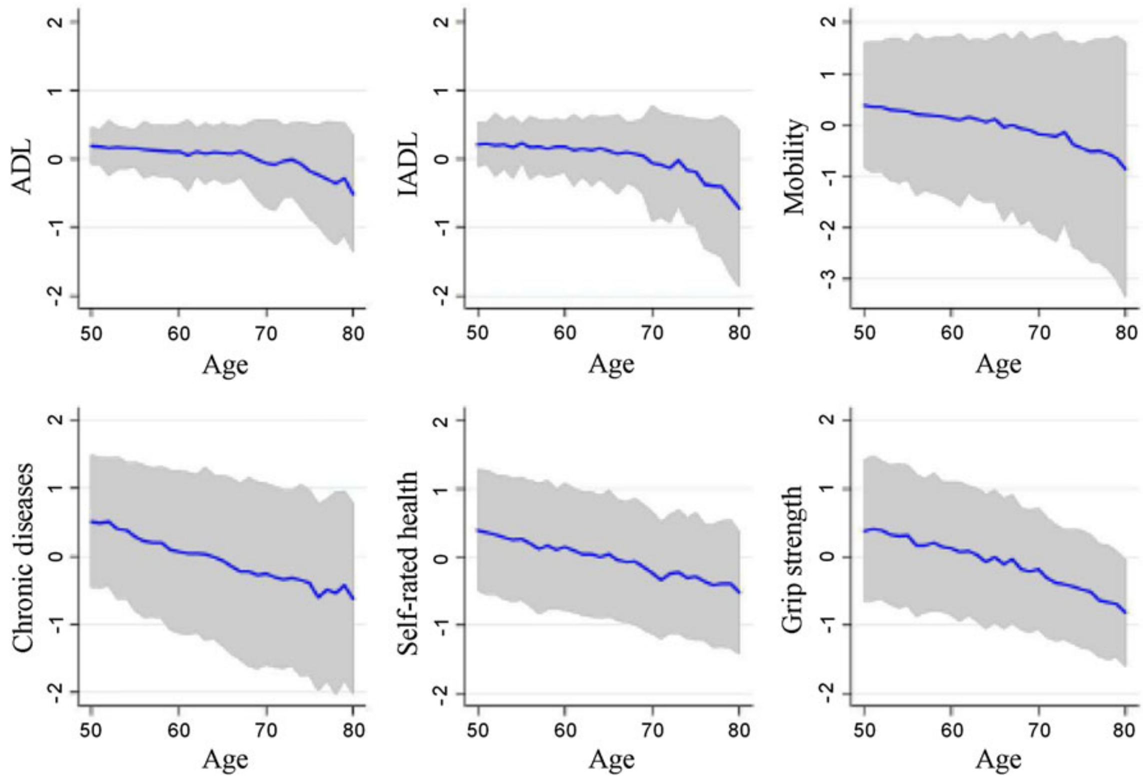

Fig. 2 Means and standard deviations of z-standardized measures of six physical limitations by age. Source: SHARE 2004–2007, Release 2.5.0, Countries: Belgium, Denmark, Germany, France, Greece, Italy, The Netherlands, Austria, Switzerland, Sweden, and Spain. Own calculations

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 5-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. Note that the two waves of SHARE covered a rather short period of approximately 3 years. Although the magnitude of change in health is generally small across an observation window of only 3 years, previous studies have shown that a short period of time is still sufficient to identify the trajectories of educational health gaps (Avendano et al. 2009; Ross and Wu 1996). To analyze change in health related to education, we follow the approach proposed by Ross and Wu (1996). Similar to our study, these authors examined educational health change across a rather short period of 2 years. We estimate the following OLS regression model for each of our health measures:

$$(\text{health}_{w2} - \text{health}_{w1}) = \hat{\beta}_0 + \hat{\beta}_1 \text{age}_{w1} + \hat{\beta}_2 \text{education} + \hat{\beta}_3 \text{age}_{w1} \times \text{education} + \hat{\beta}_4 \text{health}_{w1} + \hat{\beta}_5 \text{male} + \sum\nolimits_{j=6}^{J} X_j \hat{\beta}_j$$

The dependent variable $(\text{health}_{w2} - \text{health}_{w1})$ is the change in a health indicator between the first and the second wave of SHARE. For the reasons of comparability, we also standardized these scores of health change between two waves with the mean of zero and a standard deviation of one. 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

Table 1 Descriptive statistics

	Mean	SD	Min	Max
Age 2004	62.71	8.26	50	80
Years of education	10.40	4.32	0	25
Male	0.46	0.49	0	1
Health measures				
ADL 2004	5.88	0.52	0	6
[*z* score ADL 2004]	[0.03]	[0.92]	−9.92	0.23
ADL 2007	5.86	0.59	0	6
Change in ADL	−0.02	0.57	−6	6
[*z* score change in ADL]	[0.02]	[0.94]	−9.47	9.58
IADL 2004	6.82	0.61	0	7
[*z* score IADL 2004]	[0.05]	[0.91]	−9.23	0.29
IADL 2007	6.77	0.73	0	7
Change in IADL	−0.05	0.67	−7	7
[*z* score change in IADL]	0.02	[0.93]	−9.00	9.19
Mobility 2004	8.81	1.82	0	10
[z score mobility 2004]	[0.03]	[0.96]	−4.64	0.65
Mobility 2007	8.67	2.00	0	10
Change in mobility	−0.14	1.62	−10	10
[*z* score change in mobility]	[0.01]	[0.97]	−5.86	6.05
Chronic diseases 2004	10.54	1.37	0	12
[*z* score chronic diseases 2004]	[0.01]	[0.99]	−7.62	1.06
Chronic diseases 2007	10.48	1.42	2	12
Change in chronic diseases	−0.06	1.18	−7	12
[*z* score change in chronic diseases]	[0.00]	[0.99]	−4.95	10.00
Self-rated health 2004	3.16	1.03	1	5
[z-score self-rated health 2004]	[0.03]	[0.99]	−2.06	1.80
Self-rated health 2007	3.00	1.04	1	5
Change in self-rated health	−0.16	0.94	−4	4
[*z* score change in self-rated health]	[0.00]	[0.99]	−4.08	4.41
Grip strength 2004	35.60	12.12	2	85
[*z* score grip strength 2004]	[0.01]	[1.00]	−2.74	4.10
Grip strength 2007	34.80	11.83	1	80
Change in grip strength	−0.70	7.26	−53	53
[*z* score change in grip strength]	[0.00]	[1.00]	−7.21	7.12

Source: SHARE 2004–2007; Release 2.5.0; Statistics over countries: Belgium, Denmark, Germany, France, Greece, Italy, the Netherlands, Austria, Switzerland, Sweden, and Spain. Own calculations

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 age^2 and education was slightly better as 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 ($\sum_{j=6}^{J} X_j \hat{\beta}_j$) 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.

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 3 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 change in health for a low level of education (5 years of education below average). The second scenario estimates the change in health for a high level of education (5 years of education above average). Across countries, this difference of about 10 years of schooling corresponds to the educational gap between the bottom 10 % and the top 10 % of the educational distribution. Thus, our illustration shows the model-based development of the health gap between two educational extremes. The initial level of health is fixed at the value of the 75th percentile of the total sample. The gender is set to male, and all other covariates are fixed at their means or shares. This procedure also allows plotting the confidence intervals

Table 2 OLS regression models for the change in physical health between Wave 1 (2004/2005) and Wave 2 (2006/2007)

	M1 ADL	M2 IADL	M3 Mobility	M4 Chronic diseases	M5 Self-rated health	M6 Grip strength
Male	0.01	0.03**	0.08***	0.07***	0.03*	0.45***
	(0.69)	(2.92)	(6.82)	(5.66)	(2.49)	(30.81)
Age	−0.01***	−0.01***	−0.01***	−0.01***	−0.01***	−0.02***
	(−11.30)	(−16.52)	(−18.20)	(−16.42)	(−12.08)	(−27.31)
Years of education	0.01***	0.01***	0.01***	0.01***	0.02***	0.01***
	(5.07)	(6.12)	(8.18)	(6.40)	(10.53)	(4.28)
Age × education/10	0.08***	0.11***	0.08***	0.00	0.01	0.03*
	(4.85)	(6.80)	(4.83)	(0.17)	(0.41)	(2.09)
Health 2004	−0.55***	−0.53***	−0.42***	−0.41***	−0.47***	−0.40***
	(−80.27)	(−75.30)	(−63.87)	(−62.87)	(−66.56)	(−50.74)
R^2	0.305	0.280	0.223	0.214	0.237	0.181
Observations	14,818	14,818	14,818	14,818	14,818	13,666

All models additionally control for country heterogeneity using 10 country dummies (Belgium, Denmark, Germany, France, Greece, the Netherlands, Austria, Switzerland, Sweden, and Spain); $|t|$ values in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Source: SHARE 2004–2007; Release 2.5.0; own calculations

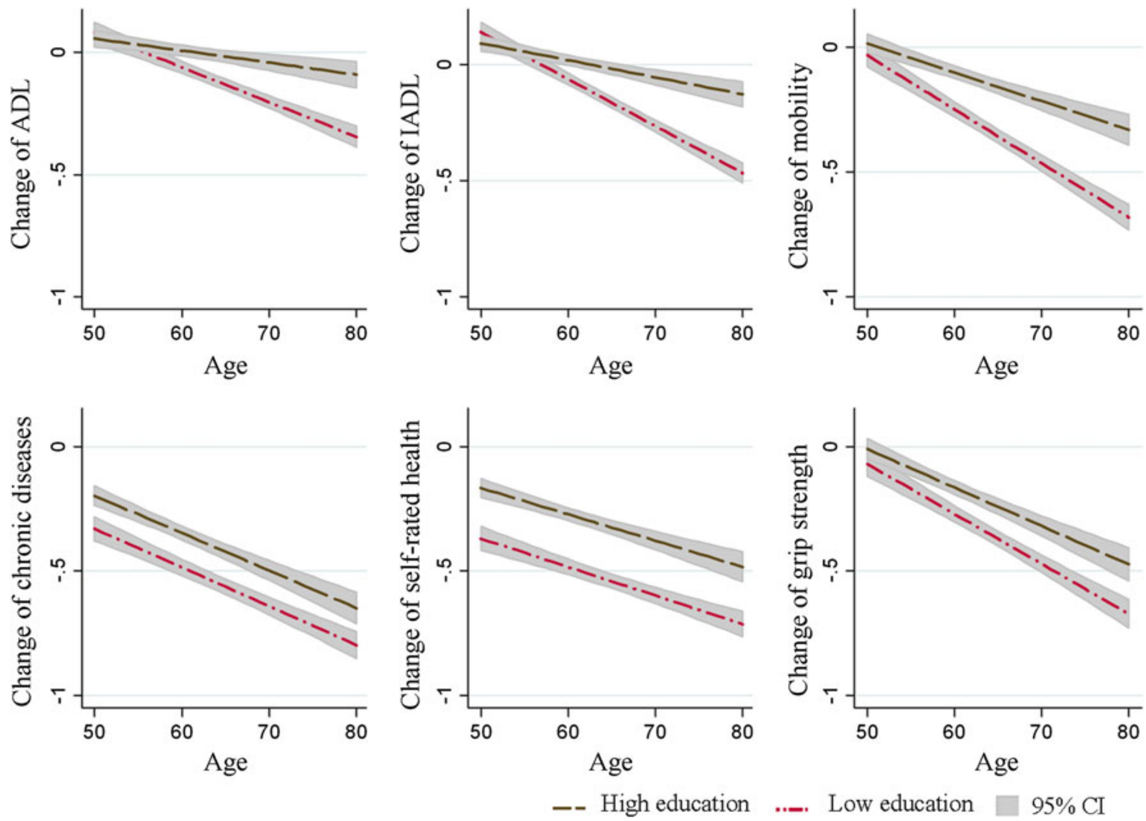

Fig. 3 Simulation of change in physical health based on the estimations from Table 2

for the estimated values which yield additional information on the age at which the estimated health differences between very high and very low educational levels become statistically significant.

As Fig. 3 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 statements about change in various physical health dimensions across educational levels. 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 and comparable results on the trajectories of inequality in different dimensions of physical health, including both self-reported and objective measures. Thus, it contributed to understanding to what extent contradictory trajectories reported by previous research could be due to differences in research designs.

Overall, we found that divergence is the main trajectory of educational health inequality: The health gap between educational levels increases with age. This result applies both to self-reported measures and to an objective measure of grip strength. For two indicators (number of chronic diseases and self-rated health), we observed a continuous pattern of health decline.

Using a standardized research design, this study revealed variation in the trajectory of health inequality across different measures of physical health. These results suggest that the contradictory evidence reported by previous studies is not primarily attributable to methodological differences. Instead, the heterogeneity of health inequality trajectories is likely to reflect substantive differences in the characteristics that are measured by specific indicators of health. For example, self-rated health 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. With regard to 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. Inclusion of these aspects may affect 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 a person's cognitive abilities and self-control, suggesting a constant or even converging trajectory of the education-health gradient. Such substantive differences in the characteristics that are measured by a specific indicator of health, however, are largely ignored in the current literature. We propose that consideration of these aspects will contribute to understanding the multiple shapes of the education-health gradient.

The main implication for future research is, thus, to justify the use of specific health indicators more carefully, considering their conceptual features as well as their statistical properties. In particular, research on trajectories of health inequality would benefit from an integrative theoretical framework specifying the mechanisms that link education to *different* dimensions of health. This approach would allow for more accurate predictions of the trajectories of educational health inequality over the life course.

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 aged 50 and older. Therefore, our results only represent a truncated test of the theoretical considerations. Second, only two waves of data covering a time span of approximately 3 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 showed 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 (Knesebeck et al. 2006; Avendano et al. 2009). Studies that reported a constant health gap between educational levels have speculated that a strong welfare state may reduce health inequality (Schöllgen et al. 2010). However, a sound theoretical framework that allows 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.

References

Avendano M, Jürges MH, Mackenbach JP (2009) Educational level and changes in health across Europe: longitudinal results from SHARE. J Eur Soc Policy 19:301–316

Blane D, Bartley M, Smith GD (1997) Disease aetiology and materialist explanations of socioeconomic mortality differentials. Eur J Public Health 7:385–391

Blane D, Netuveli G, Stone J (2007) The development of life course epidemiology. Rev Epidemiol Sante Publique 55:31–38

Börsch-Supan A, Brugiavini A, Jürges H, Kapteyn A, Mackenbach JP, Siegrist J, Weber G (eds) (2008) First results from the survey of health, ageing and retirement in Europe (2004–2007). Starting the Longitudinal Dimension, Druckerei Schwörer

Chandola T, Clarke P, Morris JN, Blane D (2006) Pathways between education and health: a causal modelling approach. J R Stat Soc A Stat 169:337–359

Dannefer D (1987) Aging as intracohort differentiation: accentuation, the matthew effect, and the life course. Soc Forum 2:211–237

Dannefer D (2003) Cumulative advantage/disadvantage and the life course: cross fertilising age and social science theory. J Gerontol B Psychol 58:327–337

Dupre ME (2007) Educational differences in age-related patterns of disease: reconsidering the cumulative disadvantage and age-as-leveler hypotheses. J Health Soc Behav 48:1–15

Ferraro KF, Shippee TP (2009) Aging and cumulative inequality: how does inequality get under the skin? Gerontologist 49:333–343

Goldman D, Smith JP (2002) Can patient self-management help explain the SES health gradient? Proc Natl Acad Sci 99(16): 10929–10934

Hank K, Jürges H, Schupp J, Wagner GG (2006) Die Messung der Greifkraft als objektives Gesundheitsmaß in sozialwissenschaftlichen Bevölkerungsumfragen. DIW Discussion Papers. http://www.diw.de/documents/publikationen/73/diw_01.c.44221.de/dp577.pdf

Henretta JC, Campbell RT (1976) Status attainment and status maintenance: a study of stratification in old age. Am Soc Rev 41:981–992

Herd P (2006) Do functional health inequalities decrease in old age? Educational status and functional decline among the 1931–1941 birth cohort. Res Aging 28:375–392

House JS, Kessler RC, Herzog RA, Mero RP, Kinney AM, Breslow MJ (1990) Age, socioeconomic status, and health. Milbank Q 68:383–411

House JS, Lantz PM, Herd P (2005) Continuity and change in the social stratification of aging and health over the life course: evidence from a nationally representative longitudinal study from 1986 to 2001/2002 (American's Changing Lives Study). J Gerontol B Psychol 60B(Special Issue II):15–26

Knesebeck O (2005) Soziale Einflüsse auf die Gesundheit alter Menschen. Eine deutsch-amerikanische Vergleichsstudie. 1st edn. Verlag Hans Huber, Hogrefe AG, Bern

Knesebeck O, Verde PE, Dragano N (2006) Education and health in 22 European countries. Soc Sci Med 63:1344–1351

Lynch SM (2003) Cohort and life-course patterns in the relationship between education and health: a hierarchical approach. Demography 40:309–331

Power C, Hertzman C (1997) Social and biological pathways linking early life and adult disease. Br Med Bull 53(1):210–221

Power C, Manor O, Matthews S (1999) The duration and timing of exposure: effects of socioeconomic environment on adult health. Am J Public Health 89:1059–1065

Read JG, Gorman BK (2010) Gender and health inequality. Annu Rev Sociol 36:371–386

Ross CE, Wu C (1996) Education, age, and the cumulative advantage in health. J Health Soc Behav 37:104–120

Schöllgen I, Oliver H, Tesch-Römer C (2010) Socioeconomic status and health in the second half of life: findings from the German Ageing Survey. Eur J Ageing 7:17–28

Sturgis P, Allum N, Brunton-Smith I (2009) Attitudes over time: the psychology of panel conditioning. In: Lynn P (ed) Methodology of longitudinal survey, Wiley, New York, pp 113–127

Williams DR, Collins C (1995) US socioeconomic and racial differences in health: patterns and explanations. Annu Rev Sociol 21:349–386

Willson AE, Kim MS, Glen HE Jr (2007) Cumulative advantage processes as mechanisms of inequality in life course health. Am J Sociol 112:1886–1924