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THE EFFECT OF EDUCATION ON HEALTH: EVIDENCE FROM NATIONAL COMPULSORY SCHOOLING REFORMS

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The Effect of Education on Health: Evidence from National Compulsory Schooling Reforms

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ABSTRACT

This paper sheds light on the causal relationship between education and health outcomes. We combine three surveys (SHARE, HRS and ELSA) that include nationally representative samples of people aged 50 and over from fifteen OECD countries. We use variations in the timing of educational reforms across these countries as an instrument for education. Using IV-Probit models, we find causal evidence that more years of education lead to a lower probability of reporting poor health, less likely of having limitations in functional status (ADL and iADLs), and lower prevalence for diabetes. These effects are larger than those from the Probit that do not control for the endogeneity of education. The relationship between education and cancer is positive in both Probit and IV-Probit models. The causal impacts of education on other chronic conditions as well as functional status are not established using IV-Probit models.

JEL: I1, I2

Keywords: education, health, causality, compulsory schooling laws

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1. INTRODUCTION

There is abundant evidence on the associations between education and health, whether health is measured by mortality, morbidity, or health behaviors.[4] International comparative studies have documented that the associations exist in multiple countries, although magnitudes might differ (Banks, et al. 2006; Andreyeva, et al. 2007; Mackenbach, et al. 2008; Avendano, et al. 2009; Michaud, et al. 2011). If the association is causal, then the effect of education on health should be taken into account when forming education and health policies.

Education could improve health through at least the following channels: raising efficiency in health production (productive efficiency) (Grossman, 1972), changing inputs in health production (allocative efficiency) (Grossman, 2005), changing time preference (Fuchs, 1982), changing behavioral patterns, e.g. smoking, obesity, preventive care (Huisman, et al. 2005; Mackenback, et al. 2008); and finally, gaining more resources, e.g., higher income, occupational status, better housing, better food, better quality of care, and living environment (i.e. Case and Deaton, 2005; Cutler, et al., 2008).

Observational studies examining correlations between education and health cannot be interpreted causally because education might be endogenous. First, earlier health endowments could affect both education and health in later life. Second, an unobserved variable, like time preference, genetic factors, family background, could affect both education and health. An array of studies has examined the causal relationship between education and health in specific countries. Most of these employed institutional changes as instruments for education.

One study used quarter of birth and family background as instruments for education in the US and analyzed the first wave of the Health and Retirement Study (HRS) (Adams, 2002).

[4] For a review, see Grossman (2005), Cutler and Lleras-Muney (2006) and Cutler, et al. (2008) among others.

The study found a positive effect of education on self-reported health status (SRH hereafter) and functional status in both OLS and IV estimates. Lleras-Muney (2005) explored state variations in compulsory education laws from 1915 to 1939 in the US as instruments for education. She found each additional year of education lowers the probability of dying in the next 10 years by as much as 3.6 percentage points. This result was much larger than that obtained using OLS methods, but the two estimates were not statistically different.

Using nationwide compulsory schooling law changes as instruments for education, Oreopoulos (2006) found a statistically significant relationship between education and SRH in UK and negative effect of education on physical and mental disability in the US. Mazumder (2008) extends and performs the Lleras-Muney's analysis by using data from the Survey of Income and Program Participation rather than US Census. His results are larger effects of the education on health using compulsory schooling laws and including robustness with state-specific time trends. Using UK data, Silles (2009) found increased schooling cause more self-reported good health and lower probabilities of long-term illness, activity-limiting experience, and work-preventing experience. Jürges, et al. (2013) studied the causal link of education and health using two nationwide changes in minimum school leaving age in Britain as exogenous variation for education. The health outcomes include SRH and two biomarkers, blood fibrinogen and blood C-reactive protein. No causal effects between education and the two biomarkers were found. Further, the effect of education on SRH was positively significant only among the cohorts of older women, whereas it was negative among cohorts younger of women and insignificant among men regardless of age. Exploring both the 1947 and 1972 changes to British compulsory schooling laws and using regression discontinuity methods, Clark and Royer (2013) found little evidence that additional schooling improved health outcomes or changed health behaviors.

Using a French longitudinal dataset, Albouy and Lequien (2009) applied two increases on minimum school age in France as instruments for education. They failed to find a statistically significant causal effect of education on mortality. Employing Danish school reforms as instrumental variable for education in a Danish panel dataset, Arendt (2005) found that the IV estimates of education on SRH and body mass index (BMI) were statistically insignificant and not statistically different from those estimated using OLS. Kemptner et al. (2010) applied state variations in the timing of introducing a 9th grade as instruments for years of schooling. Using microcensus data from West Germany, they found that more years of schooling had a negative causal effect on long-term illness, work disability and obesity among men but not among women. The smoking behavior was not causally affected by education in either gender. Using Dutch data, van Kippersluis, et al. (2011), they also exploit the compulsory schooling law to estimate the causal effect of education on mortality. Their estimates results conclude that for men surviving to age 81, an extra year of schooling reduces the probability of dying before the age of 89 by almost 3 percentage points relative to a baseline of 50 percent. While Fischer, et al. (2013) also find evidence, for Sweden, suggesting that education reduces mortality. Specific health interventions and programs may also have had an effect on schooling.[5]

Studies examining the causality between education and health within a specific country have generated different results. Focusing on older populations across different countries, our

[5] More discussion and an extended survey about the use of compulsory schooling laws as instruments to study causation of education on health can be found in Eide and Showalter (2011).

goal is to shed further light on the causal effect of education on health.[6] We use three data sets across different countries. These are the Health and Retirement Study (HRS) for the U.S., the English Longitudinal Study of Ageing (ELSA), and the Study of Health, Ageing and Retirement in Europe (SHARE). This paper adds to the current literature the following contributions. First, we find a causal relationship between education and health by using cross-country variation in compulsory schooling laws over time as an instrumental variable. Second, we examine a wide range of health outcomes, from SRH to chronic conditions, psychological illness, functional status and instrumental functional status. Our main findings are that more years of education lead to better SRH, better functional status (both ADL and iADLs) and lower prevalence of diabetes. The effects are larger than the Probit estimates, which do not control for the endogeneity of education.

2. DATA AND DESCRIPTIVE ANALYSIS

2.1. HRS, SHARE and ELSA

We focus on the individual aged 50 and over in fifteen countries using comparable survey data: the United States, England, and thirteen continental European countries.[7] Our main data sources are the three longitudinal surveys on aging: the Health and Retirement Study (HRS) in the U.S., the English Longitudinal Study of Ageing (ELSA) in England, and the Study of Health, Ageing and Retirement in Europe (SHARE). These surveys were specifically designed to be comparable with one another and each targeted people living in the community and aged 50 and over. Follow-up surveys were conducted biennially. We used data from wave 10 of HRS (2006), wave 3 of ELSA (2006), and wave 2 of SHARE (2006), all of which had been collected during the

[6] Brunello et al. (2011) use compulsory laws as instruments to 6 countries in SHARE and ELSA focusing on health behaviors.

[7] Countries included in our study from SHARE are: Austria, Sweden, the Netherlands, Italy, France, Denmark, Greece, Switzerland, Belgium, Germany, Czech Republic, Poland and Spain. These are the countries with two waves in SHARE.

period 2006 to 2007[8]. The surveys provide harmonized data on health and socio-demographic variables relevant for our analysis. The aged include a useful group to identify the causal relationship between education and health, since there are likely to be large changes in their health but generally, while their educational background remains unchanged.

All study surveys contain a large set of measures of health status, most of which are comparable across surveys. We constructed from the data a set of subjective and objective measures of health outcomes. Subjective measures for this analysis included overall self-rated health status (SRH), self-reported difficulties with activities of daily living (*ADLs*) as well as instrumental ADLs (*IADLs*). SRH was measured by asking respondents to rate their health on a five-point scale: excellent, very good, good, fair, poor. We defined a binary variable of "poor health," which takes value of 1 if the self-rated health is fair or poor and 0 otherwise. For limitations in ADLs, questions were asked in all surveys about difficulties in five basic activities: bathing, dressing, eating, getting in and out of bed, and walking across a room. Individuals were classified as having any ADL limitation if they reported limitations with one or more of the five activities. Limitations in IADLs were measured by questions about difficulties in the following five activities: making meals, shopping, making phone calls, taking medications and managing money. Those who reported having some difficulty with any of the five activities were classified as having any IADL limitation.

Objective measures included in all surveys were the same set of doctor-diagnosed disease questions on cancer, diabetes, hypertension, heart disease, stroke, lung disease, arthritis, and

[8] Currently, twelve waves of HRS (1992 - 2010), five waves of ELSA (2002 – 2010) and four waves of SHARE (2004 – 2010) are available. Wave 3 SHARELIFE (2008) is a retrospective survey. In order to keep comparability between the three surveys and maximize the number of countries to study, we do our analyses for wave 10 of HRS, wave 3 of ELSA and wave 2 of SHARE.

psychological illness[9]. We created a binary variable "*any chronic*" when individuals report having any of these chronic conditions. We also analyzed these variables one by one.

Our main independent variable is "years of education." In HRS, respondents were asked about the highest grade of school or year of college completed. In ELSA, the variable report the last age in full-time education. We converted the values into years of education by subtracting the age when the respondent left school by the usual school started age of five. In the second wave of SHARE, the respondents were asked directly about years of full-time education.

Other demographic variables include gender and age. For checking the robustness of our results, we also consider employment status (working versus non-working), marital status (1. Married/partner 2. Divorced/separated 3. Widowed and 4. Never married), and household size.

2.1.1. Descriptive Statistics: Table 1 presents summary statistics of the data in more detail. We report the number of observations, the mean responses and standard deviations, and the minimum and maximum values. 32% of the sample reported poor health, and 72% of the sample had one or more diagnosed chronic conditions. The prevalence for specific health conditions ranges from 5% for stroke and 42% for hypertension. For functional status, 14% reported having one or more ADL limitations, while 11% reported having one or more IADL limitations. Our key independent variable "*years of education*" ranges from no education to 25 years of education with a mean of 11.13 years with a standard deviation of 3.91. The average age of the sample is 66 years old ranging from 50 years to 89 years and 46% of respondents are male.

Insert Table 1

[9] The measure of "psychiatric illness" in SHARE is different from those in HRS and ELSA. In HRS and ELSA there is a question of "Have you ever had or has a doctor ever told you that you had any emotional, nervous, or psychiatric problems?" In SHARE the closest measure is from the question of "Has there been a time or times in your life when you suffered from symptoms of depression which lasted at least two weeks?

2.1.2. Health and Education: Table 2 shows the unadjusted prevalence of health outcomes by education and by country. For ease of presentation, we recode years of education into three categories - tertiary, secondary, and primary or less- based on educational system in each country. "Tertiary" indicates the category with the highest level of education, while "primary" indicates the category with the lowest level of education. In the first column, we list the percentage reporting "*poor health*." In all countries, there is a clear gradient for the relationship between education and poor health, with those in the highest level of education reporting better health than those in the middle category, and these reported better health than those in the lowest category. The second column shows the percentage of people with any chronic condition. Americans report higher levels of chronic disease than Europeans. England, Germany, Spain, Italy, France, Denmark, Poland, Czech Republic and Belgium report higher levels of chronic disease than the other European countries. Countries with larger gradients in reporting conditions by education are the U.S., England, Greece, Italy, Austria, Spain, Poland and Czech Republic and Germany. In columns 5 to 12, we show the prevalence of specific health conditions. The three most prevalent conditions are hypertension, arthritis and heart disease. Americans, English and Danish report higher percentages of cancer, arthritis and lung disease than other countries in each education category. Americans, Polish and Czech report higher percentages of diabetes in each educational category than the rest of the countries. For hypertension, arthritis, heart disease and lung disease, low-educated reported higher percentages than high-educated in every country. For diabetes, the percentages are higher in low-educated relative to high-educated in twelve out of the fifteen countries, with the exception of Switzerland, in which the low-educated have a prevalence of 7 percent while the high-educated have a prevalence of 8 percent. For cancer, the prevalence is higher in high-educated respondents, relative to that in low-educated, for four out of the fifteen countries. For stroke, the prevalence is higher in low-educated relative to that in high-educated in all countries with the exception of Poland, where the prevalence of the low-educated is 7 percent while the prevalence of the high-educated is 9 percent. Finally, the patterns of self-reported psychiatric illness by education differ by country. In England, Sweden, France, Denmark, Switzerland and the Czech Republic, the higher-educated individuals report more psychiatric illness than the rest of the countries where the proportions are closer between different levels of education.

Columns 3 and 4 show the percentages of people with difficulties for I(ADLs). All countries present very high proportions of low-educated individuals with I(ADLs) difficulties compared to the middle-educated and high-educated ones. In particular, these differences are larger in England, the U.S., Poland and Denmark. We are aware that self-reported health could be subject to different measurement errors (see Jürges, 2007). In our empirical analysis later, we will deal with this by controlling for country specific effects, and cluster the standard errors at the birth year - country level.

Insert Table 2

Table 3 shows the correlations between health and years of education without adjustment for other variables. Our results are in line with the literature. There is a negative correlation between poor health and years of education. All the correlation coefficients are statistically significant at the 1% level. The more educated are less likely to report poor health, any chronic condition, or any ADL or IADL limitations. One exception is the positive correlation of having cancer with education. At least one previous study also found the positive association between education and cancer (Cutler, et al. 2008). Possible explanations are that more educated people are likelier to visit the doctors and are diagnosed earlier, survive longer, or have specific risk factors related to years of education, like late childbearing among women. The correlation between self-reported health and years of education is stronger than the relationships between education and other outcomes.

Insert Table 3

2.2. Compulsory schooling laws and Education

To examine the causal relationship between education and health, we use the cross-country variation in compulsory schooling laws over time as instruments for years of education. Our hypothesis is that different compulsory schooling laws can affect education differently across birth cohorts and across countries in an exogenous way, given that the laws can change by time and/or by country. Since individuals in our sample are aged 50 years and older, we consider compulsory schooling laws that would impact individuals born between year 1905 and year 1955. For nine out of the fifteen countries in our analysis, there was a nationwide change in compulsory schooling law for cohorts born between years 1905 and 1955. For the other countries, there was either no such law change or the change varied geographically within a country. We obtain the information from different data sources. In England, the 1944 Education Act raised the minimum school leaving age from 14 to 15, for cohorts born in Apr 1933 or later (Oreopoulos 2006; Jürges, et al. 2013; Silles 2009); In France, minimum school leaving age was raised from 13 to 14 for those born after 1923 (Albouy and Lequien 2009); Information on compulsory schooling and reforms for Austria, Greece, Italy, Netherlands and Sweden was obtained from a paper by Murtin and Viarengo (2007). In Denmark, the schooling reform in 1958 reduced barriers to education and improved education attainment beyond seven years, especially for children from less educated background or countryside. Although the compulsory attendance remained to be 7 years and wasn't raised to 9 years until the 1975 reform, there have been studies documenting that the 1958 reform raised education achievement in Denmark (Arendt 2005), and we assume that the reform in 1958 is equivalent to one-year increase in compulsory attendance. Finally, in Czech Republic the compulsory schooling age was 8 years from 1869. With the education reform in 1948, the compulsory schooling age raised to 9 years (Filer et al. 1999). Five other countries are assumed to have no compulsory schooling law changes that would affect the birth cohorts from 1905 to 1955. For Switzerland, Belgium and Spain, the documented compulsory education reforms took place in 1970 or later and did not affect cohorts in our sample. The compulsory education reform for Poland was in the 1960 and small sample was affected in our sample. For Germany and the United States, education reforms varied across geographic areas within the country and we are not able to define a beginning date for a nationwide reform in compulsory schooling law.

Table 4 reports the average years of education by country, for those aged 50 and over using our sample. The table also shows the years of compulsory attendance required before and after compulsory schooling law changes for each country, as well as the first birth cohort that were subject to compulsory schooling law changes. The average years of education for aged 50 and over are lowest in Spain (7.41 years), and highest in Denmark (13.07 years).

Insert Table 4

In Figure 1, we draw the reduced-form relationship between compulsory schooling law changes and one of the health outcomes, i.e., “poor health.” We pool the data from the ten countries with law changes and calculate the proportion reporting poor health by birth cohort, for individuals born 5 years before or after the first cohort affected by law changes, adjusting for gender, cohort and country. There is a sharp reduction in the proportion reporting poor health for the cohorts affected after the year of reform and the downward shift persists after that year.

Insert Figure 1

3. EMPIRICAL STRATEGY

We first model the effect of education on different health outcomes using a Probit model. $H_{j,i}$ indicates health outcome j, a binary measure, for an individual i, $H_{j,i}$ takes the value of 1 if the underlying latent variable, $H^*_{j,i}$, is positive and zero otherwise. Ed_i represents education for the individual, measured as years of education obtained. X_i contains a set of demographic variables: gender, birth cohort dummies for nine age groups, and country. Pooling the three data sets, we estimate the latent variable $H^*_{j,i}$ for all health outcomes. For example, we estimate the probability that an individual is in "poor health" or the probability that an individual has any chronic disease using the following model:

$$H^*_{j,i} = \alpha_j + Ed_i\beta_j + X_i\gamma_j + \varepsilon_j$$

$$H_{j,i} = I(H^*_{j,i} \geq 0) \qquad (1)$$

where ε_j is a random error that is normally distributed.

However, we know that education can be endogenous. As mentioned in the introduction, different factors can drive this endogeneity, such as reverse causality or unobserved heterogeneity. This potential endogeneity can be addressed with an instrumental variable Probit model. The relationship between health and education can be estimated in a two-equation model, taking into account the possibility that education might be endogenous. The set of equations (2) is equivalent to the estimation (1) above. In equation (3), we model education as a function of a set of control variables, X_i, as well as Z_i, which is the minimum years of education required for a given individual and varies by country and birth cohort.

$$H^*_{j,i} = \alpha_j + Ed_i\beta_j + X_i\gamma_j + \varepsilon_j$$

$$H_{j,i} = I(H^*_{j,i} \geq 0) \quad (2)$$

$$Ed_i = \theta + X_i\lambda + Z_i\phi + \nu_j \quad (3)$$

ε_j, ν_j are random errors that are normally distributed. The key coefficient of interest is β_j. If education is exogenous, the Probit estimation of equation (1) generates an unbiased estimation of β_j. However, education might be endogenous. We therefore use an instrumental variable approach to estimate β_j. The variable, Z_i, minimum years of education required, is the instrument. Since we control for country and birth cohort in both stages of the model, the effect of Z_i on Ed_i is estimated after taking into account the country- and cohort-specific effects. For this instrument to be feasible and valid, it should be positively correlated with years of education. In addition, Z_i should not affect health outcomes other than through its effect on years of education. This cannot be directly tested as we only have one instrument[10]. However, it is a reasonable assumption if there were no co-occurrence factors that affected both compulsory schooling law changes and health. The use of compulsory school law changes from multiple countries reduces the possibility of such co-occurrence. Our empirical strategy is very similar to the one that Lleras-Muney (2005) does for the USA. We use the compulsory schooling minimum age laws across different countries and we analyze the effects of these changes on education and different health outcomes. We study the different variability between countries where education

[10] In the case of multiple instruments we can apply an over-identification test.

reforms were implemented compared to other countries where none reform was done as control groups.

We then first estimate a Probit model based on equation (1) for each health outcome. For the instrumental variable approach, we jointly estimate (2) and (3) using maximum likelihood and assume ε_j, ν_j are multivariate normal with correlation coefficient ρ_j. We then test whether ρ_j is statistically different from zero. If the test is statistically significant, we may reject the null hypothesis that the education variable is exogenous. If the test is not significant, then we cannot reject the null hypothesis and the multivariate Probit model estimates based on (1) is appropriate and might give smaller standard errors. All analysis is conducted using Stata Statistical Software, release 11.0, Special Edition (Stata Corporation, College Station, TX). Probit and IV-Probit models are estimated using the "probit" and "ivprobit" commands in Stata. The "ivprobit" command estimates " atanh" of ρ_j instead of ρ_j: $a\tanh(\rho_j) = \ln((1+\rho_j)/(1-\rho_j))$. While the range for ρ_j is (-1, 1), $a\tanh(\rho_j)$ varies from negative infinity to positive infinity, which eliminates the need for adding a constraint to the estimation. To test exogeneity of education, we test whether $a\tanh(\rho_j)$ is statistically different from zero.

4. RESULTS

4.1. Health and Education across countries

As we have shown in the previous sections there is much evidence in the literature about the strong correlation between health and education. We first estimate model (1) to replicate this evidence across countries and using HRS, ELSA and SHARE data sets. Main results are reported in Table 5 for different health outcomes. The table provides the marginal effects of years of education on health. The coefficients are all negative and significant at the 5% level, meaning that more education is associated with lower probability of having health problems. The only exception is cancer, for which the coefficient is positive and significant, as noted in the unadjusted results. For SRH, each additional year of schooling is associated with a 2.8 percentage-point reduction in reporting poor health. Each additional year of schooling is also associated with 1 percentage point reduction in having ADL or IADL limitations. As for chronic conditions, the marginal effects range from 1.2 percentage points reduction for arthritis, 0.8 percentage points reduction for diabetes, 0.16 percentage points reduction for stroke, and 0.2 percentage point increase in cancer. All models control for gender and birth cohort. In addition, country dummies are included in all specifications to account for institutions and cultural differences. The completed tables are available upon request to the authors.

Insert table 5

4.2. Causal Relationship between Health and Education

We next turn to instrumental variable estimation to examine the effects of education and health. Table 6 shows the first- and second-stage estimations for each of the binary health outcomes. Marginal effects and robust standard errors are displayed.

The first-stage estimation is a linear regression of the individual's years of education against minimum years of education required by compulsory schooling laws, controlling for gender, birth cohort, and country. The estimate is statistically significant at the 1% level. Raising minimum years required of education by one year increased the average years of education by 0.35 years (around 4 months).

Insert table 6

The second-stage estimation is a Probit model of a health outcome against years of education, gender, birth cohort, and country. The results are mixed for the second-stage estimates.

For three of the twelve health outcomes, i.e., poor health, diabetes, and hypertension, the effect of education remains negative. For poor health, the results are significant at the 1% level, for diabetes, they are significant at the 5% level, and for hypertension, they are not significant. For cancer, the effect of education is positive and statistically significant at the 1% level. The magnitudes of point estimates are much larger using IV estimation. For example, the marginal effect of education on the probability of reporting poor health increases from 2.8 percentage points to 6.26 percentage points and functional status both ADL and iADLs from 1 percentage point to 3.2 percentage points, non-negligible effects. The changes in estimates for the outcomes of cancer and diabetes are more dramatic. It is not uncommon that IV estimates are larger, probably due to heterogeneous treatment effects or measurement errors in reported years of education (Card 2001). Exogeneity tests for self-reported poor health, ADL and iADLs and cancer outcomes are all statistically significant at the 1% level, while diabetes outcomes are significant at the 5% level, meaning that for these outcomes we can reject the null hypothesis that education is an exogenous variable.

For the other seven outcomes, the effects are no longer significant. However, exogeneity tests for those seven outcomes are insignificant, meaning there is no sufficient evidence to consider education as an endogenous variable in the analysis.

4.3. Robustness

We have replicated our analysis with different specifications for age, using age and age quadratic instead of birth cohort dummies. The results were robust. We have controlled for additional socioeconomic variables as we described in section 2.1, including employment status, marital status, and household size. The coefficients are a bit smaller in magnitude but qualitatively similar.

In another set of regressions, we controlled for whether parents are alive at the interview in both the Probit and IV-Probit models. The rationale is that parent's survival reflects family background and genetic factors, which could be correlated with both education and health. The results for the Probit and IV-Probit models are qualitatively unchanged.

We have done other checks. The results are also robust if we include two instruments adding the minimum compulsory schooling age quadratic. We have also done regressions with Linear Probability models with compulsory schooling laws as instrumented. We find the effect of education on diabetes was no longer statistically significant, while other estimates were qualitatively unchanged.

We also extent our analysis to health behaviors as ever smoke, currently smoking and obesity. Probits and OLS regressions for smoke measures were positive and significant with years of education and for obesity was negative. However, the IV-Probits and the linear probability models with compulsory schooling laws as instruments were no longer statistically significant. We then cannot state a causal relationship between health behavior and education. This can be due to the mature and elderly sample, e.g. social smoking has a different stigma now as some decades ago and both educated and non-educated people used to smoke.

5. CONCLUSION

This paper studies the causal relationship between health outcomes and education. We combine three surveys that include nationally representative samples of aged 50 and over from fifteen OECD countries. We use differences in educational reform across these countries as an instrument for education. We found that more years of education lead to lower probability of reporting poor health and functional status (ADL and iADLs) and lower prevalence for diabetes. These effects are larger than the Probit estimates alone. The causal relationship between education and several other chronic conditions, i.e., heart disease, hypertension, lung disease, stroke, arthritis, and psychiatric illness, is statistically insignificant but not different from Probit estimates. Both Probit and IV estimates show that more education leads to higher rates of cancer. The relationship between education and reporting poor health and functional status are very robust and most likely to be causal. The relationship between education and diagnosed chronic conditions is more uncertain and requires further investigation. Our analysis focuses on health outcomes but an extension is to examine whether compulsory schooling laws can affect life expectancy through the education.

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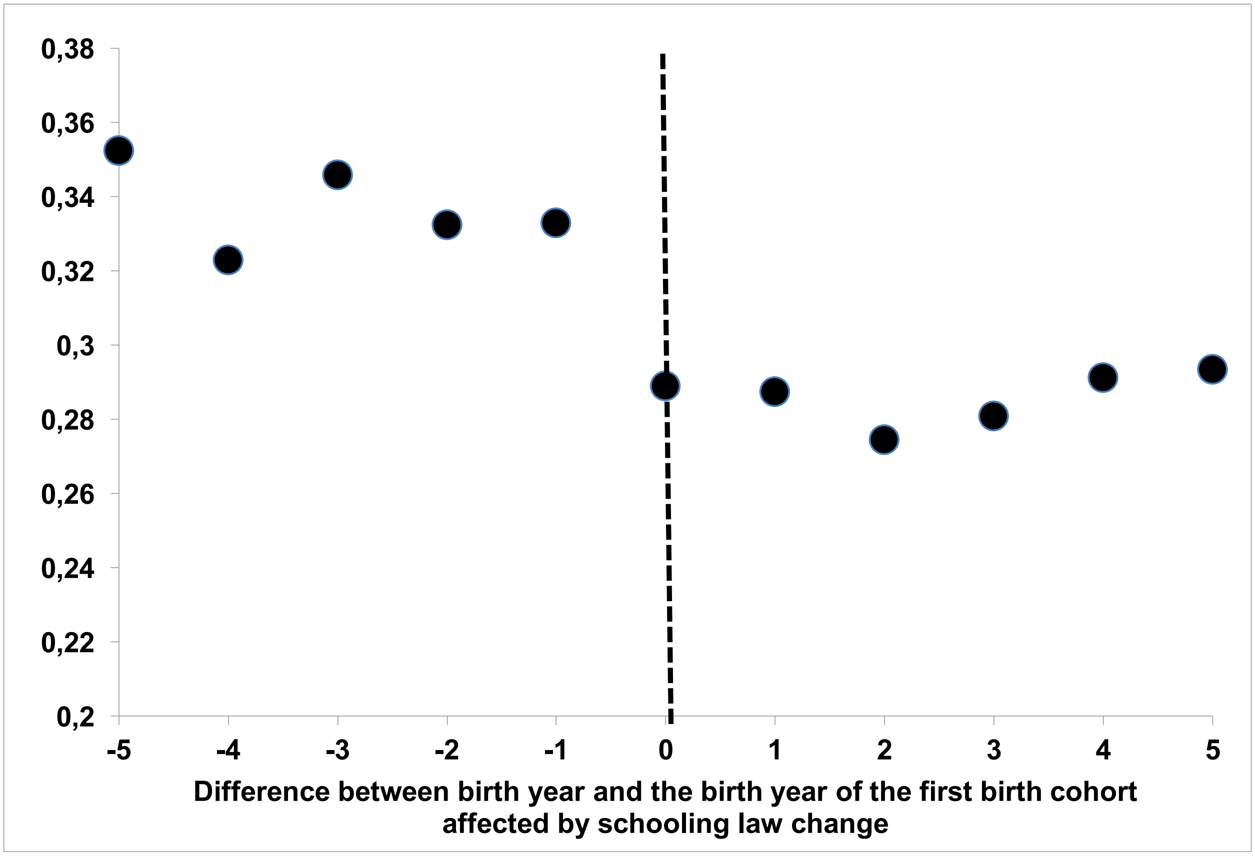
Figures

Figure 1. Adjusted proportion of reporting poor health by birth cohorts



Average proportion of reporting poor health is based a Probit regression of self-reported poor health against gender, birth cohort dummies, country dummies. The sample includes individuals born five years before and after the birth cohort affected by schooling law change.

Data source: HRS wave 10, ELSA wave 3, SHARE wave 2

Data weighted by sampling weight

Tables

Table 1. Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Health variables					
Poor health	56800	0.32	0.46	0	1
1+ Chronic illness	56942	0.72	0.45	0	1
1+ ADLs	56815	0.14	0.34	0	1
1+ IADLs	56814	0.11	0.32	0	1
Cancer	56768	0.08	0.27	0	1
Diabetes	56821	0.13	0.34	0	1
Heart disease	56820	0.18	0.38	0	1
Hypertension	56836	0.42	0.49	0	1
Arthritis	56830	0.36	0.48	0	1
Lung disease	56823	0.07	0.26	0	1
Stroke	56832	0.05	0.22	0	1
Psychiatric illness	56688	0.16	0.37	0	1
SES variables					
Years of education	55381	11.13	3.91	0	25
Age	56942	66.01	10.50	50	89
Cohort	56942	3.76	1.96	1	8
Male	56942	0.46	0.50	0	1
Marital status	55294	1.55	0.92	1	4
Employment status	56570	0.31	0.46	0	1
Household size	56942	2.18	1.05	1	14
Family background					
Mother alive	55340	0.08	0.27	0	1
Father alive	55203	0.20	0.40	0	1

Data source: HRS wave 10, ELSA wave 3, SHARE wave 2

Data are weighted by sampling weight (normalized by country)

Table 2. Health outcomes by levels of education and by country

		Poor health	1+ Chronic illness	1+ ADLs	1+ IADLs	Cancer	Diabetes	Heart disease	Hypertension	Arthritis	Lung disease	Stroke	Psychiatric illness
		(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
England	*High*	16%	65%	8%	4%	8%	7%	17%	36%	25%	3%	2%	12%
	Medium	25%	69%	14%	8%	7%	8%	20%	40%	33%	5%	4%	11%
	Low	43%	81%	26%	18%	9%	12%	26%	51%	46%	10%	7%	10%
United	*High*	16%	80%	10%	8%	13%	15%	20%	48%	51%	7%	6%	16%
States	*Medium*	28%	88%	15%	13%	13%	19%	25%	57%	62%	12%	7%	18%
	Low	52%	91%	27%	25%	16%	28%	31%	65%	68%	15%	12%	24%
Austria	*High*	20%	45%	6%	4%	2%	8%	8%	27%	7%	2%	3%	6%
	Medium	30%	57%	9%	6%	3%	10%	10%	36%	15%	4%	2%	10%
	Low	48%	66%	18%	20%	2%	15%	16%	39%	19%	7%	4%	14%
Germany	*High*	28%	57%	7%	3%	5%	8%	11%	35%	10%	5%	3%	15%
	Medium	41%	63%	11%	8%	4%	13%	12%	38%	14%	6%	4%	15%
	Low	60%	70%	20%	20%	5%	20%	14%	44%	18%	6%	5%	16%
Sweden	*High*	17%	51%	3%	1%	6%	4%	11%	23%	10%	1%	3%	18%
	Medium	29%	55%	6%	5%	5%	9%	12%	30%	10%	4%	4%	13%
	Low	36%	64%	13%	10%	6%	11%	20%	38%	12%	4%	5%	13%
Netherland	*High*	20%	49%	5%	5%	5%	6%	7%	21%	7%	4%	2%	17%
	Medium	25%	55%	4%	3%	4%	7%	10%	23%	12%	5%	3%	20%
	Low	37%	62%	10%	9%	4%	13%	11%	31%	12%	8%	5%	18%
Spain	*High*	22%	54%	2%	1%	3%	7%	3%	30%	17%	4%	0%	17%
	Medium	22%	52%	4%	3%	1%	10%	3%	23%	15%	5%	1%	17%
	Low	52%	70%	14%	11%	2%	16%	10%	36%	32%	7%	3%	26%
Italy	*High*	17%	48%	5%	5%	5%	1%	8%	27%	10%	3%	1%	12%
	Medium	30%	58%	5%	4%	4%	8%	9%	32%	21%	3%	2%	16%
	Low	53%	75%	14%	13%	3%	14%	13%	45%	40%	9%	4%	20%

To be continued on next page

Table 2. Health outcomes by levels of education and by country, continued

		Poor health (1)	1+ Chronic illness (2)	1+ ADLs (3)	1+ IADLs (4)	Cancer (5)	Diabetes (6)	Heart disease (7)	Hypertension (8)	Arthritis (9)	Lung disease (10)	Stroke (11)	Psychiatric illness (12)
France	*High*	19%	59%	4%	2%	5%	4%	9%	19%	16%	2%	2%	28%
	Medium	31%	65%	8%	5%	5%	9%	8%	28%	24%	4%	1%	23%
	Low	45%	69%	14%	14%	5%	11%	15%	31%	30%	6%	4%	21%
Denmark	*High*	16%	61%	5%	5%	6%	4%	9%	28%	24%	4%	3%	21%
	Medium	25%	66%	7%	6%	7%	9%	11%	35%	27%	7%	5%	18%
	Low	39%	75%	15%	19%	7%	10%	17%	39%	36%	11%	9%	19%
Greece	*High*	9%	40%	3%	3%	2%	7%	6%	22%	6%	1%	2%	7%
	Medium	16%	49%	3%	2%	2%	8%	7%	28%	11%	2%	1%	10%
	Low	34%	66%	9%	8%	2%	13%	14%	41%	23%	5%	3%	11%
Switzerland	*High*	12%	46%	5%	2%	3%	8%	7%	22%	8%	3%	2%	19%
	Medium	14%	52%	4%	2%	5%	5%	4%	26%	11%	3%	2%	16%
	Low	26%	56%	10%	7%	4%	7%	9%	33%	13%	3%	4%	12%
Belgium	*High*	20%	60%	8%	4%	4%	8%	10%	32%	21%	4%	2%	15%
	Medium	25%	61%	8%	4%	3%	7%	12%	32%	21%	4%	2%	14%
	Low	37%	67%	17%	13%	4%	11%	15%	37%	26%	7%	4%	16%
Czech R.	*High*	29%	74%	6%	1%	4%	11%	10%	40%	10%	2%	6%	41%
	Medium	37%	70%	7%	4%	4%	13%	11%	43%	14%	4%	4%	34%
	Low	52%	77%	9%	9%	5%	16%	17%	45%	19%	6%	5%	33%
Poland	*High*	42%	66%	11%	7%	4%	10%	20%	42%	20%	6%	9%	20%
	Medium	55%	69%	16%	9%	3%	9%	16%	38%	29%	4%	4%	21%
	Low	74%	79%	32%	26%	2%	14%	25%	48%	41%	6%	7%	20%

Data source: HRS wave 10, SHARE wave 2, and ELSA wave 3

Data are weighted by sampling weight (normalized by country)

Table 3 Correlation coefficients of years of education and health outcomes

Poor health	1+ Chronic illness	1+ ADLs	1+ IADLs	Cancer	Diabetes
-0.249	-0.0479	-0.1186	-0.1255	0.0595	-0.06
Heart disease	Hypertension	Arthritis	Lung disease	Stroke	Psychiatric illness
-0.0338	-0.0459	-0.0176	-0.05	-0.0218	-0.0169

All Spearman correlations are significant at 1%

Data source: HRS wave 10, ELSA wave 3, SHARE wave 2

Data weighted by sampling weight (normalized by country)

Table 4. Average years of education and minimum years of education required before and after compulsory schooling law changes, by country

Country	AVG. Years of Education	Minimum years of education required before compulsory schooling law change	First birth cohort affected by compulsory schooling law change	Minimum years of education required after compulsory schooling law change
Austria	8,58	8	1949	9
England	10,80	9	1933	10
Sweden	11,19	8	1936	9
Netherland	11,05	6	1938	8
Italy	7,92	5	1952	8
France	11,18	7	1923	8
Denmark	13,07	7	1946	8
Greece	8,36	6	1952	9
Czech R.	12,21	8	1935	9
Poland	9,08	7	No nationwide compulsory schooling law change	
Switzerland	11,20	8	No nationwide compulsory schooling law change	
Belgium	11,67	8	No nationwide compulsory schooling law change	
Germany	12,29	8	No nationwide compulsory schooling law change	
Spain	7,41	7	No nationwide compulsory schooling law change	
United States	12,85	8,42	No nationwide compulsory schooling law change	

Average years of education are from HRS, ELSA and SHARE weighted data (normalized by country). Information on minimum years of education required and compulsory schooling law changes is mainly obtained from Murtin and Viarengo (2007), with the following exceptions: for Britain, the compulsory schooling law and changes have been described in several papers including Jürges (2009); for Denmark, the information comes from Arendt (2005) and Murtin and Viarengo (2007); for France, the compulsory law reform was described in Albouy (2009); for Czech Republic, the information comes from Filer et al. (1999); for the United States, compulsory schooling laws varied by States and changed at different points in time from years 1915 to 1939, as described in Lleras-Muney (2005). We calculated the average minimum years of education across all countries during this period, based on the dataset of "Compulsory Attendance and Child Labor State Laws", provided by Adriana Lleras-Muney on her website: http://www.econ.ucla.edu/alleras/research/data.html

Table 5. Probit models of years of education on health outcomes (Coefficients reported as marginal effects)

	Poor health	1+ Chronic illness	1+ ADLs	1+ IADLs	Cancer	Diabetes	Heart disease	Hypertension	Arthritis	Lung disease	Stroke	Psychiatric illness
Years of education	-0.0278***	-0.008***	-0.010***	-0.0097***	0.002***	-0.008***	-0.0045***	-0.0098***	-0.012***	-0.0054***	-0.0016***	-0.0037***
	(0.00128)	(0.00071)	(0.00061)	(0.00047)	(0.00036)	(0.00052)	(0.0005)	(0.00080)	(0.00085)	(0.00038)	(0.00027)	(0.00071)
Number of observations	55 259	55 381	55 295	55 294	55 252	55 303	55 302	55 318	55 313	55 306	55 315	55 186

*** p<0.01, ** p<0.05, * p<0.1

Robust standard errors in parentheses, clustered at birth year-country level

All models control for gender, cohort dummies, and country dummies

Data source: HRS wave 10, SHARE wave 2, and ELSA wave 3

Data are weighted by sampling weight (normalized by country)

Table 6. IV-Probit models of years of education on health outcomes (Coefficients reported as marginal effects)

	Poor health	1+ Chronic illness	1+ ADLs	1+ IADLs	Cancer	Diabetes
First stage: dependent variable is years of education						
Minimum years of schooling required	0.356***	0.355***	0.354***	0.354***	0.354***	0.355***
	(0.048)	(0.048)	(0.048)	(0.048)	(0.048)	(0.048)
Second stage						
Years of education	-0.0626***	-0.0059	-0.0318***	-0.0415***	0.025***	-0.0256**
	(0.0067)	(0.038)	(0.009)	(0.0112)	(0.0115)	(0.040)
Exogeneity test						
α tanh (ρj)	-0.0626***	-0.0059	-0.0318***	-0.0415***	0.025***	-0.0256**
	(0.0067)	(0.038)	(0.009)	(0.0112)	(0.0115)	(0.040)
N.obs.	55381	55295	55294	55294	55252	55303
	Heart disease	**Hypertension**	**Arthritis**	**Lung disease**	**Stroke**	**Psychiatric illness**
First stage: dependent variable is years of education						
Minimum years of schooling required	0.355***	0.355***	0.355***	0.355***	0.355***	0.352***
	(0.048)	(0.048)	(0.048)	(0.048)	(0.048)	(0.047)
Second stage						
Years of education	-0.0071	-0.0122	0.012	-0.0073	0.004	-0.0017
	(0.011)	(0.0129)	(0.0143)	(0.0076)	(0.0082)	(0.0076)
Exogeneity test						
α tanh (ρj)	-0.0071	-0.0122	0.012	-0.0073	0.004	-0.0017
	(0.011)	(0.0129)	(0.0143)	(0.0076)	(0.0082)	(0.0076)
N.obs.	55302	55318	55313	55306	55315	55186

*** $p<0.01$, ** $p<0.05$, * $p<0.1$. Robust standard errors in parentheses, clustered at birth year-country level. All models control for gender, cohort dummies, and country dummies. Data source: HRS wave 10, SHARE wave 2, and ELSA wave 3. Data are weighted by sampling weight (normalized by country)