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Schooling has smaller or insignificant effects on adult health in the US than suggested by cross-sectional associations: New estimates using relatively large samples of identical twins

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Abstract

Numerous theoretical reasons have been posited about why more schooling might improve health. Adult health outcomes and behaviors generally are significantly *associated* with schooling. However, such associations do not necessarily imply that schooling has causal effects on health outcomes and behaviors. Causal estimates based on schooling variation from policies and from within-MZ (monozygotic) twins have reached mixed conclusions. This study contributed new estimates of cross-sectional associations and within-MZ causal effects using three relatively large US twins samples. The estimates suggested that schooling was significantly associated with numerous health outcomes and behaviors. However, with within-MZ twins control for unobserved factors, schooling was no longer associated with most indicators of better health (with the exception of self-reported health), while it continued to be associated with outcomes such as fertility and spousal schooling. Similar patterns were observed for spousal schooling.

Keywords

Health; schooling; causal effects; identical (monozygotic) twins estimators

Introduction

More-schooled individuals tend to have better adult health outcomes and behaviors. Theoretical models postulate that these associations arise because schooling causally affects

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adult health through several mechanisms (Figure 1): increasing incomes, and thus enabling purchasing better health care (particularly in the US and similar institutional contexts); improving one's rank in society, which is associated with better adult health and reduced stress and poor mental health related to actual and/or perceived social deprivation (Rose & Marmot, 1981); increasing interactions with other more-schooled peers, generating health spillovers (Fletcher 2010); lowering discount rates and extending life expectancies, thereby making individuals more patient and increasing their incentives to engage in healthier behaviors (Becker & Mulligan, 1997); increasing productive efficiency to produce more health from given inputs (Grossman, 1972); and increasing allocative efficiency through selecting inputs better for health production (Grossman 1972). While these mechanisms suggest that schooling improves health, some pathways can operate in the opposite direction. For example, higher earnings caused by more schooling increases opportunity costs of time, which may adversely affect health as many health inputs are time-intensive (e.g., doctor visits, exercising). Yet, most theoretical discussions argue that the pathways resulting in positive effects of schooling on health dominate such adverse possibilities.

Given the multitude of mechanisms through which schooling can potentially affect adult health (Figure 1), schooling and schooling-related socioeconomic differences have been characterized as '***fundamental causes***' of adult health and societal health disparities' (Link & Phlean, 1995).

However, it is important to emphasize that the frequently-observed empirical associations between schooling and health do not necessarily reflect causal relationships postulated by the above theories. These empirical associations could be confounded by unobserved genetic and social endowments at the bottom of Figure 1 such as (parental/own) preferences, abilities, cognitive functioning, parental economic/social resources that jointly affect schooling and adult health. For example, Cutler and Lleras-Muney (2010) found that 20 percent of the schooling-health gradient was driven by cognitive ability. Moreover, there is also possibly reverse causation, insofar as health (particularly early life health) affects schooling (Currie & Stabile, 2006; Royer, 2009).

Several recent studies have used schooling variation arising from policy changes, e.g. compulsory schooling laws, to estimate causal effects of schooling by using such changes as instrumental variables (IV) or employing regression discontinuity (RD) designs (comparing schooling and health outcomes of individuals just before and just after reforms). These studies, summarized below, have found mixed results; large significant effects in some cases and small or insignificant effects in others.

An alternative strategy to using policy-induced schooling variation is to use variation in schooling within MZ (monozygotic; identical) twin pairs. MZ twins share the same genetic makeup and family-rearing environment. By relating twin-pair differences in health to twin-pair differences in schooling, schooling effects on health are estimated controlling for unobserved factors that affect schooling and health of both twins such as the genetic and social endowments in the bottom of Figure 1. In contrast to a substantial literature using twins data from European countries and Australia, only two published studies applied this within-MZ twins approach to US data. Both Fujiwara and Kawachi (2009) and Lundborg

(2013) used 1995 Midlife in the United States Survey (MIDUS) data on 694–701 MZ twins. Both studies found no significant effects of schooling on health outcomes (self-reported health, perceived mental health, number of chronic conditions, body mass index/BMI) and behaviors (smoking, exercise). Lundborg (2013), however, found significant positive impacts of schooling on self-reported health and negative impacts on number of chronic conditions when using dichotomous schooling indicators for high school, some college and college degree instead of continuous schooling measures.

The present study provided more evidence of schooling health-gradients using within-MZ twins methodology and much larger US twin datasets than in MIDUS: the Mid-Atlantic Twin Registry, Minnesota Twin Registry and NAS-NRC Twin Registry of WWII Military Veterans. These new explorations with larger samples permitted assessment of whether the mostly insignificant results reported in the previous US twins studies were in part artifacts of relatively small samples. We found that more schooling was associated cross-sectionally with better health outcomes and behaviors, consistent with much previous literature and most theoretical pathways through which schooling is hypothesized to affect health as discussed above. However, after controlling for unobserved social/genetic endowments in the bottom of Figure 1 through within-MZ twins estimators, there generally was no association between schooling and health with the exception of self-reported health (though not to the extent that cross-sectional associations suggested). There remained associations in within-MZ analyses between schooling and fertility or spousal schooling, indicating that the lack of associations between schooling and health was not primarily driven by inadequate power for within-MZ analyses to detect associations between schooling and important life-course outcomes. Finally, we investigated whether there were positive spillovers of spousal schooling on own health. We found that spousal schooling was associated cross-sectionally with better own health outcomes and behaviors, but not within-MZ twin pairs.

Previous Studies

Several studies examined schooling-mortality gradients in developed economies, with mixed results. Lleras-Muney (2005) used compulsory schooling laws as an IV, and found that an extra schooling grade reduced 10-year mortality rates for US whites by 60 percent. Mazumder (2008), however, showed that this conclusion was not robust to inclusion of state-specific trends. RD estimates showed that schooling had no effect on mortality between age 46–69 in the UK (Clark & Royer, 2013) and on survival rates at ages 50 and 80 in France (Albouy & Lequien, 2009). However, schooling was found to reduce probabilities of dying between age 81–88 by 4 to 6 percent in the Netherlands (van Kippersluis, O’Donnell & van Doorslaer, 2011). Meghir, Palme and Simeonova (2012) found that a Swedish schooling reform led to declines in male mortality at ages 40–49, which was offset by higher mortality at ages 50–59 – but with no effect overall on mortality up to age 60.

Other studies used variation from compulsory schooling laws to identify schooling effects on other health outcomes and behaviors. Schooling improved US and Swedish self-reported health (Mazumder, 2008; Spasojevic, 2010), but had no effect in Denmark (Arendt, 2005). Clark and Royer (2013) found no relationship between schooling and various health outcomes and behaviors in the UK. Some studies found gender differences. Schooling reduced long-term illness of men, but not women in Germany (Kemptner, Jürges & Reinhold, 2011). Grabner (2008), and Brunnello, Fabbri and Fort (2013) found that schooling reduced BMI and probabilities of being overweight for US and European women, but not men. Schooling improved US and UK old-age cognitive functioning (Glymour, Kawachi, Jencks, & Berkman, 2008; Banks & Mazzonna, 2012), and reduced probabilities of reporting poor health and having diabetes among the elderly in Europe (Fonseca & Zheng, 2011).

Compulsory schooling laws that affect high school do not yield insights about health returns to college or other tertiary education. Some studies therefore instrumented men's college completion using college attainment variation induced by draft avoidance behavior during the Vietnam War. They found college completion reduced mortality, smoking, BMI and overweight (De Walque, 2007; MacInnis, 2006; Buckles, Ofer, Morreil & Wozinak, 2012).

The within-MZ twins approach was applied to twins data from other developed countries, in addition to the two US studies noted above, and resulted in mixed conclusions. Behrman et al. (2011) investigated relations between schooling and hospitalization and mortality using data on 5,294 MZ Danish twins. They found significant cross-sectional associations, but no significant schooling effects with within-MZ twin estimators. Lundborg, Lyttkens and Nysted (2012) used data on 18,696 MZ Swedish twins; their within-MZ twins estimates indicated that an additional schooling grade reduced the mortality hazard by 6 percent. Webbink, Martin and Visscher. (2010) found some indications of gender differences, with schooling reducing being overweight for men but not for women based on Australian MZ twins.

Datasets

The Mid-Atlantic Twin Registry (MATR)

The MATR is a population-based registry of twin pairs ascertained from birth records and school system records of Virginia, North Carolina, and South Carolina (Anderson, Beverly, Corey & Murrelle, 2002). Our analyses were based on the Virginia 30K MATR sample, which were mailed health and lifestyle questionnaires in 1987. Completed questionnaires were obtained from 14,763 twins, approximately 70 percent. We used white MZ twin pairs aged 25–75, with non-missing information on self-reported schooling, reports on co-twin's schooling, and health. Sample sizes ranged from 3,392 to 4,328.

A question on schooling had options for: (1) 0–7 grades of elementary school; (2) 8 grades of elementary school; (3) 1–3 grades of high school; (4) 4 grades of high school; (5) 1–3 years of college; and (6) 4 or more years of college. These categories were recoded as 5, 8, 10, 12, 14 and 16 schooling grades.

Self-reported health was measured by "how would you rate your health in the past 12 months" with responses of 1=very poor, 2=poor, 3=average, 4=good and 5=very good. BMI was calculated from self-reported height and weight; overweight was defined as BMI ≥ 25. Never-smoked was equal to 1 if the twin had never smoked and 0 otherwise. Twins were asked how many alcoholic drinks they consumed in a typical week with options for 0, 1–3, 4–6, 7–12, 13–18, 19–24, 25–42 and > 42 drinks per week. We recoded these categories as 0, 2, 5, 8.5, 15.5, 21.5, 33.5 and 53. Leisure exercise options were: no exercise; occasional exercise; regular exercise about once a week; exercise a couple of times a week, or jogging, cycling to work or vigorous sport activity at least 3–4 times a week. A dichotomous exercise variable was defined as 1 if the twin reported regular exercise once or more a week and 0 otherwise.

The Minnesota Twin Registry (MTR)

The MTR contains birth records on all twins born in Minnesota in 1936–1955 (Lykken, Bouchard, McGue, & Tellegen, 2002). We used data from the Socioeconomic Survey of Twins, a questionnaire sent in 1994 to 6,638 members of same sex twin pairs. We used samples ranging from 1,290 to 1,310 of white MZ twin pairs, with non-missing information on self-reported schooling, co-twin's schooling, and health.

Twins were asked to report their own schooling, their co-twin's schooling, and their spouse's schooling. We assigned actual grades of schooling if no high school diploma, 11 if GED, 12 if high school diploma, 13 if vocational diploma, 14 if associate degree, 16 if college degree, 18 if masters degree, 19 if JD or MBA and 20 if doctoral degree.

The questionnaire contained a limited number of health questions. Twins were asked "how would you rate your health at the present time?" with responses for 1=bad, 2=poor, 3=fair, 4=good, 5=excellent. BMI was calculated from self-reported height and weight. No information on health behaviors was available.

NAS-NRC Twin Registry of WWII Veterans

The NAS-NRC twin registry consists of 15,924 white male twins born in 1917–1927, both of whom served in the armed forces. Twins were mailed questionnaires in 1967, 1983 and 2000. We used data from the 2000 survey, which contained information on both health and schooling. 2,060 twin pairs responded to the questionnaire (Page, 2002). We used MZ twin pairs, with non-missing information on self-reported schooling and health. Sample sizes ranged from 1,726 to 1,902.

Schooling was measured through a question asking "what is your highest grade level, diploma, degree completed?", with options for none, 1 grade, 2 grades, …, 11 grades, high school or GED, 1 year of trade school after high school, 1, 2 or 3 years of college, bachelors degree, 1 year of graduate work, masters degree, some doctoral work, doctoral degree. We assigned actual grades if high school was not completed, 12 for graduating from high school, 13 for 1 year of trade school/ 1 year of college, 14 for 2 years of college, 15 for 3 years of college, 16 for a bachelors degree, 17 for 1 year of graduate work, 18 for a masters degree, 19 for some doctoral work and 20 for a doctoral degree.

Self-reported health was measured by "in general would you say your health is" 1=poor, 2=fair, 3=good, 4=very good, 5=excellent. BMI was calculated from self-reported height and weight. Twins were asked whether their health limited (1) vigorous activities, (2) moderate activities, (3) lifting or carrying groceries, (4) climbing several flights of stairs, (5) climbing one flight of stairs, (6) bending, kneeling or stooping, (7) walking more than one mile, (8) walking several blocks, (9) walking one block and (10) bathing or dressing yourself. The questions had 3 possible responses- 1=no, not limited at all, 2=yes limited a little, 3=yes, limited a lot. We created overall measures encapsulating how much health limited activities by summing responses to the 10 questions. We also examined the number of health problems that twins had in old age; twins were asked whether they had the following problems – abdominal or aortic aneurysm, brain aneurysm, rheumatoid arthritis, diverticulitis, emphysema, hemorrhoids or piles, hiatal hernia, kidney stone liver cirrhosis, prostate enlargement, cataracts, glaucoma, macular hole in retina, macular degeneration. For health behaviors, we used an indicator variable for having never smoked.

Statistical Analysis

Figure 2 illustrates how unobserved endowments may determine schooling and health. Schooling of twin i in pair j (S_{ij}) is determined by individual-specific shocks (ν_{ij}) and unobserved genetic and social endowments (A_j^S and C_j^S) that are shared by MZ twins, particularly those reared together. These endowments, for example, reflect abilities, preferences, parental schooling, family income, and childhood neighborhoods, including local schools. Schooling potentially has direct causal effects on the health of twin i in pair j (H_{ij}). However, health is also determined by unobserved genetic and social endowments (A_j^S , A_j^H , C_j^S , C_j^H), some of which potentially affect both schooling and health (A_j^S ,C_j^S). Health is also affected by individual-specific shocks (ε_{ij}). Combining the effect of endowments on health into a single term μ_j results in a reduced-form relationship between schooling S_{ij} and health H_{ij} that includes both endowments μ_j and individual-specific shocks ε_{ij}.

$$H_{ij}=\beta S_{ij}+\mu_j+\varepsilon_{ij} \quad (1)$$

The key empirical question addressed in this paper is if the causal pathway β from schooling to health persists once unobserved endowments affecting both schooling and health are controlled. Conventional cross-sectional analyses do not answer this question. OLS regressions of relation (1) provide *associations* between schooling and health, which are *biased* estimates of causal effects β of schooling on health if endowments (A_j^S and C_j^S in Figure 2) jointly affect schooling and health and result in a correlation between the unobserved term μ_j and S_{ij} in relation (1).

The importance of endowments that jointly affect schooling and health is suggested by a large theoretical and empirical literature that highlights roles for both schooling and health of parental social/economic backgrounds, in-utero-conditions, and genetic effects on abilities and cognitive function (Almond & Currie, 2011; Becker 1991; Behrman, Taubman & Pollak, 1995; McGue & Bouchard, 1998). As a result, the coefficient β obtained from OLS estimation of relation (1) is biased, upward (downward) if unobserved factors affect both schooling and health in the same (opposite) direction.

Our analyses rest on the insight that unobserved endowments affecting both schooling and health can be controlled through within-MZ twin estimators.

$$H_{1j} - H_{2j} = \beta(S_{1j} - S_{2j}) + (\varepsilon_{1j} - \varepsilon_{2j}) \quad (2)$$

In this relation, the influence of unobserved factors μ_j is differenced out as MZ twins are genetically identical, grow up together, and share many other socioeconomic contexts such as schools and neighborhoods.

We note three potential problems with within-MZ twins estimators. *First*, attenuation bias due to measurement error is exacerbated by first differencing. To deal with measurement error, we instrumented differences in self-reported schooling with differences in co-twin's reports (Ashenfelter & Krueger, 1994). *Second*, estimates are identified by schooling differences within MZ twin pairs. If these differences are small then it may require many observations to identify effects. We therefore examined these differences below and found them large compared to effects of compulsory schooling laws and sufficient to obtain significance for other non-health outcomes. *Third*, the estimated value of β is upward- (downward-) biased if factors leading to differences in schooling directly affect schooling and health (in addition to any indirect effect on health through schooling) in the same (opposite) direction (Bound and Solon, 1999; Behrman et al. 2011, Kohler, Behrman & Schnittker, 2011).

For example, schooling differences between MZ twins may originate in youth health, that also directly affect adult health. Both the MATR and MTR surveys asked twins whether they have ever suffered from any health conditions such as high blood pressure, asthma, hearing impairment, depression, and if so at what age these conditions were diagnosed. We attempted to control for early life health differences by including an indicator = 1 if the twin was diagnosed with a health condition at age 16 or younger in all cross-sectional and within-MZ twins regressions.

Relation (3) was used to estimate effects of spousal schooling on own health. Relation (3) is the same as relation (1), but also includes schooling of the spouse of twin i in pair j (Sp_{ij}).

$$H_{ij} = \beta S_{ij} + \delta SP_{ij} + \mu_j + \varepsilon_{ij} \quad (3)$$

In conventional cross-sectional analyses, estimated cross-spouse effects Δ are biased because of unobserved endowments that are correlated with spousal schooling and also directly affect own health. For example, high-ability individuals tend to have better-schooled spouses and better own health. The bias due to unobserved factors is differenced out by contrasting health of MZ twins with different spousal schooling in relation (4), an approach used for the first time to our knowledge in this and the concurrent study by Behrman, Xiong and Zhang (2014).

$$H_{1j} - H_{2j} = \beta(S_{1j} - S_{2j}) + \delta(SP_{1j} - SP_{2j}) + (\varepsilon_{1j} - \varepsilon_{2j}) \quad (4)$$

Because within-MZ schooling differences exist over most schooling levels, within-MZ estimates are likely to be closer to average treatment effects (ATE) than local average treatment effects (LATE) (Moffitt, 2009). IV-approaches that rely on compulsory schooling variations to predict schooling yield LATE relevant for individuals affected by instruments used (e.g., close to completing only compulsory schooling) but not ATE for broader populations (Behrman et al. 2011). For understanding the role of schooling differentials for population-level health gradients, and for informing policies that aim at addressing health differences through enhancements of schooling levels, ATE (or approximations thereof) as provided by within-MZ approaches are likely preferable to LATE estimates that based on compulsory schooling regulations.

Results

Table 1 provides descriptive statistics. Average twins ages at the survey times were 46 (MTR), 52 (MATR) and 74 years (NAS-NRC). The majority of MTR and MATR twins were female. Average schooling grades attained were similar in the MTR and NAS-NRC (approximately 14 grades), and lower in the MATR (13.5 grades). Only 2 percent of twins did not graduate from high school in the MTR, compared to 9 and 12 percent in the MATR and NAS-NRC. The proportions of twins that graduated from high school, had some post-high school schooling, and had bachelor degrees were similar across datasets. On average MATR twin pairs had differences of 0.69 grades and 71 percent of twin pairs had no difference in grades. In the MTR and NAS-NRC, 51 and 43 percent of twin pairs had the same grades of schooling, and on average twin pairs had differences of 1.1 and 1.4 grades. The within-MZ twin pair variation in schooling was quite substantial when compared to the estimate that compulsory schooling laws in the US only increased schooling by 0.05 grades (Lleras-Muney, 2005).

Within-MZ twins estimates are closer to ATE if within-MZ twin pair schooling differences are distributed across the schooling distribution. Appendix table 1 summarizes differences in schooling for twin pairs in which at least one twin has (1) 12 schooling grades or lower, (2) 13–15 grades of schooling or (3) 16 grades of schooling or more. The most variation for the MATR and NAS-NRC occurred when at least one twin had 13–15 schooling grades (1.24 and 1.91 grades). For the MTR the most variation occurred in twin pairs where one twin had 16 schooling grades or more (1.94 grades).

Average self-reported health was similar in the MATR and MTR (4.34 and 4.37) but substantially lower in the NAS-NRC (3.48). Average BMI was similar in all datasets. Approximately half of twins were overweight in the MATR and NAS-NRC; in the MTR only 38 percent of twins were overweight. In the MTR 16 percent of twins had an early health problem, more than double the proportion in the MATR.

There was also fairly substantial within-twin pair variation in health measures. The absolute within-twin pair difference in self-reported health was 0.48 in the MTR, 0.58 in the MATR and and much higher in the NAS-NRC (0.84). In all three datasets, absolute within-twin pair differences in BMI were over 2 units, and over 18 percent of twin pairs were discordant on overweight status. 20 percent of twin pairs differed on smoking status in the MATR and NAS-NRC. The absolute within-twin pair difference in number of health problems for the NAS-NRC twins was 1.22.

The main results are in table 2. The MATR and MTR datasets were combined for self-reported health, BMI, overweight to improve precision. For these outcomes, the null hypothesis of equality of coefficients in the within-MZ twins regressions was not rejected at the 5 percent level. Cross-sectional regressions in the MATR-MTR dataset controlled for age, age squared, gender, early health problems and if the twin was from the MATR. Cross-sectional regressions in the NAS-NRC dataset controlled for age and age squared.

The cross-sectional estimates indicated that schooling was associated with higher self-reported health, lower BMI and lower probabilities of being overweight. Moreover, for the NAS-NRC twins, more schooling was associated with fewer health-limiting problems. However, there was no relationship between schooling and the total number of health problems in old age. More schooling was associated with better health behaviors in the MATR, in particular with higher probabilities of having never smoked and of undertaking some exercise in leisure time. Surprisingly, more schooling was associated with more alcohol consumption in the MATR. The positive association may be plausible if people believed that there were health benefits of modest alcohol consumption or if alcohol was more affordable to more-schooled individuals due to higher income. These associations increased in magnitude once measurement error was controlled by instrumenting self-reported schooling with reports from co-twins.

Compared to cross-sectional estimates, within-MZ twins estimates indicated that schooling was *not* associated with BMI, probability of being overweight in the MATR-MTR dataset, or with any health behaviors in the MATR, or with old-age health in the NAS-NRC. In case within-MZ twin pair schooling variation was not sufficient to identify positive schooling effects, we restricted the sample to twin pairs where one twin had 16 grades of schooling or more, and the other twin had 14 grades or less. One might expect it more likely to find schooling effects within twin pairs with these larger schooling differences. However, within-MZ twins estimates on this restricted sub-sample still showed no associations between schooling and health.

The only exception was that schooling was still significantly associated with better self-reported health within-MZ twins in the MATR-MTR dataset. An extra schooling grade increased self-reported health by 0.04 units, on a scale of 0–5 (95% CI 0.01 to 0.06). When self-reported schooling was instrumented using co-twins' reports of the others' schooling to control for random measurement error the point estimate increased to 0.05 but no longer was statistically significant (95% CI −0.01 to 0.10).

Appendix table 2 reports results by gender. There were some indications of gender differences, with schooling associated with larger declines in BMI for women, and higher probability of never smoking for men in cross-sectional estimates. No significant gender differences were indicated in the within-MZ twins estimates. Appendix table 3 shows results by different age groups (25–44, 45–65, 65–75). There were significant cross-sectional associations between schooling and better health outcomes across age groups, which were similar in magnitude in the MATR-MTR dataset. The within-MZ twin pair analyses indicated smaller associations that were not significant. For health behaviors, schooling was associated with higher probabilities of exercising for all age groups. Positive associations between schooling and never smoking (alcohol consumption) were only for those aged 25–44 (65–75). Within-MZ twins estimates, as in table 2, indicated no significant associations.

Table 3 explores nonlinear effects of having (1) some post-high school schooling (13–15 grades) and (2) bachelors degree or higher (16 grades or more) relative to having graduated high school or lower (12 grades or lower). No measurement-error-corrected IV estimates are presented because with binary variables measurement error is non-classical. The cross-sectional results indicated that those with some post-high school schooling and those with bachelors degrees had better health outcomes and behaviors compared to those who graduated from high school or lower. The coefficient on having bachelors degrees or higher was almost twice the coefficient on some post-high school schooling, suggesting that there were larger health returns from completing college. Controlling for unobserved factors using within-MZ twins estimators produced estimates that generally were smaller in magnitude and statistically insignificant, both in the full sample of MZ twins and in the sub-sample with large schooling differences. Also note, as before there was still some indication that schooling led to better self-reported health in the MATR-MTR dataset, even after controlling for endowments. Further note that the null hypothesis of equal coefficients between the MATR and MTR datasets in the within-MZ twins regression for overweight status was rejected. This was driven by the surprising finding that in the MTR, individuals with college degrees were 11 percentage points more likely to be overweight relative to high school graduates or lower, whereas they were 6 percentage points less likely to be overweight in the MATR.

Table 4 reports estimates of spousal schooling on own health. The sample was restricted to MZ twin pairs in which both were currently married, reported spouses' schooling and had reported health measures. Individuals who were divorced, widowed, or separated may have been different than currently-married individuals, in ways that were related to spousal schooling and health, which would bias the estimates. For example, individuals who provided less health benefits to their spouses may have been less likely married, and therefore including only married individuals may have overstated cross-spouse health benefits. The cross-sectional estimates in column 1 show that spousal schooling was associated with better health outcomes and behaviors. The absolute magnitudes of estimated associations with spousal schooling decreased in column 2, when own schooling was introduced. Spousal schooling still had positive associations with health outcomes, but no longer had significant associations with health behaviors with the exception of alcohol consumption. In contrast, the within-MZ twins estimates were smaller in absolute magnitudes and statistically insignificant, suggesting that associations between spousal schooling and health were due to unobserved factors.

Appendix table 4 shows estimates of spousal schooling and own health by gender. The cross-sectional associations indicated that husband's schooling had greater effects in reducing (increasing) BMI (alcohol consumption) than wife's schooling, whereas wives' schooling had greater effects in increasing probabilities of never smoking compared to husbands' schooling. The within-MZ twins estimates showed no evidence of differences between effects of husbands' and wives' schooling.

Discussion

As noted in the introduction, there are many theoretical reasons why more schooling may improve health (Figure 1): improving productive and allocative efficiency, lowering discount rates, extending life expectancy, improving social rank, increasing interactions with other more-schooled peers generating health spillovers, affecting access to resources (money, knowledge, prestige, power, social networks) that impact health, among other possibilities. But the extent to which schooling improves health and health-related behaviors is an empirical, not a theoretical, question. And (perhaps) surprisingly, despite robust associations between schooling and health that are frequently interpreted to support theoretical pathways, empirical evidence about causal effects of schooling on health from IV and within-MZ twins estimates is mixed. One reason for these mixed findings is the challenge of controlling roles of social and genetic endowments that jointly affect schooling and health (Figures 1 and 2), which cause biases in many conventional analyses of schooling-health relationships.

To address this issue, this study used three large US MZ twins datasets. We found almost no associations between schooling and adult health once unobserved confounders were controlled with within-MZ twins estimators. We only found some evidence that schooling was still associated with better self-reported health, with the beneficial effect mainly driven by completing college. We also found that spousal schooling was associated with better health outcomes and behaviors, but the associations disappeared within MZ twin pairs.

Our estimates imply that policies aimed at increasing schooling attainment will not have much, if any, health benefits. This conclusion, though controversial, is consistent with some, though not all, previous studies that attempted to control for unobserved confounders to obtain estimates of the causal effects of schooling on health (e.g., Behrman et al. 2011; Lundborg, 2013; Clark & Royer 2013; Mazumder 2008).

Our conclusions rest on the ability of within-MZ twins estimators to identify causal relations. The within-MZ twin pair schooling differences used to identify schooling effects were much larger than the increased schooling attainment caused by US compulsory schooling laws. Moreover, the results were robust for a sub-sample with relatively large schooling differences. Further, we found statistically-significant and substantively-relevant within-MZ associations between schooling and some non-health non-market outcomes, namely completed fertility (reduced by 0.10 child per additional schooling grade) and spousal schooling (increased by 0.34 grades per additional grade of own schooling) (appendix table 5), suggesting that our results on schooling effects on health do not reflect sample sizes too small to detect any possible schooling effects or peculiarities of our schooling measures.

We also note that our study permits inferences for broader populations than just twins. It is true that twins are a small proportion of the population and being a twin is often thought to be different from being a singleton. However our within-MZ twins estimates controlled for unobservable ways in which twins were different from singletons. On the other hand, our results focus only on one country, and generalizing to other contexts may not be valid. Also within the US schooling-health associations differ by race (Liu & Hummer, 2008), and our data did not permit us to address racial differences.

In summary, our results align with some other recent studies that have found small or non-significant schooling impacts on health once there was control for unobserved confounders. Nevertheless, given theoretical arguments for causal relationships between schooling and health and that some studies that control for unobserved confounders have also found significant effects on health, more research is needed for fully understanding these mixed findings and to what extent they reflect differences in empirical strategies or in empirical contexts.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights

- Schooling is associated with adult health behaviors and outcomes.
- Schooling is not associated with adult health within-MZ twin pairs.
- Spouses' schooling has little or no significant causal effects on own health
- Associations between schooling and adult health are misleading regarding effects

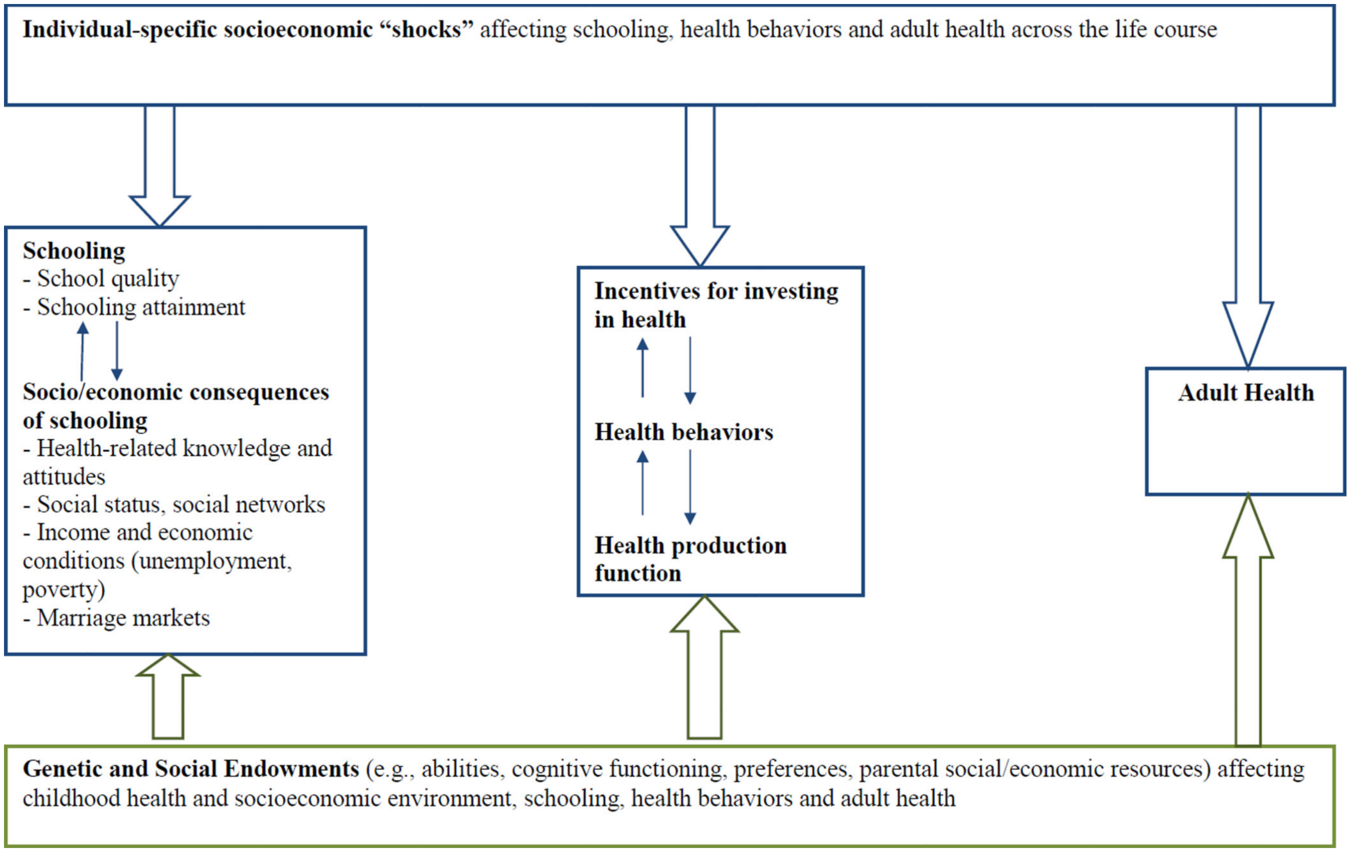

Figure 1.

Conceptual Theoretical Framework between Schooling and Health

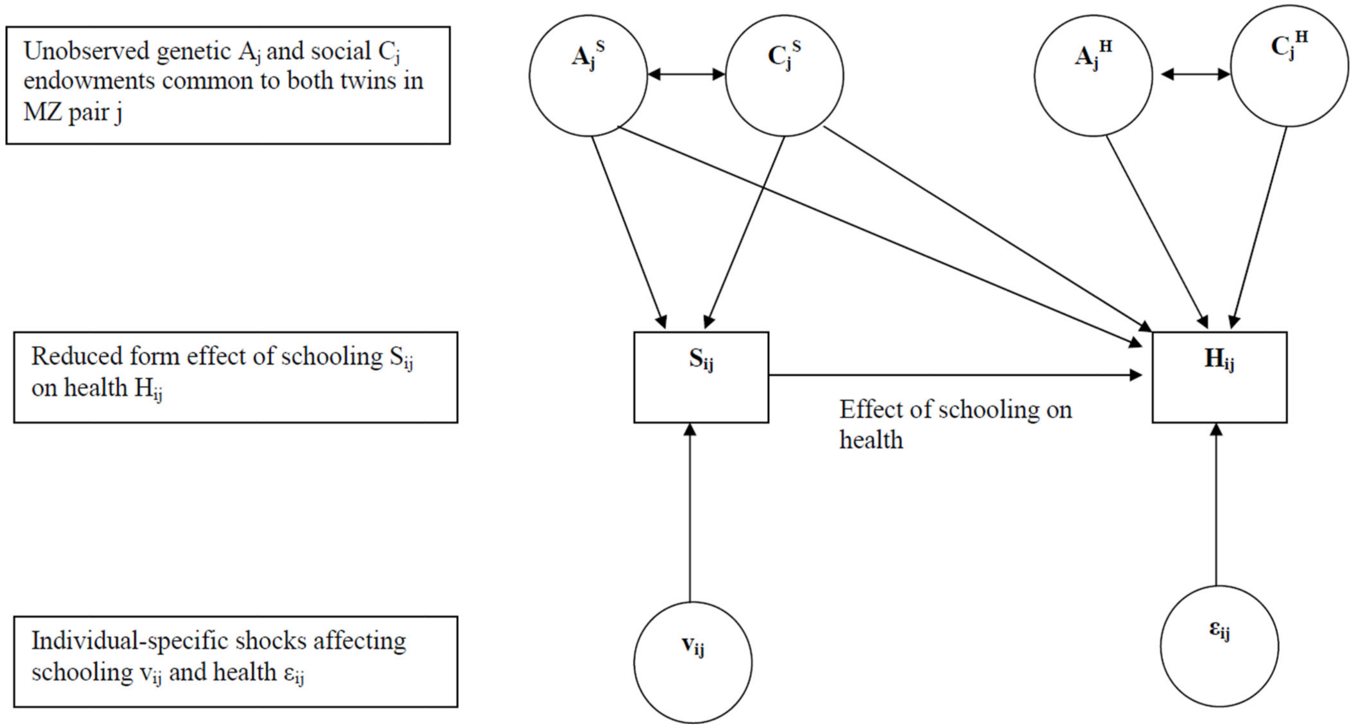

Figure 2.
Role of Unobserved Endowments in determining Schooling and Health

Table 1

Descriptive Statistics

	MATR	MTR	NAS-NRC
	(1)	(2)	(3)
Background Characteristics			
Age	52.41 (15.04)	46.63 (5.49)	74.16 (2.76)
25–34	0.22 (0.40)		
35–44	0.12 (0.33)	0.42 (0.49)	
45–54	0.12 (0.33)	0.47 (0.50)	
55–64	0.29 (0.45)	0.11 (0.31)	
65–75	0.26 (0.44)		0.66 (0.47)
76–85			0.30 (0.46)
Female	0.71 (0.45)	0.65 (0.47)	0.00 (0.00)
Grades of schooling	13.52 (2.10)	14.03	14.02 (3.00)
Absolute within-twin difference in grades of schooling	0.69 (1.17)	1.10 (1.52)	1.40 (1.87)
Difference in grades of Schooling			
0	0.71 (0.46)	0.51 (0.50)	0.43 (0.48)
1		0.19 (0.39)	0.23 (0.42)
2	0.25 (0.43)	0.14 (0.35)	0.14 (0.35)
3	0.00 (0.05)	0.05 (0.22)	0.06 (0.24)
4	0.04 (0.18)	0.07 (0.25)	0.07 (0.26)
5 or more	0.01 (0.07)	0.04 (0.18)	0.06 (0.24)
Less than 12 grades	0.09 (0.28)	0.02 (0.12)	0.12 (0.32)
12 grades	0.34 (0.48)	0.33 (0.47)	0.25 (0.43)
13–15 grades	0.26 (0.44)	0.30 (0.46)	0.25 (0.43)
16 grades or more	0.31 (0.46)	0.35 (0.48)	0.38 (0.48)
Co-twin's grades of schooling	13.43 (2.12)	13.91 (2.37)	
Spouse's grades of schooling	13.46 (2.34)	13.81 (2.47)	
Early health problem	0.07 (0.25)	0.16 (0.36)	
Health Outcomes			
Self-reported health	4.34 (0.86)	4.37 (0.67)	3.48 (0.98)
BMI	24.54 (4.27)	25.74 (4.49)	25.79 (3.31)
Overweight	0.38 (0.47)	0.50 (0.50)	0.58 (0.49)
Limiting activities			14.54 (4.90)
Number of health problems			1.97 (1.48)
Health Behaviors			
Never Smoked	0.53 (0.50)		0.37 (0.48)
Exercise	0.52 (0.50)		

	MATR	MTR	NAS-NRC
	(1)	**(2)**	**(3)**
Alcohol Consumption	2.48 (5.81)		
Absolute within-twin pair difference in			
Self-reported health	0.58 (0.76)	0.48 (0.63)	0.82 (0.78)
BMI	2.08 (2.28)	2.49 (2.44)	2.28 (2.01)
Number of health problems			1.22 (1.05)
Limiting activities			3.84 (4.29)
Alcohol consumption	2.45 (5.68)		
Proportion of twin pairs that differ in			
Overweight	0.19 (0.40)	0.23 (0.42)	0.30 (0.45)
Never Smoked	0.20 (0.40)		0.20 (0.40)
Exercise	0.33 (0.47)		

Notes: Standard deviations in parentheses.

Table 2

Cross-Section and Within-MZ Twin Pairs Association between Grades of Schooling and Health

	Cross-Section		Cross-Section with measurement error		Within-MZ Twins		Within-MZ Twins for twin pairs where one has ≥16 & other has ≤14 grades		Within-MZ Twins with measurement error	
	β	95% CI	β	95% CI	β	95% CI	β	95% CI	β	95% CI
MATR-MTR										
Self-reported health	0.07	0.06 to 0.08	0.08	0.06 to 0.08	0.04	0.01 to 0.06	0.04	0.01 to 0.07	0.05	−0.01 to 0.10
N		5638		5638		2819		367		2819
BMI	−0.23	−0.27 to −0.17	−0.28	−0.34 to −0.21	−0.02	−0.11 to 0.07	0.03	−0.11 to 0.17	−0.03	−0.22 to 0.16
N		5562		5562		2781		364		2781
Overweight	−0.02	−0.03 to −0.02	−0.03	−0.04 to −0.02	−0.00	−0.01 to 0.01	−0.00	−0.01 to 0.01	−0.01	−0.04 to 0.02
N		5562		5562		2781		364		2781
MATR										
Never Smoked	0.02	0.01 to 0.02	0.02	0.01 to 0.03	0.00	−0.01 to 0.02	0.00	−0.02 to 0.02	0.01	−0.04 to 0.06
N		4126		4126		2063		256		2063
Alcohol Consumption	0.09	−0.02 to 0.18	0.12	0.01 to 0.22	−0.06	−0.29 to 0.17	0.17	−0.22 to 0.57	−0.35	−1.25 to 0.56
N		3392		3392		1696		207		1696
Exercise	0.04	0.03 to 0.05	0.04	0.03 to 0.05	0.01	−0.01 to 0.03	0.02	−0.01 to 0.05	0.08	0.01 to 0.14
N		4240		4240		2120		258		2120
NAS-NRC										
Self-reported health	0.07	0.05 to 0.08			0.03	−0.00 to 0.07	0.02	−0.02 to 0.08		
N		1868				934		116		
BMI	−0.12	−0.16 to 0.07			−0.06	−0.15 to −0.04	−0.05	−0.18 to 0.08		
N		1844				922		114		
Overweight	−0.01	−0.21 to −0.01			−0.00	−0.02 to 0.01	−0.00	−0.02 to 0.22		
N		1844				922		114		
Limiting Activities	−0.26	−0.33 to −0.18			−0.03	−0.19 to 0.13	0.06	−0.16 to 0.28		
N		1726				863		107		
No. of health problems	−0.01	−0.03 to 0.02			−0.03	−0.08 to 0.06	−0.02	−0.09 to 0.05		
N		1342				671		81		
Never Smoked	0.03	0.02 to 0.04			0.01	−0.01 to 0.02	0.01	−0.01 to 0.03		

	Cross-Section		Cross-Section with measurement error		Within-MZ Twins		Within-MZ Twins for twin pairs where one has ≥16 & other has ≤14 grades		Within-MZ Twins with measurement error	
	β	**95% CI**	**β**	**95% CI**	**β**	**95% CI**	**β**	**95% CI**	**β**	**95% CI**
N		1902				951		117		

Notes: Cross sectional regressions in MATR-MTR control for age, age squared, gender, early health problems and an indicator for MATR. Cross-sectional regressions for MATR control for age, age squared, gender and early health problems. Cross-sectional regressions in NAS-NRC control for age and age squared. For the cross-section corrected for measurement error, twin 1's schooling is instrumented by twin 2's report of twin 1's schooling and vice versa. Within-MZ twins estimates for MATR-MTR and MATR control for early health problems. For within-MZ twins estimates corrected for measurement error, the difference in self-reported schooling is instrumented by the difference in the co-twin's report of the other's schooling. 95% confidence intervals based on standard errors clustered by twin pairs.

Table 3

Cross-Section and Within-MZ Twin Pairs Association of having some post high school education, a bachelors degree relative to high school graduates and dropouts

	Cross-Section		Within-MZ Twins		Within-MZ Twins for twin pairs where one twin has ≥16 and other twin has ≤14 grades	
	β	**95% CI**	**β**	**95% CI**	**β**	**95% CI**
MATR-MTR						
Self-reported health						
Some post high school education	0.16	0.10 to 0.22	0.06	−0.03 to 0.15	−0.03	−0.25 to 0.19
Bachelors degree or higher	0.30	0.24 to 0.34	0.19	0.07 to 0.31	0.12	−0.07 to 0.32
N		5638		2819		367
BMI						
Some post high school education	−0.38	−0.66 to −0.09	−0.10	−0.44 to 0.24	0.18	−0.88 to 1.24
Bachelors degree or higher	−1.03	−1.29 to −0.77	−0.02	−0.52 to 0.47	0.18	−0.80 to 1.18
N		5562		2781		364
MTR						
Overweight						
Some post high school education	−0.03	−0.09 to 0.03	0.05	−0.03 to 0.13	−0.06	−0.23 to 0.11
Bachelors degree or higher	−0.06	−0.13 to 0.00	0.11	0.01 to 0.21	0.05	−0.09 to 0.19
		1290		645		106
MATR						
Overweight						
Some post high school education	−0.03	−0.07 to 0.01	−0.03	−0.08 to 0.02	−0.02	−0.14 to 0.10
Bachelors degree or higher	−0.12	−0.16 to −0.09	−0.06	−0.13 to −0.001	−0.05	−0.15 to 0.05
N		4272		2136		258
Never Smoked						
Some post high school education	0.02	−0.02 to 0.05	0.02	−0.03 to 0.07	0.03	−0.08 to 0.15
Bachelors degree or higher	0.10	0.06 to 0.12	0.01	−0.05 to 0.07	0.02	−0.07 to 0.12
N		4126		2063		256
Alcohol consumption						
Some post high school education	0.39	−0.10 to 0.88	−0.66	−1.51 to 0.20	−0.31	−2.84 to 2.23
Bachelors degree or higher	0.30	−0.17 to 0.78	−0.14	−1.35 to 1.06	0.13	−2.14 to 2.41

	Cross-Section		Within-MZ Twins		Within-MZ Twins for twin pairs where one twin has ≥16 and other twin has ≤14 grades	
	β	95% CI	β	95% CI	β	95% CI
N		3392		1696		207
Exercise						
Some post high school education	0.09	0.05 to 0.13	0.00	−0.07 to 0.08	−0.13	−0.31 to 0.04
Bachelors degree or higher	0.18	0.14 to 0.21	0.07	−0.02 to 0.16	−0.04	−0.20 to 0.12
N		4240		2120		258
NAS-NRC						
Self-reported health						
Some post high school education	0.23	0.11 to 0.34	0.05	−0.12 to 0.23	−0.09	−0.55 to 0.31
Bachelors degree or higher	0.42	0.32 to 0.51	0.16	−0.18 to 0.40	0.05	−0.35 to 0.45
N		1868		934		144
BMI						
Some post high school education	−0.56	−0.95 to −0.16	−0.37	−0.85 to −0.16	−0.64	−1.92 to 0.64
Bachelors degree or higher	−1.02	−1.21 to −0.38	−0.57	−1.21 to 0.07	−0.77	−1.92 to 0.37
N		1844		932		141
Overweight						
Some post high school education	−0.05	−0.11 to 0.01	−0.03	−0.11 to 0.06	−0.15	−0.36 to 0.06
Bachelors degree or higher	−0.07	−0.12 to −0.02	−0.04	−0.15 to 0.06	−0.13	−0.32 to 0.05
N		1844		932		141
Limiting Activities						
Some post high school education	−0.69	−1.31 to −0.07	−0.10	−1.02 to 0.82	1.46	−0.75 to 3.67
Bachelors degree or higher	−1.58	−2.11 to −1.05	0.01	−1.19 to 1.20	1.18	−0.71 to 3.06
N		1726		863		133
Never Smoked						
Some post high school education	0.04	−0.01 to 0.10	−0.02	−0.09 to 0.05	0.05	−0.11 to 0.21
Bachelors degree or higher	0.21	0.17 to 0.27	0.05	−0.04 to 0.14	0.08	−0.05 to 0.21
N		1902		951		117

Notes: The omitted schooling category is high school graduate or lower. Cross sectional regressions in MATR-MTR control for age, age squared, gender, early health problems and an indicator for MATR. Cross-sectional regressions for the single MATR and MTR datasets control for age, age squared, gender and early health problems. Cross-sectional regressions in NAS-NRC control for age and age squared. Within-MZ twins estimates for combined MATR-MTR and single MATR, MTR datasets control for early health problems. 95% confidence intervals based on standard errors clustered by twin pairs.

Table 4

Cross-Section and Within-MZ Twin Pairs Association between Spousal Schooling and Health

	Cross-Section		Cross-Section		Within-MZ Twins		Within-MZ Twins		Within-MZ Twins for twin pairs where one twin has ≥16 & other has ≤14 grades	
	β	95% CI	β	95% CI	β	95% CI	β	95% CI	β	95% CI
MATR-MTR										
Self-reported health										
Spousal schooling	0.05	0.04 to 0.06	0.03	0.02 to 0.04	0.01	−0.01 to 0.03	0.01	−0.01 to 0.03	0.05	−0.00 to 0.10
Own schooling			0.04	0.03 to 0.06			0.03	0.01 to 0.06	0.03	−0.01 to 0.07
N		3204		3204		1602		1602		217
BMI										
Spousal schooling	−0.29	−0.36 to −0.23	−0.25	−0.33 to −0.17	−0.02	−0.09 to 0.04	−0.01	−0.07 to 0.05	−0.07	−0.27 to 0.12
Own schooling			−0.11	−0.19 to −0.03			−0.09	−0.22 to 0.03	−0.03	−0.24 to 0.19
N		3174		3174		1587		1587		218
Overweight										
Spousal schooling	−0.03	−0.03 to −0.02	−0.02	−0.03 to −0.01	0.00	−0.01 to 0.01	0.00	−0.01 to 0.10	−0.00	−0.03 to 0.02
Own schooling			−0.01	−0.02 to −0.00			0.00	−0.02 to 0.01	−0.01	−0.03 to 0.01
N		3174		3174		1587		1587		128
MATR										
Never Smoked	0.01	0.00 to 0.02	0.01	−0.00 to 0.02	0.00	−0.01 to 0.01	0.00	−0.01 to 0.01	0.00	−0.02 to 0.02
Spousal schooling			0.02	0.00 to 0.03			−0.00	−0.02 to 0.01	−0.01	−0.03 to 0.01
Own Schooling										
N		2306		2306		1153		1153		148
Exercise										
Spousal schooling	0.02	0.01 to 0.03	0.01	−0.00 to 0.02	0.00	−0.01 to 0.02	0.00	−0.01 to 0.02	−0.02	−0.07 to 0.02
Own schooling			0.02	0.01 to 0.04			0.01	−0.02 to 0.03	0.02	−0.02 to 0.06
N		2282		2281		1141		1141		145
Alcohol Consumption	0.22	0.10 to 0.33	0.15	0.01 to 0.30	0.08	−0.10 to 0.26	0.09	−0.10 to 0.29	0.35	0.01 to 0.69
Spousal schooling			0.15	−0.01 to 0.30			−0.11	−0.42 to 0.19	0.02	−0.44 to 0.49
Own Schooling										
N		1844		1844		922		922		120

Notes: Cross sectional regressions control for age, age squared, gender, early health problems, spousal age categories (20–29 reference category, 30–39, 40–49, 50–59, 60–69 and 70 plus) and an indicator for MATR in MATR-MTR dataset. Within-MZ twins regressions control for early health problems and spousal age categories. 95% confidence intervals based on standard errors clustered by twin pairs.