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Short communication

## The Education-health Nexus: Fact and fiction

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## ABSTRACT

This paper examines the link between schooling and health. We provide new evidence on the relationship between formal schooling completed and several aspects of health by using Finnish twin data matched to individual information on schooling. Health is measured in 1990 (and 1981). Schooling is defined using comprehensive register-based information. All models account for initial health endowment in 1975. The sample sizes vary from 2542 to 4402 identical twins, depending on the specification. Using twin design, we find that unobserved family and genetic factors drive the cross-sectional correlations between schooling and many health measures, especially for females. Our within-MZ twin results for males show that high school (or vocational) or lowest level tertiary education reduces BMI and medication use. High school (or vocational) or university graduated males also exercise more than males who have completed primary education only. Given that high school or basic tertiary education have the strongest positive health effects for males, our results suggest that policies that prevent secondary school dropout alone may yield social benefits in the form of better health.

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## 1. Introduction

Since Grossman's (1972) article on the health effects of schooling, empirical literature on this issue has emerged (Cutler and Lleras-Muney, 2008; Eide and Showalter, 2011; Grossman, 2006, 2015). In this research, several measures of health have been used, including self-assessed health, age-adjusted mortality and health inputs such as smoking and alcohol consumption. This variability stems from data availability and also reflects the fact that health is composed of various aspects. The literature provides a uniform picture: higher schooling is significantly positively correlated with health.

There are many pathways through which schooling may affect health (Cutler and Lleras-Muney, 2008). For instance, schooling is related to the general level of information, the ease of adopting new information, and valuable personal characteristics such as self-control, position in work, and wealth level. A higher social rank may reduce stress and thereby alleviate mental health problems (e.g., Reading and Reynolds, 2001).

This paper examines the consequences of schooling on health

using twin data. The identification of the effect of schooling on health is difficult because there are unobservable factors that are correlated with both schooling and health. Thus, the cross-sectional estimates are likely to be biased. The use of MZ (monozygotic) twin data makes it possible to account for both shared environmental factors and genetic factors.

Previous studies have used twin data to estimate how schooling is related to health (Amin et al., 2015; Behrman et al., 2011, 2015; Fujiwara and Kawachi, 2009; Gerdttham et al., 2015; Lundborg, 2013; Webbink et al., 2010). The positive relationship between schooling and health weakens considerably or becomes statistically insignificant with the MZ-twin control of unobserved factors.

We contribute to the literature in four ways. First, we focus on the effects of the level of schooling, which allows us to examine the nonlinear relationships. Schooling is defined using register data, following ISCED (International Standard Classification of Education), making our results internationally comparable.

Second, we use comprehensive measures of health inputs and outcomes, which allows us to identify the heterogeneity in the effects. These measures also capture mental health. The potential protective effect of schooling on mental health has not been investigated, although mental health is a crucial aspect of an individual's overall health (Layard, 2013).

Third, we control for the individual's initial health endowment.

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This point is particularly important because it allows us to address the two-way causality between schooling and health. Fourth, our twin data are a nationally representative sample of all Finns (Hyytinen et al., 2013; Maczulskij, 2013).

## 2. Data and methods

### 2.1. Data sources and the sample

The twin data we use is the Older Finnish Twin Cohort Study (of the Department of Public Health in the University of Helsinki), which was compiled from the Central Population Registry of Finland. The initial candidates were persons with the same birth date, community of birth, sex, and surname at birth, born before 1958 (Kaprio et al., 1979). Three surveys were conducted in 1975, 1981 and 1990.

We linked the twin data to the Finnish Longitudinal Employer-Employee Data (FLEED) by using personal identifiers (Hyytinen and Lahtonen, 2013). FLEED is an annual panel for the years 1990–2010 and is constructed from administrative registers of individuals and firms that are collected by Statistics Finland (SF). FLEED includes register-based information on the highest completed schooling level. The record linkages of linked data comply the Data Protection Act and have been approved by the ethical committee of the Department of Public Health, University of Helsinki and SF.

We focus on twin pairs for whom we observe information on schooling, pre-existing health endowment, and health. All health measures come from the 1990 twin survey, except the measure for exercise, which is constructed from the 1981 twin survey. Our sample includes a cohort of twin pairs aged 33–60, and the sample sizes vary from 2542 to 4402 MZ twins. Of these twins, 55% are female.

### 2.2. Variable definitions

Our measure for schooling is based on comprehensive register-based information and captures the highest schooling level completed. Using ISCED classification, we assigned the twins to four categories: Primary education (=completed primary education only, level 1); Secondary education (=completed secondary but not tertiary education, i.e., high school or vocational education, levels 2–4); Lowest level tertiary education (=completed basic tertiary education, level 5B); and Higher degree or above (=completed BA, MA or doctorate or equivalent education, levels 5A and 6). Primary education is the reference group in all models.

We examine the effect of the level of schooling on health inputs and outcomes. The quantity of alcohol consumption is measured by self-reported weekly average consumption. The twin survey gathered information on the frequency of alcohol consumption, as measured by daily consumption per month using a five-point scale (1 = 'never', 5 = 'over 16 days a month'), and separately for various types of alcohol: beer, wine and spirits. The quantities were measured on a seven-point scale for each alcohol type, with upper limits for consumption of more than 48 bottles of beer (10 bottles of wine) per week or more than 20 bottles of spirits per month (Salonsalmi et al., 2012). A unit of alcohol is defined as 12 g of pure alcohol. Alcohol consumption was converted into grams of pure alcohol consumed per week.

Smoking is measured using self-reported retrospective cigarette pack-years; it captures the lifetime consumption of cigarettes. The cigarette pack-years were calculated as follows: average number of cigarettes smoked per day  $\times$  (person's age — age when the person started smoking). This information has been used in previous research (Böckerman et al., 2015; Huovinen et al., 1997).

Leisure time physical activity is measured using the MET index (Metabolic Equivalent Tasks). The MET index was constructed using information including the frequency of participation in sport activities during a typical month (a six-point scale: 1 = 'less than once a month', 6 = 'over 20 times a month'), the intensities of these activities ('light', 'moderate' and 'vigorous'), and the typical amount of time spent performing these activities (a five-point scale: 1 = 'less than 15 min', 5 = 'over 2 h').

BMI is calculated from self-reported height and weight. Schooling may affect both the presence of the diseases and the diagnosis/treatment of them. The twins were asked how many chronic diseases they had in 1990. These diseases included emphysema, chronic obstructive pulmonary disease, high blood pressure, angina pectoris, peptic ulcer, diabetes, and gout. Our measure for medication use is the self-reported sum of heart, hypertensive and antacid medications taken. The use of tranquilizers captures an aspect of mental health. Tranquilizer use has the value of one if the twin reports using a positive amount of tranquilizers. Health is a durable good. Thus, all models control for initial health endowment by using the number of chronic diseases in 1975.

Table 1 reports the descriptive statistics for the sample of all twins and separately for DZ and MZ twins. 43% of MZ twins have completed only primary education, 35% secondary level education, 12% the lowest level tertiary education, and 10% the highest education level. The MZ twins in our sample reported slightly more than one diagnosed disease. They were of normal weight (the mean of BMI = 24.3), consumed on average 62 g of alcohol per week and smoked on average one pack of cigarettes daily for 6 years. A total of 10% of the MZ twins are using tranquilizers. There are differences between genders (not reported). Alcohol consumption and smoking are more prevalent among males, and the fraction of highest educated persons is lower for females. The means of the absolute values of the twin differences show that there is a sufficient amount of within-twin pair variation in the data among MZ twins, which is necessary for model identification. For example, approximately 20% of the observations in the two lowest education level categories differed between MZ twins.

### 2.3. Empirical modeling

Following Amin et al. (2015), we focus on two types of analysis. First, we use Ordinary Least Squares (OLS) to regress our health measures on schooling for a sample of MZ twins:

$$H_{ij} = \alpha + \beta' \mathbf{S}_{ij} + f_j + g_{ij} + \varepsilon_{ij} \quad (1)$$

where  $H_{ij}$  represents the health of twin  $i$  in twin-pair  $j$ ,  $\mathbf{S}_{ij}$  is a vector of schooling levels,  $f_j$  is an unobserved family effect,  $g_{ij}$  is an unobserved genetic effect, and  $\varepsilon_{ij}$  is a random shock. If  $f_j$  or  $g_{ij}$  is correlated with schooling, then the condition  $E[f_j + g_{ij} + \varepsilon_{ij} | \mathbf{S}_{ij}] = 0$  does not hold, and the estimates for  $\beta$  are biased.

As a second type of analysis, we apply the twin differences to all variables before running the regressions. In the within-MZ twins sample, the estimator is consistent if  $E[(f_2 - f_1) + (g_{2j} - g_{1j}) + (\varepsilon_{2j} - \varepsilon_{1j}) | (\mathbf{S}_{2j} - \mathbf{S}_{1j})] = 0$ , where the terms inside the brackets refer to the within-MZ twin differences in variables. As MZ twins share a common family environment ( $(f_2 - f_1) = 0$ ) and are similar in their genetic inheritance ( $(g_{2j} - g_{1j}) = 0$ ), both the unobserved family and genetic effects are differenced out. The twin differences do not reveal a causal effect if there are unobservable factors that affect both schooling and health after accounting for shared family background and genetics (cf. Boardman and Fletcher, 2015). The twin differences control fully for the age and cohort effects, even if they have a complex non-linear effect on health.

**Table 1**  
Descriptive statistics.

	Data source	Mean, all	Mean, DZ twins	Mean, MZ twins	Within-MZ twin differences
<b>Health inputs</b>					
Alcohol use	Twin survey 1990	65.36 [8554]	67.10 [5598]	62.05 [2956]	48.2
Smoking	Twin survey 1990	6.73 [7982]	6.93 [5194]	6.37 [2788]	4.73
Physical activity	Twin survey 1981	2.89 [13322]	2.89 [8920]	2.90 [4402]	2.22
<b>Health outcomes</b>					
BMI	Twin survey 1990	24.54 [8514]	24.69 [5558]	24.26 [2956]	2.04
Number of chronic diseases	Twin survey 1990	1.22 [8648]	1.22 [5662]	1.18 [2986]	0.99
Medication use	Twin survey 1990	0.81 [7260]	0.81 [4718]	0.80 [2542]	0.37
Tranquilizer use	Twin survey 1990	0.09 [7590]	0.09 [4932]	0.10 [2658]	0.13
<b>Education level</b>					
Primary	Statistics Finland (FLEED)	0.46 [16996]	0.46 [11584]	0.43 [5412]	0.19
Secondary	Statistics Finland (FLEED)	0.34 [16996]	0.34 [11584]	0.35 [5412]	0.23
Lowest level tertiary	Statistics Finland (FLEED)	0.11 [16996]	0.11 [11584]	0.12 [5412]	0.12
Higher degree or above	Statistics Finland (FLEED)	0.09 [16996]	0.09 [11584]	0.10 [5412]	0.07
<b>Health endowment</b>					
Number of chronic diseases	Twin survey 1975	0.66 [16996]	0.66 [11584]	0.64 [5412]	0.64

Notes: Sample sizes reported in square brackets. Within-MZ twin differences: the means of the absolute values of the twin differences in the MZ sample.

### 3. Results

The cross-sectional OLS estimates for MZ males show that higher schooling is statistically significantly correlated with better health (Table 2). This pattern is similar for health inputs and outcomes, excluding our measure for mental health, for which the

**Table 2**  
Cross-sectional and within MZ-regressions of schooling level and health: bivariate regressions for males.

	Cross-section, MZ (1)	Within MZ twins (2)
<b>Alcohol use</b>		
Secondary	-6.044 (7.853)	2.897 (9.872)
Lowest level tertiary	22.473 (11.899)*	-1.135 (13.666)
Higher degree or above	15.287 (11.956)	-23.863 (24.171)
N	1202	601
<b>Smoking</b>		
Secondary	-2.921 (1.155)**	-0.372 (1.465)
Lowest level tertiary	-3.463 (1.528)**	0.320 (1.824)
Higher degree or above	-7.974 (1.185)***	-2.371 (2.515)
N	1136	568
<b>Physical activity</b>		
Secondary	0.452 (0.221)**	0.885 (0.326)***
Lowest level tertiary	0.769 (0.325)**	0.700 (0.469)
Higher degree or above	1.008 (0.321)***	1.031 (0.511)**
N	1916	958
<b>BMI</b>		
Secondary	-0.706 (0.251)***	-0.456 (0.249)*
Lowest level tertiary	-0.954 (0.367)**	-0.670 (0.329)**
Higher degree or above	-1.031 (0.318)***	-0.184 (0.444)
N	1192	596
<b>Diseases</b>		
Secondary	-0.126 (0.086)	0.007 (0.142)
Lowest level tertiary	-0.232 (0.112)**	0.147 (0.181)
Higher degree or above	-0.264 (0.108)**	0.053 (0.203)
N	1206	603
<b>Medication use</b>		
Secondary	-0.088 (0.048)*	-0.157 (0.078)**
Lowest level tertiary	-0.085 (0.060)	-0.215 (0.086)**
Higher degree or above	0.018 (0.059)	-0.111 (0.121)
N	1064	532
<b>Tranquilizer use</b>		
Secondary	0.007 (0.020)	-0.001 (0.032)
Lowest level tertiary	-0.035 (0.023)	-0.001 (0.039)
Higher degree or above	0.016 (0.028)	-0.017 (0.064)
N	1100	550

Notes: The reference group consists of those who have only primary education. Heteroscedasticity-robust standard errors are reported in parenthesis. The sample size varies by specification and health outcome. All models control for initial health endowment using the number of chronic diseases in 1975. \*\*\* ( $p < 0.01$ ), \*\* ( $p < 0.05$ ), \* ( $p < 0.10$ ).

results do not reveal a significant relationship. For example, higher schooling reduces smoking, BMI and the number of chronic diseases and increases exercising. This pattern accords well with previous research.

The within-MZ twin estimates show that many of the cross-sectional correlations between schooling and health diminish and become statistically insignificant. Interestingly, we observe that males with a high school (or vocational) or lowest level tertiary education have an average BMI 0.5–0.7 units lower than males who have completed primary education only. The same schooling levels also reduce medication use. The total number of medicines used is 0.16–0.22 units lower for males with secondary or lowest level tertiary education compared to males with primary education. Higher schooling is also positively related to exercise. Both high school (or vocational) and university completion increases the MET index by ~1.0, which is roughly equivalent to the change in energy expenditure from sitting to slow walking, or from jogging to running (cf. Ainsworth et al., 2000).

The within-MZ estimates show larger negative effects on medication use than the cross-sectional estimates. Behrman et al. (2015) found a similar pattern for some health measures. Our results suggest that unobserved family or genetic endowments are positively correlated with medication use.

The cross-sectional OLS estimates for MZ females in Table 3 show a similar pattern that was observed for MZ males in Table 2. The most interesting exceptions are that both alcohol consumption and medication use are at the highest level for females with the highest educational attainment. The preferred within-MZ twin estimates reveal no relationship between schooling and health. We find that only the number of chronic diseases is marginally lower for females with the lowest level tertiary education.

### 4. Conclusions

This paper used twin data linked to register-based information on individuals' schooling levels to examine the relationship between schooling and health measures. The use of twin data constitutes a promising approach to examine this policy-relevant topic. First, time and risk preferences are important determinants of schooling choices (Fuchs, 1982). If time-invariant preferences are partially genetically inherited, they are more fully accounted for by using the within-MZ differences. Second, Lundborg (2013) argues that research design based on twin differences identifies the average treatment effect, which is more policy-relevant for a wider

**Table 3**  
Cross-sectional and within MZ-regressions of education level and health: bivariate regressions for females.

	Cross-section, MZ (1)	Within MZ twins (2)
<b>Alcohol use</b>		
Secondary	−3.990 (4.068)	3.559 (3.920)
Lowest level tertiary	−2.677 (4.833)	−0.531 (7.492)
Higher degree or above	15.594 (8.046)*	5.223 (11.861)
N	1754	877
<b>Smoking</b>		
Secondary	−1.232 (0.570)**	0.330 (0.705)
Lowest level tertiary	−2.772 (0.643)***	−0.997 (0.838)
Higher degree or above	−3.133 (0.642)***	−0.131 (0.811)
N	1652	826
<b>Physical activity</b>		
Secondary	0.211 (0.124)*	0.144 (0.211)
Lowest level tertiary	0.455 (0.177)**	0.260 (0.304)
Higher degree or above	0.832 (0.211)***	0.448 (0.403)
N	2486	1243
<b>BMI</b>		
Secondary	−1.047 (0.243)***	−0.155 (0.264)
Lowest level tertiary	−1.792 (0.292)***	−0.025 (0.340)
Higher degree or above	−2.411 (0.380)***	−0.147 (0.315)
N	1764	882
<b>Diseases</b>		
Secondary	−0.001 (0.074)	0.057 (0.107)
Lowest level tertiary	−0.268 (0.091)***	−0.280 (0.164)*
Higher degree or above	−0.081 (0.132)	−0.231 (0.225)
N	1780	890
<b>Medication use</b>		
Secondary	−0.060 (0.037)	−0.008 (0.052)
Lowest level tertiary	−0.067 (0.042)	0.003 (0.065)
Higher degree or above	0.077 (0.045)*	0.108 (0.069)
N	1478	739
<b>Tranquilizer use</b>		
Secondary	−0.020 (0.020)	0.029 (0.030)
Lowest level tertiary	−0.039 (0.024)	0.015 (0.040)
Higher degree or above	0.029 (0.036)	0.040 (0.070)
N	1558	779

Notes: The reference group consists of those who have only primary education. Heteroscedasticity-robust standard errors are reported in parenthesis. The sample size varies by specification and health outcome. All models control for initial health endowment using the number of chronic diseases in 1975. \*\*\* ( $p < 0.01$ ), \*\* ( $p < 0.05$ ), \* ( $p < 0.10$ ).

population than the local average treatment effect (LATE) estimated for the compliers using schooling reforms. This requires that twin differences in schooling must be distributed throughout the schooling distribution and that the effect of schooling on the twin sample must be generalizable to the overall population. Lundborg (2013) also argues that within-MZ twin estimates can reflect the LATE if schooling differences within MZ twin pairs are more common among certain types of MZ twin pairs.

Our data have strengths. First, we measured educational attainment using register-based information on the levels of schooling. The literature has typically used the imputed years of schooling from surveys that may contain (classical) measurement error, which attenuates the estimated effects of schooling on health. Second, we controlled for the initial health endowment in 1975, which addresses the two-way causality between schooling and health.

We find that unobserved family and genetic factors drive the cross-sectional correlations between schooling and many health measures, especially for females. Behrman et al. (2011) and Amin et al. (2015) have reported similar patterns. For males we also observe that high school (or vocational) or lowest level tertiary education reduces BMI and medication use. High school (or vocational) or university graduated males also exercise more than males who have completed primary education only. In this respect, our estimates contrast with the results reported by Amin et al. (2015),

whose preferred within-MZ twin estimates indicated that schooling was not associated with BMI or exercise at any level. Lundborg (2013) found similarly no association between different schooling levels and BMI but did report a positive association between higher schooling levels and exercise. The connection between schooling and health is much weaker for females, at least in the Finnish context. Thus, our estimates for females are fully consistent with Amin et al. (2015), who argued for the non-existence of the relationship after accounting for shared family and genetic factors.

The individual health effects of schooling are of considerable importance. If the non-monetary returns of schooling are large, the case for public support for schooling is substantially strengthened. However, schooling is not a “magic bullet” for improving population health, because the effect of schooling on health may not be linear, as some of our measures suggest. Given that high school or basic tertiary education have the strongest positive health effects for males, policies that prevent secondary school dropout alone may yield social benefits in the form of better health. This conclusion is in accordance with the summary of the literature by Lochner (2011), who concluded that the completion of high school causes the strongest non-production benefits of schooling.

#### Declaration of interests

None.

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