Journal of Development Economics 146 (2020) 102493

Contents lists available at ScienceDirect

Journal of Development Economics

journal homepage: www.elsevier.com/locate/devec

Regular Article

# The cross-spousal effect of education on health☆

Rufei Guo [a], Lin Lin [b], Junjian Yi [c], Junsen Zhang [d,e,*]

[a] Center for Health Economics and Management, Economics and Management School, Wuhan University, China
[b] Department of Economics, Chinese University of Hong Kong, Hong Kong
[c] Department of Economics, National University of Singapore, Singapore
[d] School of Economics, Zhejiang University, China
[e] Department of Economics, Chinese University of Hong Kong, Hong Kong

ARTICLE INFO

*JEL classification:*
I12
I26
J12

*Keywords:*
Education
Spousal health
Within-twin fixed-effect estimation

ABSTRACT

This paper studies the cross-spousal effect of education on health. We address the endogeneity of education that arises from one's own unobserved endowment using the within-twin fixed-effect method. We explore unique information on spousal health at both wedding and survey times to investigate the role of spousal unobserved endowment. We find that wives' education reduces husbands' consumption on cigarettes and alcohol, increases exercise frequency, lowers the probability of being overweight, and decreases the number of chronic diseases. By contrast, the effect of husbands' education on wives' health is weak.

## 1. Introduction

The external effect of human capital has been at the heart of theories of sustained economic growth and drawn great attention from both academic researchers and policymakers (Lucas Jr., 1988). Microeconomic evidence on the external effect of human capital comes from the workplace, classroom, community, and family (Hoxby, 2000; Moretti, 2004; Wantchekon et al., 2014). In particular, the recent literature examines the effect of mothers' education on children's life-cycle outcomes, such as education, health, and employment (Currie and Moretti, 2003; McCrary and Royer, 2011).

We contribute to the literature on the external effect of human capital by offering the first investigation of the cross-spousal effect of education on health—that is, whether education improves spousal health after the couple marries. When estimating this cross-spousal effect of education on health, we face two challenges. The first is the endogeneity of education caused by one's own unobserved endowment. For example, a person's health habits, which are unobserved by researchers, may not only influence his or her educational attainments, but also have a direct effect on spousal health after they get married. This problem of endogeneity is similar to that in the literature on economic returns to schooling (Card, 1999). The literature has offered two strategies to solve this problem. The first uses changes in compulsory education laws as an instrumental variable (IV) for education (Lleras-Muney, 2005; Kemptner et al., 2011; Clark and Royer, 2013). This strategy is hardly applicable to our study on the effect of education on spousal health, because the change in a specific education law is likely to affect the outcomes of both the husband and wife who are of a similar age. Therefore, we cannot use the change in the law as an IV for education, because the change does not satisfy the exclusion restriction in our study. We use the second strategy, which exploits differences in education between monozygotic (MZ) twins, based on the Chinese Adult Twins Survey (CATS) (Rosenzweig and Wolpin, 1980; Behrman et al., 2015). Because MZ twins have the same genes and family background, within-MZ-twin differences in education largely remove one's own unobserved endowment.

The second challenge arises from the mating effect: One's education may correlate with spousal unobserved endowment, which in turn

☆ We wish to thank the editor and two anonymous referees for their valuable comments. Guo and Zhang acknowledge partial financial support from the Fundamental Research Funds for the Central Universities of China and the RGC-GRF CUHK Project 14500719, respectively.

* Corresponding author. School of Economics, Zhejiang University, China.
*E-mail addresses:* rufei_guo@whu.edu.cn (R. Guo), michellelinlin@link.cuhk.edu.hk (L. Lin), junjian@nus.edu.sg (J. Yi), jszhang@cuhk.edu.hk (J. Zhang).

https://doi.org/10.1016/j.jdeveco.2020.102493
Received 20 May 2019; Received in revised form 5 April 2020; Accepted 10 April 2020
Available online 20 April 2020

affects spousal health.[1] Spousal unobserved endowment includes the genetic health endowment and all other environmental factors affecting spousal health before the person gets married. The observed association between one's education and spousal health at the survey time may be driven by the mating effect rather than the cross-spousal effect. For example, a person with better education may prefer potential partners with better health in the marriage market.

CATS and the Chinese marriage tradition together provide a rare opportunity to address the second challenge. CATS uniquely contains health information for twins and their spouses at both wedding and survey times. Under the Chinese marriage tradition, the couple seldom live together and hardly influence each other before the wedding ceremony. A common practice in China is that a couple is matched with each other by their parents or relatives (Huang et al., 2017). According to survey data from the 2010 China Family Panel Studies, out of 26,722 married people, only about one-fifth get to know their spouses on their own, while the remaining four-fifths are introduced by friends and relatives. Parental involvement shortens the dating period and leaves a minimal window for a couple to influence each other before getting married. In the survey, only 8% of married couples live together before they get married, with an average duration of premarital cohabitation of six months. Therefore, the correlation between one's education and spousal health at the wedding time mainly reflect the mating effect but not the cross-spousal effect. We examine whether spousal unobserved endowment confounds our within-twin fixed-effect (FE) estimate of the cross-spousal effect in the empirical analysis, using the information on spousal health at the wedding time.

We find a positive cross-spousal effect of education on health using the within-twin FE method. The effect of wives' education on husbands' health is larger than the effect of husbands' education on wives' health. In our preferred specification, one additional year of a wife's schooling decreases her husband's probability of being overweight by 5.2 percentage points and decreases his number of chronic diseases by 16.9%. One additional year of a husband's schooling decreases his wife's probability of being overweight by 3.5 percentage points; husbands' education does not have a statistically significant effect on wives' number of chronic diseases. This finding is consistent with the recent literature that mothers' education is more important than fathers' education for children's outcomes (Holmlund et al., 2011).

Our within-twin FE estimates remain robust when we consider the limitations of the method. First, if self-reported education contains measurement errors, attenuation bias is present, which is larger for the within-twin FE estimate than the OLS estimate (Bound and Solon, 1999). We employ the IV method proposed by Ashenfelter and Krueger (1994) to address this problem, using cross-twin-reported education as an IV for the self-reported education. Second, if the within-twin difference does not completely eliminate twins' unobserved endowment, the within-twin FE estimate remains biased. We examine the magnitude of this remaining bias following Ashenfelter and Rouse (1998).

The mating effect is not a main driver of our within-twin FE estimates. We examine the association between education and spousal health at the wedding time, which is used as a proxy for spousal unobserved endowment. The difference in twins' schooling years is not statistically significantly correlated with differences in their spouses' overweight status, number of chronic diseases, body mass index (BMI), or height measured at the wedding time. We conduct two robustness checks to verify the result. First, when we add spousal health at the wedding time as a control, within-twin FE estimates of the effect of education on spousal health at the survey time remain almost unchanged. Second, we replace the dependent variable of spousal health at the survey time with the variable of the change in spousal health between the survey time and wedding time, and find that the new estimates are not statistically significantly different from our previous within-twin FE estimates.

We explore the channels through which one's education improves spousal health. Besides the mating effect, we discuss three channels: labor market conditions, bargaining power, and information sharing. First, better-educated people have higher income or better jobs, which enables them to access more health-related resources (Cutler et al., 2008; Cutler and Lleras-Muney, 2010). Our estimates change little after we control for the couple's income, spousal working status, and spousal occupational categories, suggesting that the estimated cross-spousal effect is unlikely driven by labor market conditions. Second, we find that a better-educated wife decreases her husband's consumption on cigarettes and alcohol and increases his time spent exercising. We do not detect a statistically significant effect of husbands' education on wives' exercise frequency. These results indicate that a wife's education puts her in a better bargaining position, inducing her husband to keep fit and to reduce unhealthy consumption. Third, better-educated people obtain better health knowledge (Grossman, 1972, 2006). We discuss the possibility of the sharing of health knowledge between couples.

Our results enrich the literature on the cross-spousal effect of education from a new perspective (Carrell et al., 2009; Chevalier et al., 2013). We find that education improves spousal health, and the effect mainly runs from wives to husbands. The correlation between education and spousal health has been investigated in public health and population studies (Lipowicz, 2003; Li et al., 2013; Brown et al., 2014); ours is the first in economics to study this topic. We show two sources of endogeneity when estimating the cross-spousal effect of education on health. The endogeneity of education arises not only from one's own unobserved endowment but also that of the spouse. We use unique CATS data to address both sources of endogeneity. Moreover, the cross-spousal effects of education on health found in our study are comparable to the effects of education on one's own health documented by previous studies (Kemptner et al., 2011; Behrman et al., 2015; Huang, 2015).[2] Therefore, neglecting the cross-spousal effect will substantially underestimate the overall contribution of education to health within the family and society.

Our finding of gender difference in the cross-spousal effect of education on health is intriguing. Studies on the external effect of education find that mothers' education is more important than fathers' education in fostering children's human capital, but husbands' education is more important than wives' in enhancing spousal wage (Huang et al., 2009; Holmlund et al., 2011). It appears that gender differences in the external effect of education are contextually dependent.

## 2. Data

### 2.1. The Chinese Adult Twins Survey

We use CATS to carry out our empirical analysis. CATS was conducted by the Urban Survey Unit of the National Bureau of Statistics in June and July 2002 in five cities in China: Chengdu, Chongqing, Haerbin, Hefei, and Wuhan.[3] To the best of our knowledge, CATS is the

[1] Since Becker (1973), early studies of assortative mating focus on one-dimensional matching on income, wage, or education. More recent literature investigates multidimensional matching in the marriage market. Chiappori et al. (2012) use a single index to summarize each person's multiple attributes. Matching between two individuals is then based on their indices. Chiappori et al. (2017) go beyond the index assumption by studying a two-dimensional matching model. In this model, everyone has two attributes: education and an indicator for smoking.

[2] Behrman et al. (2015) find that one additional year of schooling decreases own number of chronic diseases by 5.3 percentage points, using the same data source we use. Kemptner et al. (2011) exploit changes in compulsory schooling laws in Germany as an exogenous variation in education. They find that one additional year of schooling decreases the probability of overweight by 3.1 and 4.7 percentage points for men and women, respectively.

[3] All twins in this survey were born before the launch of the One-Child Policy, so "fake twins" are not a concern with our data (Huang et al., 2016).

**Table 1**
Summary statistics.

| Variable | Whole Sample | | Male Twin Sample | | Female Twin Sample | |
|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD |
| **Dependent Variables** | | | | | | |
| Spousal BMI Value (Survey Time) | 22.11 | 3.05 | 21.59 | 2.93 | 22.64 | 3.08 |
| Spousal Overweight Status (Survey Time) | 0.15 | 0.35 | 0.10 | 0.31 | 0.19 | 0.39 |
| Spousal No. of Chronic Diseases (Survey Time) | 0.56 | 1.10 | 0.61 | 1.19 | 0.51 | 1.01 |
| Spousal BMI Value (Wedding Time) | 20.02 | 2.49 | 19.69 | 2.38 | 20.36 | 2.54 |
| Spousal Overweight Status (Wedding Time) | 0.02 | 0.12 | 0.01 | 0.10 | 0.02 | 0.14 |
| Spousal No. of Chronic Diseases (Wedding Time) | 0.07 | 0.40 | 0.07 | 0.40 | 0.07 | 0.39 |
| Spousal Height (m) (Wedding Time) | 1.66 | 0.07 | 1.60 | 0.05 | 1.71 | 0.05 |
| **Interested Independent Variables** | | | | | | |
| Twins' Years of Schooling (Self-reported) | 11.45 | 2.68 | 11.25 | 2.79 | 11.65 | 2.55 |
| Twins' Years of Schooling (Cross-twin-reported) | 11.49 | 2.73 | 11.35 | 2.81 | 11.63 | 2.64 |
| **Characteristics of Twins and Their Spouses** | | | | | | |
| Twins' Age | 41.57 | 8.19 | 41.95 | 7.88 | 41.20 | 8.49 |
| Twins' Birth Weight (kg) | 2.36 | 0.65 | 2.42 | 0.70 | 2.30 | 0.58 |
| Twins' Monthly Income (Chinese yuan) | 783.43 | 555.53 | 898.28 | 602.16 | 668.36 | 478.12 |
| Spousal Age | 41.33 | 8.70 | 39.33 | 8.15 | 43.33 | 8.79 |
| Spousal Years of Schooling | 10.84 | 2.98 | 10.29 | 2.86 | 11.39 | 3.00 |
| Spousal Monthly Income (Chinese yuan) | 729.07 | 583.96 | 565.67 | 520.06 | 893.73 | 598.86 |
| Spousal Working Status | 0.62 | 0.48 | 0.53 | 0.50 | 0.72 | 0.45 |
| **No. of Twin Pairs** | 525 | | 263 | | 262 | |

Note: Data sources: CATS. The survey time is 2002. The wedding time is the year when the twin marries. BMI is defined as the body weight divided by the square of the body height, expressed as $kg/m^2$. *Overweight Status* is a dummy variable that equals 1 if the BMI is equal to or greater than 25 and zero otherwise. *Number of Chronic Diseases* is the number of chronic diseases twins' spouses have.

first household survey of adult twins in China. Through various channels, the survey collects information on households with adult twins aged between 18 and 65 years living in these five cities in 2002.[4] The dataset contains information on 2990 twins, of which 919 pairs are MZ twins and 576 pairs are dizygotic (DZ) twins. MZ twins result from the splitting of one fertilized egg, and are thus genetically identical (Ashenfelter and Krueger, 1994, p. 1158). DZ twins result from the fertilization of separate eggs at the same time. DZ twins resemble ordinary siblings in genetic similarity. Following the literature, we consider a pair of twins as MZ twins if they have the same hair color, appearance, and gender (Rosenzweig and Wolpin, 1980; Behrman et al., 2011). All questionnaires were completed through face-to-face personal interviews. For a detailed description of CATS, see Huang et al. (2009).

CATS uniquely fits our analysis. First, the twin data enable us to eliminate unobserved endowment within MZ twin pairs. Second, CATS covers an extensive array of socioeconomic information on adult twins and their spouses, including birth weight, consumption, income, and education. Third, in CATS, twins report not only their own schooling years, but also those of their siblings, which enables us to address the concern regarding measurement error in self-reported education. Finally, and most importantly, CATS contains detailed health information on twins and their spouses at both wedding and survey times.

Our estimation sample includes MZ twin pairs who are both married. In total, we obtain 525 pairs with complete information for our regression analysis, of which 263 pairs are male twins and 262 pairs are female twins.

### *2.2. Main variables and summary statistics*

#### *2.2.1. Health status at the survey time*

We construct two variables to measure the health of twins' spouses at the survey time. The first measures overweight status. Using self-reported height and weight, we calculate the BMI of twins' spouses.[5] We then define an indicator of spousal overweight status, which equals one if the BMI is equal to or greater than 25 and zero otherwise.[6] The medical literature has documented a strong association between BMI and health risk (Stommel and Schoenborn, 2010). People with higher BMI are more likely to suffer from chronic diseases such as hypertension, diabetes, coronary heart disease, asthma, and arthritis. In addition, a high risk of type 2 diabetes and cardiovascular disease reveals at lower BMI levels for Asian populations than European populations (Barba et al., 2004). Our measure of overweight status is a good indicator of health for the Chinese population. Table 1 shows that 15% of twins' spouses are overweight at the survey time, with a standard deviation of 0.35.

Our second measure is the number of chronic diseases at the survey time. CATS records 12 types of chronic diseases of twins and their spouses: hemicrania, hay fever, skin rash, hearing damage, hypertension, neurasthenia, alcohol addiction, cardiomyopathy, neck injury, dorsum injury, arm injury, and leg injury. The average number of chronic diseases that CATS records for twins' spouses is 0.56, with a standard deviation of 1.10.

#### *2.2.2. Health status at the wedding time*

We construct four variables to measure spousal health at the wedding time as proxy variables for spousal premarital health endowment. CATS records the height and weight of twins and their spouses not only at the survey time, but also at the wedding time. This allows us to calculate the BMI and construct an indicator of overweight status at the wedding time. CATS further records the age of onset for each of the 12 chronic diseases, which enables us to calculate the number of chronic diseases in the marriage year.

[4] These twins are identified through diverse channels, including colleagues, friends, relatives, newspaper advertising, neighborhood notices, neighborhood management committees, and household records from the local public security bureau.

[5] BMI is defined as body weight divided by the square of body height, expressed as $kg/m^2$.

[6] BMI is used to categorize people as underweight, normal weight, overweight, or obese. According to the customary BMI thresholds of the 1995 World Health Organization report, 25 is the commonly accepted cut-off point for being overweight.

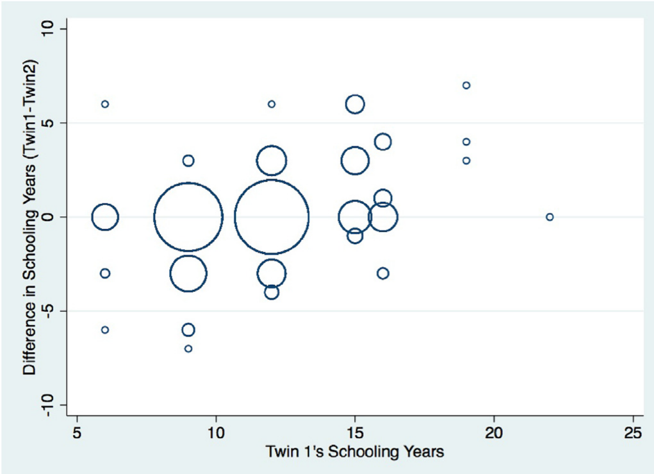


**Fig. 1.** Within-twin differences of schooling years by twin 1's schooling years.

The overweight status and number of chronic diseases may not sufficiently capture premarital health endowment, as most people are healthy at their marriage age. We therefore use BMI at the wedding time as the third variable, which is associated with people's health risk in the future as discussed above. Table 1 shows that the average BMI of twins' spouses at the wedding time is 20.02, with a standard deviation of 2.49. Moreover, we use spousal height at the wedding time as the fourth variable. Deaton (2008) points out that height is determined not only by genetic potential, but also by nutrition intake and the disease environment, especially during early childhood. Childhood disease or insufficient nutrition intake can prevent people from achieving their genetic potential in height, particularly for our sample twins and their spouses, who experienced China's Great Famine. Moreover, shorter people are more prone to chronic diseases in later life and are likely to die earlier (Deaton, 2007). So, height is a good indicator of premarital health endowment. Table 1 shows that the average height of twins' spouses is 1.66 m, with a standard deviation of 0.07.

### 2.2.3. Schooling years

CATS records two measures of schooling years for each twin. One is reported by the twins themselves, and the other by their co-twin. Table 1 shows that twins have an average schooling of 11.45 years as reported by themselves, and an average schooling of 11.49 years as reported by their co-twin. Within-twin FE estimation requires sufficient within-twin variation in education, which is present in our sample: Within-twin standard deviations account for about 71% of total standard deviations in twins' schooling years. Fig. 1 shows within-twin differences of schooling years. The average within-twin difference in schooling is nontrivial and amounts to 0.98 years. By contrast, the average increase in schooling years by compulsory schooling laws is 0.05 years in the US, 0.6 years in Germany, and 0.8 years in China (Lleras–Muney, 2005; Kemptner et al., 2011; Fang et al., 2012).

### 2.2.4. Socioeconomic and demographic characteristics

CATS contains rich socioeconomic and demographic information on twins and their spouses. Table 1 shows that the twins are around 42 years old on average, have an average birth weight of 2.36 kg, and they earn 783 RMB per month. Their spouses are 41 years old on average, have 10.8 years of schooling, and they earn 729 RMB per month.

## 3. Empirical strategy

We begin by considering the following equation:

$$y_{ij}^s = \alpha_0 + \alpha_1 * edu_{ij} + X_{ij}\alpha_2 + X_{ij}^s\alpha_3 + \mu_{ij} + \mu_{ij}^s + \epsilon_{ij}, \tag{1}$$

where $y_{ij}^s$ refers to the health of the spouse of twin $i(i = 1, 2)$ in pair $j(j = 1, \ldots, n)$ at the survey time. The variable $edu_{ij}$ measures schooling years of twin $i$. The vector $X_{ij}$ is a set of observed variables of twin $i$, including birth weight and city dummy variables. The vector $X_{ij}^s$ represents a set of observed variables of twin $i$'s spouse, including age and years of schooling. As spousal education might be endogenous, below we report the estimates of Equation (1) both without and with controlling for spousal education. The variable $\mu_{ij}$ represents twin $i$'s unobserved endowment related to both education and spousal health. The variable $\mu_{ij}^s$ represents twin $i$'s spouse's unobserved endowment related to both spousal health at the survey time and the twin's education. The error term $\epsilon_{ij}$ is *i.i.d.*

We are interested in the coefficient $\alpha_1$ in Equation (1). Conditional on all of the observed and unobserved variables, the coefficient $\alpha_1$ captures the cross-spousal effect of education on health.

Because both $\mu_{ij}$ and $\mu_{ij}^s$ are not observed, the OLS estimate of $\alpha_1$ in Equation (1) is generally biased. First, $\mu_{ij}$ may be correlated simultaneously with twins' education ($Cov(edu_{ij}, \mu_{ij}) \neq 0$) and spousal health ($Cov(y_{ij}^s, \mu_{ij}) \neq 0$). That is, twins' unobserved endowment (e.g., innate health, innate intellectual ability, or family background) may affect not only their educational attainment, but also spousal health after they marry. In such a case, the observed correlation between $y_{ij}^s$ and $edu_{ij}$ may capture the effect of twins' unobserved endowment on spousal health.

We use the within-twin FE model to eliminate $\mu_{ij}$. The two equations for health of spouses of twin 1 and twin 2 in pair $j$ are as follows:

$$y_{1j}^s = \alpha_0 + \alpha_1 * edu_{1j} + X_{1j}\alpha_2 + X_{1j}^s\alpha_3 + \mu_{1j} + \mu_{1j}^s + \epsilon_{1j}, \tag{2}$$

$$y_{2j}^s = \alpha_0 + \alpha_1 * edu_{2j} + X_{2j}\alpha_2 + X_{2j}^s\alpha_3 + \mu_{2j} + \mu_{2j}^s + \epsilon_{2j}. \tag{3}$$

Because MZ twins are genetically identical and have the same family background, we assume they have the same unobserved endowment ($\mu_{1j} = \mu_{2j}$). We examine the validity of this assumption in Section 4.3 below. Taking the difference between Equations (2) and (3), we have

$$\Delta y_j^s = \alpha_1 * \Delta edu_j + \Delta X_j\alpha_2 + \Delta X_j^s\alpha_3 + \Delta\mu_j^s + \Delta\epsilon_j. \tag{4}$$

The within-twin difference eliminates the unobserved $\mu_{ij}$.

Second, the difference in spousal unobserved endowment $\Delta\mu_j^s$ remains in Equation (4), which may still bias the within-twin FE estimate of $\alpha_1$. The identification assumption for the FE estimation is $Cov(\Delta edu_j, \Delta\mu_j^s) = 0$. Because of the mating effect, $Cov(\Delta edu_j, \Delta\mu_j^s)$ is not necessarily zero. For example, a person with more years of schooling may marry a partner with better endowment, which correlates with spousal health by definition. In Equation (1), the correlation between $edu_{ij}$ and $\mu_{ij}^s$ can operate through their correlations with $\mu_{ij}$. The within-twin difference eliminates $\mu_{ij}$, shutting down an important channel through which $edu_{ij}$ correlates with $\mu_{ij}^s$. If $edu_{ij}$ correlates with $\mu_{ij}^s$ only through $\mu_{ij}$, we have $Cov(\Delta edu_j, \Delta\mu_j^s) = 0$.

We use spousal health at the wedding time as a proxy for $\mu_{ij}^s$ to examine whether $Cov(\Delta edu_j, \Delta\mu_j^s) = 0$. Spousal health measured at the wedding time is a good indicator for pre-wedding health endowment, because the correlation between the BMI of the twins' spouses at the wedding time and survey time is 0.34, and the correlation is as high as 0.41 for the number of chronic diseases. Therefore, we re-estimate Equation (4) using spousal health at the wedding time as the dependent variable to directly examine the correlation between $\Delta edu_j$ and $\Delta\mu_j^s$. Moreover, we conduct two robustness checks. First, we control for spousal health at the wedding time in estimating Equation (4) to investigate whether the mating effect drives our within-twin FE estimates. Second, we examine the effect of education on the change in spousal health after the couple marries, by regressing the difference of spousal health between survey and wedding times on the twin's education.

Two concerns remain with the within-twin FE model. The first is the measurement error with twins' self-reported education, which may downward bias our within-twin FE estimates (Bound and Solon, 1999). We adopt the IV method proposed by Ashenfelter and Krueger (1994) to address this concern, using cross-twin-reported education as an IV for the twin's self-reported education (Section 4.2). The second is that the within-twin difference may not completely eliminate the unobserved endowment of twins in Equation (4) (Bound and Solon, 1999; Neumark, 1999). To address this issue, we control for the within-twin difference in birth weight when estimating Equation (4). Birth weight measures prenatal endowment and correlates with education, health, and earnings in adulthood (Behrman and Rosenzweig, 2004; Almond et al., 2005; Figlio et al., 2014). In case the within-twin difference not completely eliminate the unobserved endowment, we further compare the bias of the FE estimate with that of the OLS estimate following Ashenfelter and Rouse (1998) (Section 4).

Note that our empirical strategy is different from that of Huang et al. (2009). They aim to identify the productivity effect of spousal education on the twin's earnings. They use the twin's earnings as the dependent variable and spousal education as the independent variable in their main equation. They then use the within-twin difference to eliminate the genetic component in the twin's earnings to rule out the mating effect between spousal education and the twin's earning-related endowment. Their method ensures that the correlation between spousal education and the twin's earnings does not capture the mating effect. However, spousal education might be endogenous in the equation because it could be correlated with unobserved spousal characteristics, which are not considered in Huang et al. (2009). In contrast, we use twins' spouses' health at the survey time as the dependent variable and twins' education as the independent variable. We use the within-twin difference method to obtain exogenous variations in the twin's education, which is our independent variable of interest. We then examine the association between twins' education and their spousal health at the wedding time to address the concern regarding the mating effect.

## 4. Results

In this section, we report our empirical results. We first report OLS and within-twin FE estimates of the cross-spousal effect of education on health. Second, we conduct IV estimation to address potential measurement errors. Third, we discuss potential bias in the within-twin FE estimates. In all regressions, we conduct the estimation separately for the female sample (spouses of male twins) and male sample (spouses of female twins).

### 4.1. Basic results

In this subsection, we report OLS and within-twin FE estimates. Columns (1)–(2) and Columns (3)–(4) of Table 2 report OLS estimates of Equation (1) for female and male samples, respectively. Columns (1) and (3) do not control for spousal education, while Columns (2) and (4) control for spousal education. The dependent variables are the spousal overweight indicator and number of chronic diseases at the survey time in Panels A and B, respectively. Columns (1) and (2) show a statistically insignificant effect of the male twin's education on his wife's health. By contrast, Panel A, Column (4) shows that one more schooling year of the female twin is associated with a 1.7-percentage-point decrease in her husband's likelihood of being overweight. The estimate is statistically significant at the 5% level.

OLS estimates of $\alpha_1$ in Equation (1) may be biased when either $\mu_{ij}$ or $\mu_{ij}^s$ is unobserved. The magnitude and sign of this bias are not determined as a prior. As a first step, we eliminate $\mu_{ij}$ by estimating Equation (4) and report estimation results in Columns (5)–(8) of Table 2. Columns (5) and (7) do not control for spousal education, while Columns (6) and (8) control for spousal education. Again, Columns (5)–(6) show statistically insignificant effects of the male twin's education on his wife's overweight status and number of chronic diseases. In contrast, Columns (7)–(8) show that the estimated effect of the female twin's education on her husband's health is statistically significant. Specifically, Panel A, Column (8) shows that when the female twin's schooling increases by one year, her husband's probability of being overweight decreases by 4.6 percentage points. The effect is statistically significant at the 5% level. Panel B, Column (8) shows that one additional year of the female twin's schooling decreases her husband's number of chronic diseases by 15.5%. The effect is statistically significant at the 10% level.

Within-twin FE estimation results show that the cross-spousal effect of education on health differs by gender. We find strong evidence of a positive effect of wives' education on their husbands' health, but the effect of husbands' education on their wives' health is small and statistically insignificant. We explore the mechanism underlying the gender difference in Section 5.[7]

Our results show that OLS estimates are smaller than within-twin FE estimates in terms of absolute values, implying that $Cov(\mu_{ij}, edu_{ij})$ and $Cov(\mu_{ij}, y_{ij}^s)$ have opposite signs. This possibility arises when we consider that either the parental investment strategy differs across different dimensions of human capital or the marriage matching pattern differs for different attributes. By modeling the multidimensionality of human capital, for example, Yi et al. (2015) show evidence that parents compensate for and reinforce investments in different dimensions of human capital across children. The differences between our OLS estimates and within-twin FE estimates are certainly subject to alternative interpretations.

### 4.2. Measurement errors and IV estimation

Before investigating the mating effect caused by $\Delta\mu_j^s$ in Equation (4), in this subsection we examine potential measurement errors associated with twins' self-reported education. In CATS, a twin not only reports own schooling years, but also the schooling years of his or her co-twin. We use the instrumental variable fixed-effect (IVFE) method developed by Ashenfelter and Krueger (1994) to address the measurement-error problem.

Denote $Z_i^k$ twin $i$'s schooling years reported by twin $k$ ($k = 1, 2$). We use the difference in self-reported education ($Z_1^1 - Z_2^2$) as the regressor in Equation (4), which is instrumented by the difference in cross-reported education ($Z_1^2 - Z_2^1$). The identification assumption for this IV estimation method is that the measurement errors in $Z_1^1 - Z_2^2$ and $Z_1^2 - Z_2^1$ are uncorrelated. We call this IV estimation method IVFE-1.

If the measurement errors in $Z_1^1 - Z_2^2$ and $Z_1^2 - Z_2^1$ are correlated, IVFE-1 estimates are biased. Following Ashenfelter and Krueger (1994) and Huang et al. (2009), we use the difference in schooling years reported by twin 1 ($Z_1^1 - Z_2^1$) as the regressor in Equation (4), which is instrumented by the difference in schooling years reported by twin 2 ($Z_1^2 - Z_2^2$). We call this method IVFE-2, which eliminates the individual-specific components of the measurement errors. We take IVFE-2 as our preferred specification. In our sample, the correlation coefficient between $Z_1^1$ and $Z_1^2$ is 0.918, and that between $Z_2^2$ and $Z_2^1$ is 0.952. The first-stage F-statistics for both IVFE-1 and IVFE-2 estimations are above 20.

Table 3 shows both the IVFE-1 and IVFE-2 estimation results. Columns (1) and (2) of Table 3 report the IVFE-1 estimates of Equation (4) for female and male samples, respectively. Similarly, Columns (3) and (4) of Table 3 report the IVFE-2 estimates of Equation (4) for female and male samples, respectively. We use the spousal overweight indicator and number of chronic diseases at the survey time as dependent variables in Panels A and B, respectively.

In Columns (1) and (3) of Table 3, we find that the male twin's education lowers his wife's probability of being overweight, but we do not

[7] We refer the readers to Behrman et al. (2015), who also use the same CATS data, look at the effects of education on own health.

**Table 2**
Education and spousal health at the survey time, OLS and fixed-effect estimates.

| | OLS Estimation | | | | Fixed-effect Estimation | | | |
|---|---|---|---|---|---|---|---|---|
| | Female Sample (Spouses of Male Twins) | | Male Sample (Spouses of Female Twins) | | Female Sample (Spouses of Male Twins) | | Male Sample (Spouses of Female Twins) | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | Panel A. Dependent Variable: Twins' Spouses' Overweight Status at the Survey Time | | | | | | | |
| Twins' Education | −0.000 | −0.003 | −0.012 | −0.017** | −0.017 | −0.019 | −0.043** | −0.046** |
| | (0.004) | (0.005) | (0.008) | (0.008) | (0.013) | (0.012) | (0.020) | (0.020) |
| Spousal Education | No | Yes | No | Yes | No | Yes | No | Yes |
| Mean (depvar) | 0.10 | | 0.19 | | 0.10 | | 0.19 | |
| | Panel B. Dependent Variable: Twins' Spouses' Number of Chronic Diseases at the Survey Time | | | | | | | |
| Twins' Education | −0.019 | −0.013 | 0.005 | 0.012 | 0.003 | 0.020 | −0.082* | −0.079* |
| | (0.016) | (0.021) | (0.013) | (0.015) | (0.045) | (0.044) | (0.044) | (0.044) |
| Spousal Education | No | Yes | No | Yes | No | Yes | No | Yes |
| Mean (depvar) | 0.61 | | 0.51 | | 0.61 | | 0.51 | |
| No. of Twin Pairs | 263 | | 262 | | 263 | | 262 | |

Note: Columns (1)–(4) control for twins' birth weight, spousal age, and city dummies. Columns (5)–(8) control for twins' birth weight and spousal age. Additionally, Columns (2), (4), (6), (8) control for spousal education. Columns (1)–(2) and Columns (3)–(4) reports OLS estimates for female and male samples, respectively. Columns (5)–(6) and Columns (7)–(8) reports FE estimates for female and male samples, respectively. In Panels A and B, dependent variables are *Twins' Spouses' Overweight Status* and *Twins' Spouses' Number of Chronic Diseases*, respectively. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

**Table 3**
Education and spousal health at the survey time, IVFE estimates.

| | IVFE-1 | | IVFE-2 | |
|---|---|---|---|---|
| | Female Sample (Spouses of Male Twins) | Male Sample (Spouses of Female Twins) | Female Sample (Spouses of Male Twins) | Male Sample (Spouses of Female Twins) |
| | (1) | (2) | (3) | (4) |
| | Panel A. Dependent Variable: Twins' Spouses' Overweight at the Survey Time | | | |
| Twins' Education | −0.026* | −0.054** | −0.035** | −0.052** |
| | (0.015) | (0.023) | (0.017) | (0.022) |
| Controls | Yes | Yes | Yes | Yes |
| Mean (depvar) | 0.10 | 0.19 | 0.10 | 0.19 |
| | Panel B. Dependent Variable: Twins' Spouses' Number of Chronic Diseases at the Survey Time | | | |
| Twins' Education | 0.010 | −0.089* | −0.006 | −0.086* |
| | (0.052) | (0.050) | (0.051) | (0.050) |
| Controls | Yes | Yes | Yes | Yes |
| Mean (depvar) | 0.61 | 0.51 | 0.61 | 0.51 |
| No. of Twin Pairs | 263 | 262 | 263 | 262 |

Note: All regressions control for twins' birth weight, spousal age, and spousal schooling years. Columns (1) and (2) report IVFE-1 estimates for female and male samples, respectively. Columns (3) and (4) report IVFE-2 estimates for female and male samples, respectively. In Panels A and B, dependent variables are *Twins' Spouses' Overweight Status* and *Twins' Spouses' Number of Chronic Diseases*, respectively. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

detect a statistically significant effect of the male twin's education on his wife's number of chronic diseases. Specifically, Panel A, Column (3) of Table 3 shows that as the male twin's schooling increases by one year, his wife's probability of being overweight decreases by 3.5 percentage points. The estimate is statistically significant at the 5% level. Columns (2) and (4) of Table 3 shows that the estimated effects of the female twin's education on her husband's overweight status and number of chronic diseases are all statistically significant. Specifically, Panel A, Column (4) of Table 3 shows that as the female twin's schooling increases by one year, her husband's probability of being overweight decreases by 5.2 percentage points. Panel B, Column (4) of Table 3 shows that one more schooling year of the female twin also reduces her husband's number of chronic diseases by 16.9%. Both estimates are statistically significant at least at the 10% level. These results are consistent with our previous finding that the effect of wives' education on husbands' health is larger than the effect of husbands' education on wives' health.

### 4.3. Omitted variable bias

If within-twin difference did not completely eliminate twins' unobserved endowment, our estimates of $\alpha_1$ in Equation (4) are biased (Ashenfelter and Rouse, 1998; Bound and Solon, 1999; Neumark, 1999). Given this concern, we control for within-twin difference in birth weight, which is an important determinant of life-cycle outcomes (Behrman and Rosenzweig, 2004; Almond et al., 2005; Figlio et al., 2014). The remaining within-twin difference in prenatal endowment should be less of a concern in estimating Equation (4).

We build on Ashenfelter and Rouse (1998) to compare the potential bias in our within-twin FE estimates with that in the OLS estimates. Consider the equation,

$$y = \alpha + \beta x + \lambda \mu + \varepsilon,$$

where $y$ is the outcome variable, $x$ is education, and $\mu$ is the unobserved endowment. For simplicity, we suppress the control variables. The estimated equation without $\mu$ is,

$$y = \alpha^{bias} + \beta^{bias} x + \xi,$$

**Table 4**
Evaluating the omitted variable bias.

| | OLS Regression | | Within-twin FE Regression | | *BiasFE/BiasOLS* |
|---|---|---|---|---|---|
| | Coefficient | Std. Error | Coefficient | Std. Error | |
| Self-employed | −0.021*** | 0.004 | −0.010 | 0.008 | – |
| Log Wage | 0.085*** | 0.008 | 0.055** | 0.024 | 0.65 |
| Years of Job Tenure | 0.105 | 0.067 | 0.131 | 0.144 | – |
| Spousal Years of Schooling | 0.531*** | 0.033 | 0.256*** | 0.071 | 0.48 |

Note: We regress the four proxies on twins' years of schooling using OLS and within-twin FE models. We obtain an estimate of $\frac{BiasFE}{BiasOLS}$ for each proxy. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Using the formulae of omitted-variable bias, we obtain,

$$BiasOLS = \beta^{bias} - \beta = \lambda\theta_{\mu x}, \quad (5)$$

where $\theta_{\mu x}$ captures the association between $x$ and $\mu$, with $\mu = \delta + \theta_{\mu x}x + v$.

Then consider the within-twin FE model,

$$\Delta y = \beta\Delta x + \lambda\Delta\mu + \Delta\epsilon,$$

where $\Delta$ is the operator of the within-twin difference. A similar derivation gives,

$$BiasFE = \lambda\theta_{\Delta\mu\Delta x}, \quad (6)$$

where $\theta_{\Delta\mu\Delta x}$ is defined by $\Delta\mu = \theta_{\Delta\mu\Delta x}\Delta x + \tau$.

Combining Equations (5) and (6), we obtain the relative size of the biases in the within-twin FE specification compared with that in the OLS specification.

$$\frac{BiasFE}{BiasOLS} = \frac{\theta_{\Delta\mu\Delta x}}{\theta_{\mu x}},$$

To estimate $\frac{BiasFE}{BiasOLS}$, we need proxy variables of the unobserved endowment $\mu$. Suppose that $p$ is a proxy of $\mu$, Then,

$$p = \pi_0 + \pi_1(\delta + \theta_{\mu x}x + v) + \epsilon = \pi_0 + \pi_1\delta + \pi_1\theta_{\mu x}x + \pi_1 v + \epsilon,$$

where $\theta_{px} = \pi_1\theta_{\mu x}$ can be estimated from a regression of $p$ on $x$. Similarly,

$$\Delta p = \pi_1\Delta\mu + \Delta\epsilon = \pi_1(\theta_{\Delta\mu\Delta x}\Delta x + \tau) + \Delta\epsilon, = \pi_1\theta_{\Delta\mu\Delta x}\Delta x + \pi_1\tau + \Delta\epsilon,$$

where $\theta_{\Delta p\Delta x} = \pi_1\theta_{\Delta\mu\Delta x}$ can be estimated from a regression of $\Delta p$ on $\Delta x$. Given that $\frac{\theta_{\Delta p\Delta x}}{\theta_{px}} = \frac{\theta_{\Delta\mu\Delta x}}{\theta_{\mu x}}$, we can use $\frac{\hat{\theta}_{\Delta p\Delta x}}{\hat{\theta}_{px}}$ as an estimate of $\frac{BiasFE}{BiasOLS}$.

In the within-twin specification, Ashenfelter and Rouse (1998) used five proxies of $\mu$: "married," "self-employed," "covered by a union," "years of job tenure," and "spousal years of schooling." The selection criterion is that the variables need to be correlated with the unobserved endowment ($\pi_1 \neq 0$). Our empirical design requires a sample of married people. We do not use "married" as a proxy for unobserved endowment. Following Ashenfelter and Rouse (1998), we choose "self-employed," "log wage," "years of job tenure," and "spousal years of schooling" to proxy for unobserved endowment. For each proxy, we obtain an estimate of $\frac{BiasFE}{BiasOLS}$.

As shown in Table 4, "years of job tenure" does not appear to correlate with twins' education in FE or OLS regressions, suggesting that "years of job tenure" is not a good proxy for the unobserved endowment in our sample. The other three variables present statistically significant correlations with twins' education in the OLS regressions. For "log wage" and "spousal years of schooling," the correlations are smaller in magnitude but remain statistically significant in the FE regressions. The ratio $\frac{BiasFE}{BiasOLS}$ is 0.65 for "log wage" and 0.48 for "spousal years of schooling." For "self-employed," the correlations become smaller and statistically insignificant in the FE regressions. Overall, compared with the OLS specification, the FE specification significantly reduces the bias.

## 5. Discussions

### 5.1. Mating effect

In this subsection, we examine whether the mating effect drives our within-twin FE estimates of the cross-spousal effect of education on health. As discussed in the introduction, Chinese couples usually do not live together before getting married. The correlation between one's education and spousal health at the wedding time, therefore, mainly reflects the mating effect rather than the cross-spousal effect of education on health. Therefore, if the mating effect drives our within-twin FE estimates, we should observe a statistically significant correlation between the within-twin difference in twins' schooling years and the within-twin difference in their spouses' health measured at the wedding time. We directly examine the correlation between the difference in twins' schooling years and the difference in their spouses' health at the wedding time.

We re-estimate Equation (4), using four variables measuring spousal health at the wedding time as the dependent variables. Columns (1) and (2) of Table 5 report IVFE-1 estimates for female and male samples, respectively. Columns (3) and (4) of Table 5 report IVFE-2 estimates for female and male samples, respectively. Dependent variables are the spousal overweight indicator, spousal number of chronic diseases, spousal BMI, and spousal height at the wedding time. All estimates, except for the two estimates of male spouses' overweight status, are statistically insignificant at the 10% level. Female twins' schooling years are positively correlated with spousal overweight status, and the estimates are statistically significant at the 10% level (Panel A, Columns (2) and (4)). However, the magnitudes of the estimates are small and the sign of the estimates is opposite to the estimated cross-spousal effect of the female twin's education on her husband's overweight status at the survey time. When we use spousal BMI and spousal height as the dependent variables, the estimates are almost zero (Panels C and D). These results suggest that the mating effect has been well addressed by our within-twin FE method.

We conduct two robustness checks to further verify that the mating effect has been well addressed by the within-twin FE model. First, we control for spousal health at the wedding time in the estimation of Equation (4). For each health outcome at the survey time as the dependent variable, we control for the corresponding health measure at the wedding time as an independent variable.[8] Columns (1) and (2) of Table 6 show IVFE-1 estimates for female and male samples, respectively. Columns (3) and (4) of Table 6 show IVFE-2 estimates for female and male samples, respectively. We find that the magnitudes and statistical significance of estimates of $\alpha_1$ remain almost unchanged after controlling for spousal health at the wedding time.

Second, we examine whether twins' education affects the change in spousal health after they marry, using the difference in spousal health

[8] Alternatively, we control for all four health measures at the wedding time at the same time (Table A1 in the Appendix). The results change little either we control for one health measure at a time or for four health measures at the same time.

**Table 5**
Education and spousal health at the wedding time, IVFE estimates.

| | IVFE-1 | | IVFE-2 | |
|---|---|---|---|---|
| | Female Sample (Spouses of Male Twins) | Male Sample (Spouses of Female Twins) | Female Sample (Spouses of Male Twins) | Male Sample (Spouses of Female Twins) |
| | (1) | (2) | (3) | (4) |
| | Panel A. Dependent Variable: Twins' Spouses' Overweight Status at the Wedding Time | | | |
| Twins' Education | −0.0003 | 0.0102* | −0.0003 | 0.0105* |
| | (0.0064) | (0.0055) | (0.0068) | (0.0056) |
| Controls | Yes | Yes | Yes | Yes |
| Mean (depvar) | 0.01 | 0.02 | 0.01 | 0.02 |
| | Panel B. Dependent Variable: Twins' Spouses' Number of Chronic Diseases at the Wedding Time | | | |
| Twins' Education | 0.0119 | 0.0113 | 0.0161 | 0.0044 |
| | (0.0224) | (0.0196) | (0.0238) | (0.0191) |
| Controls | Yes | Yes | Yes | Yes |
| Mean (depvar) | 0.07 | 0.07 | 0.07 | 0.07 |
| | Panel C. Dependent Variable: Twins' Spouses' BMI Value at the Wedding Time | | | |
| Twins' Education | 0.050 | −0.108 | 0.077 | −0.131 |
| | (0.148) | (0.129) | (0.158) | (0.125) |
| Controls | Yes | Yes | Yes | Yes |
| Mean (depvar) | 19.69 | 20.36 | 19.69 | 20.36 |
| | Panel D. Dependent Variable: Twins' Spouses' Height at the Wedding Time | | | |
| Twins' Education | 0.0019 | 0.0022 | 0.0026 | 0.0021 |
| | (0.0020) | (0.0025) | (0.0023) | (0.0024) |
| Controls | Yes | Yes | Yes | Yes |
| Mean (depvar) | 1.60 | 1.71 | 1.60 | 1.71 |
| No. of Twin Pairs | 263 | 262 | 263 | 262 |

Note: All regressions control for twins' birth weight, spousal age at the wedding time, and spousal schooling years. Columns (1) and (2) reports IVFE-1 estimation results for female and male samples, respectively. Columns (3) and (4) reports IVFE-2 estimation results for female and male samples, respectively. In Panels A, B, C, and D, dependent variables are *Twins' Spouses' Overweight Status*, *Twins' Spouses' Number of Chronic Diseases*, *Twins' Spouses' BMI*, and *Twins' Spouses' Height*, respectively. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

**Table 6**
Education and spousal health at the survey time, IVFE estimates with wedding-time health controls.

| | IVFE-1 | | IVFE-2 | |
|---|---|---|---|---|
| | Female Sample (Spouses of Male Twins) | Male Sample (Spouses of Female Twins) | Female Sample (Spouses of Male Twins) | Male Sample (Spouses of Female Twins) |
| | (1) | (2) | (3) | (4) |
| | Panel A. Dependent Variable: Twins' Spouses' Overweight Status at the Survey Time | | | |
| Twins' Education | −0.026* | −0.060*** | −0.035** | −0.058*** |
| | (0.015) | (0.024) | (0.017) | (0.023) |
| Spouse's Wedding-time Health | Yes | Yes | Yes | Yes |
| Mean (depvar) | 0.10 | 0.19 | 0.10 | 0.19 |
| | Panel B. Dependent Variable: Twins' Spouses' Number of Chronic Diseases at the Survey Time | | | |
| Twins' Education | −0.004 | −0.103** | −0.025 | −0.091** |
| | (0.050) | (0.045) | (0.048) | (0.044) |
| Spouse's Wedding-time Health | Yes | Yes | Yes | Yes |
| Mean (depvar) | 0.61 | 0.51 | 0.61 | 0.51 |
| No. of Twin Pairs | 263 | 262 | 263 | 262 |

Note: All regressions control for twins' birth weight, spousal age, spousal schooling years, and the corresponding health measure of the spouse at the wedding time. Columns (1) and (2) report IVFE-1 estimates for female and male samples, respectively. Columns (3) and (4) report IVFE-2 estimates for female and male samples, respectively. In Panels A and B, dependent variables are *Twins' Spouses' Overweight Status* and *Twins' Spouses' Number of Chronic Diseases*, respectively. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

between the survey time and wedding time as the dependent variable in Equation (4). Table A2 reports the estimation results. Columns (1) and (2) of Table A2 show IVFE-1 estimates for female and male samples, respectively. Columns (3) and (4) of Table A2 show IVFE-2 estimates for female and male samples, respectively. The magnitudes and statistical significance of estimates of $\alpha_1$ are very similar to the corresponding results in Table 3.

Although we do not detect statistically significant effects of education on spousal health at the wedding time, and the change of spousal health between wedding and survey time is responsive to education, we cannot fully rule out the mating effect. The potential husband and wife, although not living together before marriage, may have close interactions, and they know each other's health way better than what reflected by our four static measures. More importantly, even the four static mea-

**Table 7**
Two groups of diseases.

| | IVFE-1 | | IVFE-2 | |
|---|---|---|---|---|
| | Female Sample (Spouses of Male Twins) | Male Sample (Spouses of Female Twins) | Female Sample (Spouses of Male Twins) | Male Sample (Spouses of Female Twins) |
| | (1) | (2) | (3) | (4) |
| | Panel A. Dependent Variable: Twins' Spouses' Number of Group-One Diseases | | | |
| Twins' Education | −0.002 | −0.011 | −0.004 | −0.014 |
| | (0.020) | (0.011) | (0.021) | (0.012) |
| Spouse's Wedding-time Health | Yes | Yes | Yes | Yes |
| Mean (depvar) | 0.11 | 0.08 | 0.11 | 0.08 |
| | Panel B. Dependent Variable: Twins' Spouses' Number of Group-Two Diseases | | | |
| Twins' Education | −0.003 | −0.092** | −0.022 | −0.078** |
| | (0.039) | (0.041) | (0.039) | (0.039) |
| Spouse's Wedding-time Health | Yes | Yes | Yes | Yes |
| Mean (depvar) | 0.50 | 0.43 | 0.50 | 0.43 |
| No. of Twin Pairs | 263 | 262 | 263 | 262 |

Note: All regressions control for twins' birth weight, spousal age, spousal schooling years, and spousal number of chronic diseases at the wedding time. Columns (1) and (2) report IVFE-1 estimates for female and male samples, respectively. Columns (3) and (4) report IVFE-2 estimates for female and male samples, respectively. Group-one diseases include hay fever, arm injury, leg injury, and hearing damage. Group-two diseases include hemicrania, skin rash, hypertension, neurasthenia, alcohol addiction, cardiomyopathy, neck injury, and dorsum injury. In Panels A and B, dependent variables are *Twins' Spouses' Number of Group-One Diseases* and *Twins' Spouses' Number of Group-Two Diseases*, respectively. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

sures are the same across couples, the future health status could be quite different. The potential spouses should have some information on each other's future health status. A complete evaluation of the mating effect requires health measures beyond our four static variables.[9]

To further evaluate the mating effect, we divide the 12 chronic diseases into two groups. Group-one diseases are largely unresponsive to health behaviors, including hay fever, arm injury, leg injury, and hearing damage. Group-one diseases are either genetically encoded or mainly caused by accidents. We take the other diseases as group-two diseases, which are at least partly caused by unhealthy behaviors or the environment. We discuss the classification of the 12 diseases in Appendix A.

The mating effect would be weakened if education affects the spouses' number of group-two diseases, but not that of group-one diseases. Table 7 shows the IVFE estimates of the effect of education on the number of group-one and group-two diseases at the survey time. We do not detect a statistically significant effect of education on the number of group-one diseases for both the female and male samples (Panel A). We find that one additional year of the female twin's schooling decreases her husband's number of group-two diseases by 21.4% or 18.1% (columns (2) and (4) of Panel B). The effects are statistically significant at the 5% level. We also employ an alternative classification. We move hemicrania and cardiomyopathy, which have clear genetic roots, from group two to group one to balance the number of diseases in the two groups. The estimates remain robust under the alternative classification (Table A3 in the Appendix).

In summary, the estimation results consistently suggest that the mating effect is unlikely to drive the estimates of the within-twin FE model. We conclude that estimates of $\alpha_1$ in Equation (4) using spousal health at the survey time as the dependent variable capture the cross-spousal effect of education on health.

### 5.2. Labor market conditions

Better-educated people have higher income or better jobs, which provides their family with better living conditions and healthcare services (Cutler et al., 2008; Cutler and Lleras-Muney, 2010). To examine whether the income effect drives our results, we control for within-twin differences in the monthly incomes of both the twins and their spouses in Equation (4). Our estimates of $\alpha_1$ remain almost the same when we include these income controls (Table A4). The results suggest that the income effect is not the main driver of the cross-spousal effect. From a policy perspective, unconditional monetary transfer may not achieve the same effect on health as education subsidy does (Cutler et al., 2008).

However, the correlation between contemporaneous and permanent income can be far below one. Following Fan et al. (2020), we calculate the correlation between contemporaneous income and permanent income in China for the cohorts in our sample. We use the 2010, 2012, 2014, and 2016 waves of the China Family Panel Studies to compute a four-wave average income as a proxy for permanent income for the 1947–1985 cohorts. We find that the correlation between the permanent income and the contemporaneous income in China is 0.54. Controlling for contemporaneous income leaves open the possibility that permanent income is a driver.

Better-educated individuals may marry people with better jobs that pay higher wages, provide better health insurance, and offer safer work environments. To further examine whether twins' spouses' job characteristics may affect our results, we add controls for spousal labor force participation status and occupational categories in Equation (4).[10] Table A5 reports the results. The coefficients on twins' schooling years change little after we control for these additional variables. Although controlling for income and occupation does not fully rule out the labor

[9] We thank two anonymous referees for pointing out that the tests using the four wedding-time health measures cannot fully rule out the mating effect. The two referees also suggest the classification of the 12 chronic diseases into two groups, which we discuss in the next paragraph.

[10] The occupation variable in our data only has eight categories: 1, Various kind of specialized technical personnel; 2, Heads of state organs, party and mass organizations, and enterprises and institutional units; 3, Clerks and managers; 4, People engaged in commerce; 5, People engage in service work; 6, Labors engage in farming, forestry, animal husbandry and fishery works and operation of farm machines and hunting; 7, Production workers, transportation workers and related personnel; 8, Other workers unsuitable for classification.

**Table 8**
Cigarettes and alcohol at the survey time.

| | Male Sample (Spouses of Female Twins) | |
|---|---|---|
| | IVFE-1 (1) | IVFE-2 (2) |
| Twins' Education | −0.081 | −0.092* |
| | (0.056) | (0.055) |
| Twins' and Spouses' Income | Yes | Yes |
| Controls | Yes | Yes |
| Mean (depvar) | 4.736 | |
| No. of Twin Pairs | 138 | 138 |

Note: All regressions control for spousal age and schooling years. The dependent variable is *Logarithm of Twins' Spouses' Monthly Spending on Cigarettes and Alcohol*. Column (1) (Column (2)) reports IVFE-1 (IVFE-2) estimates of the effect of female twins' education on their husbands' spending on cigarettes and alcohol. Because very few females smoke or drink alcohol in China, we only focus on the effect of female twins' education on their husbands' consumption. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

market channel, the results suggest that labor market conditions are not of first-order importance behind the cross-spousal effect of education on health.

### 5.3. Bargaining power

This section examines whether education changes the bargaining power within a household, which may serve as a mechanism underlying the cross-spousal effect of education on health. First, we estimate the effect of education on spousal monthly spending on cigarettes and alcohol. We only focus on the effect of wives' education on their husbands' spending, as few females smoke or drink alcohol in China.[11] Columns (1) and (2) of Table 8 report IVFE-1 and IVFE-2 estimates, respectively. IVFE-2 estimates show that one more schooling year of wives reduces their husbands' consumption of cigarettes and alcohol by 9.2%, and the estimate is statistically significant at the 10% level. The results are consistent with the gender-differentiated consumption of unhealthy goods. As females consume healthier goods than males do, an increase in the bargaining power of wives reduces their husbands' purchase and consumption of unhealthy goods.

Second, we examine the cross-spousal effect of education on exercise frequency. As CATS only provides information on exercise for the twins, we examine the effect of twins' spouses' education on twins' exercise frequency.[12] Columns (1) and (2) of Table 9 report IVFE-1 estimates for male twins and female twins, respectively. Columns (3) and (4) of Table 9 report IVFE-2 estimates for male twins and female twins, respectively. Columns (1) and (3) show that the estimated effect of the female spouse's education on her husband's exercise frequency is statistically significant. Specifically, Column (3) of Table 9 shows that one more schooling year of the wife increases her husband's exercise frequency by 0.34 times per month. The estimate is statistically significant at the 10% level. By contrast, Columns (2) and (4) suggest that the effect of husbands' schooling on their wives' exercise frequency is not only statistically insignificant but also small in magnitude. The results

[11] According to statistics published by the Chinese Center for Disease Control and Prevention in 2015, 52.1% of male adults smoke, but only 2.7% of female adults do. Based on the National Nutrition and Health Survey in 2002, 39.6% of male adults drink alcohol, but only 4.5% of female adults do.

[12] Exercise frequency is defined as the number of times per month that the twin does exercise. According to the survey question in CATS, the duration of the exercise should be above 30 min.

**Table 9**
Spousal education and Twin's exercise frequency at the survey time.

| | IVFE-1 | | IVFE-2 | |
|---|---|---|---|---|
| | Male Twins | Female Twins | Male Twins | Female Twins |
| | (1) | (2) | (3) | (4) |
| Spouse's Education | 0.363* | 0.096 | 0.335* | 0.099 |
| | (0.192) | (0.169) | (0.194) | (0.171) |
| Controls | Yes | Yes | Yes | Yes |
| Mean (depvar) | 4.411 | 5.239 | 4.411 | 5.239 |
| No. of Twin Pairs | 261 | 259 | 261 | 259 |

Note: All regressions control for twins' schooling years and birth weight. The dependent variable is *The Number of Times per Month that Twins Do Exercise*. Columns (1) and (2) (Columns (3) and (4)) report IVFE-1 (IVFE-2) estimates of the effect of spousal education on twins' exercise frequency, for male twins and female twins, respectively. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

are consistent with a bargaining power story. Education puts the wife in a better bargaining position. Taking divorce as a threat point, the husband may want to keep healthy or look fit to be competitive in the (re)marriage market.

The gender pattern of the effect of education on spousal consumption and exercise is consistent with our previous results on health outcomes. The cross-spousal effect of wive's education on husbands' health works through the channel of intra-household bargaining.

### 5.4. Information sharing

Studies on the education gradient suggest that better-educated people are more likely to acquire health knowledge, and make efficient use of the knowledge (Grossman, 1972, 2006; Cutler et al., 2008; Cutler and Lleras-Muney, 2010). Although we have no direct measures of health knowledge by education in China, we examine the proportion of the smoking population by education level. We use the 2010 wave of the China Family Panel Study, a national representative survey implemented by the Peking University. As shown in Figs. A1 and A2, better-educated people are less likely to smoke.

Husbands can benefit from wives' education by sharing the health knowledge of wives. Although information sharing is a potentially important channel, we do not have strong evidence on the behaviors by the wife to help out her husband. The data do not allow a direct examination of the information sharing mechanism.

## 6. Conclusion

We find that wives' education reduces husbands' consumption on cigarettes and alcohol, increases exercise frequency, lowers the probability of being overweight, and decreases the number of chronic diseases. We also find that husbands' education enhances wives' health, but the evidence is weak. In our study, the endogeneity of education arises not only from one's own unobserved endowment but also that of the spouse. It's challenging to fully address both sources of endogeneity. Combining (*i*) the within-twin FE estimator, (*ii*) the unique design of CATS, which collects health information for twins and their spouses at both wedding and survey times, and (*iii*) the Chinese marriage tradition, ours is the first study to address both sources of endogeneity and estimate the cross-spousal effect of education on health. Specifically, we address the first source of endogeneity using the within-twin FE method and examine the second using unique health information at both wedding and survey times. The external validity of our study may remain a concern because we use a twin sample from China, where couples are traditionally introduced to each other by their parents or relatives. The mating effect of one's education on spousal health may be less significant in China than other societies, and the within-twin difference further mitigates the concern regarding the mating effect. Further research on the cross-spousal effect of education within the household in societies other than China is warranted.

Our estimated effect of education on spousal health is sizable, and comparable to the effect of education on own health (Kemptner et al., 2011; Behrman et al., 2015). The results imply that focusing on the effect of education on own health would largely overlook the overall effects of education on health in a society, and in particular the cross-spousal effect of wives' education on husbands' health. Finally, in light of recent literature on positive assortative mating in education, our estimated cross-spousal effect has profound implications for health inequality across households (Eika et al., 2018).

## Author statement

**Rufei Guo:** Methodology, Writing - review & editing. **Lin Lin:** Formal analysis, Writing - original draft. **Junjian Yi:** Conceptualization, Writing - original draft. **Junsen Zhang:** Investigation, Writing - review & editing.

## Appendix A. Classification of chronic diseases

We look at the nature of each of the 12 diseases. We have consulted medical experts and leveraged on common sense to check to what extent each disease is responsive to health behaviors. We divide the 12 chronic diseases into two groups. Group-one diseases are largely unresponsive to health behaviors, including hay fever, arm injury, leg injury, and hearing damage. Group-one diseases are either genetically encoded or mainly caused by accidents. Group-two diseases are at least partly caused by unhealthy behaviors or the environment, including hemicrania, skin rash, hypertension, neurasthenia, alcohol addiction, cardiomyopathy, neck injury, and dorsum injury. We also employ an alternative classification. To balance the number of diseases in the two groups, we select two diseases from group two which are less susceptible to behavioral change than the others and move them to group one. The two diseases are hemicrania and cardiomyopathy.

Hemicrania is a kind of unilateral headache. Although the exact cause of hemicrania is still unclear, a combination of genetic and behavioral factors is believed to cause hemicrania. Medical researchers believe it is highly heritable. Some food and medicine, as well as overwork and overstress, may trigger this disease. We classify hemicrania as a group-two disease in the baseline classification, and move hemicrania to group one in a robustness test.

Hypertension also results from a complicated interaction of genes and environmental factors. Bad lifestyles, such as excess salt in the diet, excess body weight, smoking, and alcohol use, will largely increase the risk of hypertension. We classify hypertension as a group-two disease.

Hay fever is typically triggered by environmental allergens such as pollen. Inherited genetics and environmental exposures contribute to the development of allergies. However, the environmental exposures cannot be fully avoided by individual effort. Therefore, hay fever is classified as a group-one disease.

The common triggers of skin rashes include food allergy, medication side effects, solarization, and poor personal hygiene. Unlike the environmental triggers of hay fever, the triggers of skin rash can be effectively prevented with medical knowledge and good living habits. In our questionnaire, the respondents are required to report having skin rash only when they frequently suffer from this disease. We classify skin rash as a group-two disease.

Hearing damage has multiple causes, including genetics and acquired causes like noise and disease. Noise exposure is the cause of approximately half of all cases of hearing damage. The other half of the cases show a high degree of heritability. We classify hearing damage as a group-one disease.

Neurasthenia is a persistent mental disorder with symptoms of weakness, anxiety, tension-induced pain, and sleep disturbances. Mental and environmental factors are believed to drive neurasthenia. We classify neurasthenia as a group-two disease.

Both genetic and environmental factors contribute to the development of cardiomyopathy. Some of the cases is inherited, whereas the others may result from alcohol, coronary artery disease, hypertension, obesity, cocaine use, and viral infections. We classify cardiomyopathy as a group-two disease in the baseline classification, and move cardiomyopathy to group one in a robustness test.

Alcohol addiction is naturally classified as a group-two disease. For the four body injuries, neck injury and dorsum injury are typically resulted from poor posture habits, while arm injury and leg injury are often the results of accidents. Therefore, we classify neck injury and dorsum injury as group-two diseases, and arm injury and leg injury as group-one diseases.

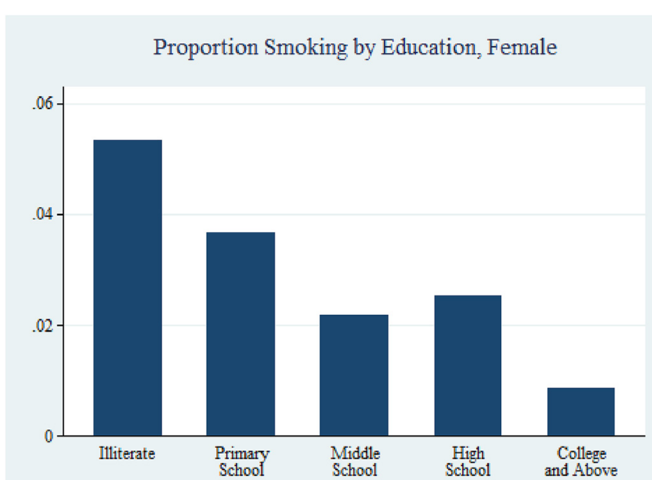


**Fig. A1** Proportion Smoking by Education, Female. Note: The data source is the 2010 wave of the China Family Panel Study.

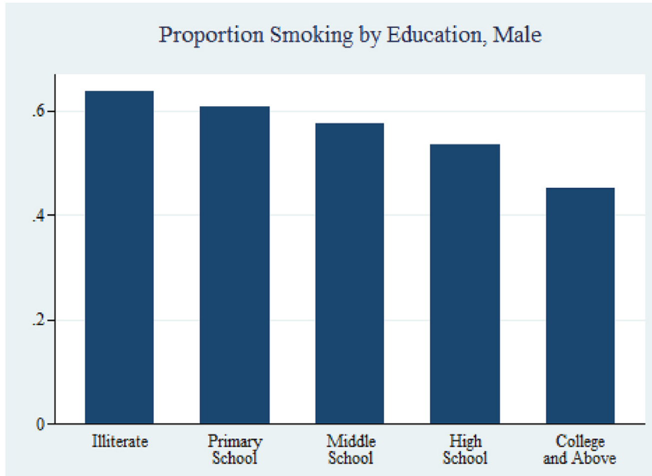


**Fig. A2** Proportion Smoking by Education, Male. Note: The data source is the 2010 wave of the China Family Panel Study.

**Table A1**
Education and spousal health at the survey time, controlling for four spousal health measures at the wedding time.

| | IVFE-1 | | IVFE-2 | |
|---|---|---|---|---|
| | Female Sample (Spouses of Male Twins) | Male Sample (Spouses of Female Twins) | Female Sample (Spouses of Male Twins) | Male Sample (Spouses of Female Twins) |
| | (1) | (2) | (3) | (4) |
| | Panel A. Dependent Variable: Twins' Spouses' Overweight Status at the Survey Time | | | |
| Twins' Education | −0.027* | −0.053** | −0.037** | −0.051** |
| | (0.015) | (0.022) | (0.017) | (0.021) |
| Spouse's Wedding-time Health | Yes | Yes | Yes | Yes |
| Mean (depvar) | 0.10 | 0.19 | 0.10 | 0.19 |
| | Panel B. Dependent Variable: Twins' Spouses' Number of Chronic Diseases at the Survey Time | | | |
| Twins' Education | 0.003 | −0.098** | −0.015 | −0.085** |
| | (0.049) | (0.044) | (0.047) | (0.043) |
| Spouse's Wedding-time Health | Yes | Yes | Yes | Yes |
| Mean (depvar) | 0.61 | 0.51 | 0.61 | 0.51 |
| No. of Twin Pairs | 263 | 262 | 263 | 262 |

Note: All regressions control for twins' birth weight, spousal age, spousal schooling years, and all the four health measures of the spouse at the wedding time. Columns (1) and (2) report IVFE-1 estimates for female and male samples, respectively. Columns (3) and (4) report IVFE-2 estimates for female and male samples, respectively. In Panels A and B, dependent variables are *Twins' Spouses' Overweight Status* and *Twins' Spouses' Number of Chronic Diseases*, respectively. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

**Table A2**
Education and changes in spousal health between the survey time and the wedding time.

| | IVFE-1 | | IVFE-2 | |
|---|---|---|---|---|
| | Female Sample (Spouses of Male Twins) | Male Sample (Spouses of Female Twins) | Female Sample (Spouses of Male Twins) | Male Sample (Spouses of Female Twins) |
| | (1) | (2) | (3) | (4) |
| | Panel A. Dependent Variable: Change in Twins' Spouses' Overweight Status between Survey Time and Wedding Time | | | |
| Twins' Education | −0.026 | −0.065*** | −0.035* | −0.064*** |
| | (0.016) | (0.024) | (0.018) | (0.022) |
| Controls | Yes | Yes | Yes | Yes |
| | Panel B. Dependent Variable: Change in Twins' Spouses' Number of Chronic Diseases between Survey Time and Wedding Time | | | |
| Twins' Education | 0.004 | −0.104*** | −0.014 | −0.094** |
| | (0.049) | (0.045) | (0.046) | (0.044) |
| Controls | Yes | Yes | Yes | Yes |
| No. of Twin Pairs | 263 | 262 | 263 | 262 |

Note: All regressions control for twins' birth weight, spousal age at the survey time, spousal age at the wedding time, and spousal schooling years. Columns (1) and (2) report IVFE-1 estimates for female and male samples, respectively. Columns (3) and (4) report IVFE-2 estimates for female and male samples, respectively. In Panels A and B, dependent variables are *Change in Twins' Spouses' Overweight Status between Survey Time and Wedding Time* and *Change in Twins' Spouses' Number of Chronic Diseases between Survey Time and Wedding Time*, respectively. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

**Table A3**
Two groups of diseases, alternative classification.

| | IVFE-1 | | IVFE-2 | |
|---|---|---|---|---|
| | Female Sample (Spouses of Male Twins) | Male Sample (Spouses of Female Twins) | Female Sample (Spouses of Male Twins) | Male Sample (Spouses of Female Twins) |
| | (1) | (2) | (3) | (4) |
| | Panel A. Dependent Variable: Twins' Spouses' Number of Group-One Diseases | | | |
| Twins' Education | 0.004 | −0.034 | −0.003 | −0.035 |
| | (0.027) | (0.023) | (0.025) | (0.023) |
| Spouse's Wedding-time Health | Yes | Yes | Yes | Yes |
| Mean (depvar) | 0.29 | 0.19 | 0.29 | 0.19 |
| | Panel B. Dependent Variable: Twins' Spouses' Number of Group-Two Diseases | | | |
| Twins' Education | −0.008 | −0.068** | −0.023 | −0.056* |
| | (0.029) | (0.032) | (0.032) | (0.031) |
| Spouse's Wedding-time Health | Yes | Yes | Yes | Yes |
| Mean (depvar) | 0.32 | 0.31 | 0.32 | 0.31 |
| No. of Twin Pairs | 263 | 262 | 263 | 262 |

Note: All regressions control for twins' birth weight, spousal age, spousal schooling years, and spousal number of chronic diseases at the wedding time. Columns (1) and (2) report IVFE-1 estimates for female and male samples, respectively. Columns (3) and (4) report IVFE-2 estimates for female and male samples, respectively. Group-one diseases include hemicrania, cardiomyopathy, hay fever, arm injury, leg injury, and hearing damage. Group-two diseases include skin rash, hypertension, neurasthenia, alcohol addiction, neck injury, and dorsum injury. In Panels A and B, dependent variables are *Twins' Spouses' Number of Group-One Diseases* and *Twins' Spouses' Number of Group-Two Diseases*, respectively. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

**Table A4**
Controlling for income.

| | IVFE-1 | | IVFE-2 | |
|---|---|---|---|---|
| | Female Sample (Spouses of Male Twins) | Male Sample (Spouses of Female Twins) | Female Sample (Spouses of Male Twins) | Male Sample (Spouses of Female Twins) |
| | (1) | (2) | (3) | (4) |
| | Panel A. Dependent Variable: Twins' Spouses' Overweight Status at the Survey Time | | | |
| Twins' Education | −0.026 | −0.053** | −0.037** | −0.051** |
| | (0.016) | (0.024) | (0.019) | (0.023) |
| Twins' and Spouses' Income | Yes | Yes | Yes | Yes |
| Controls | Yes | Yes | Yes | Yes |
| | Panel B. Dependent Variable: Twins' Spouses' Number of Chronic Diseases at the Survey Time | | | |
| Twins' Education | 0.011 | −0.091* | −0.008 | −0.087* |
| | (0.056) | (0.050) | (0.054) | (0.050) |
| Twins' and Spouses' Income | Yes | Yes | Yes | Yes |
| Controls | Yes | Yes | Yes | Yes |
| No. of Twin Pairs | 258 | 255 | 258 | 255 |

Note: All regressions control for twins' birth weight, spousal age, spousal schooling years, and twins' and spouses' income measured at the survey time. Columns (1) and (2) report IVFE-1 estimation results for female and male samples, respectively. Columns (3) and (4) report IVFE-2 estimation results for female and male samples, respectively. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

**Table A5**
Controlling for occupation.

| | IVFE-1 | | | | IVFE-2 | | | |
|---|---|---|---|---|---|---|---|---|
| | Female Sample (Spouses of Male Twins) | | Male Sample (Spouses of Female Twins) | | Female Sample (Spouses of Male Twins) | | Male Sample (Spouses of Female Twins) | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | Panel A. Dependent Variable: Twins' Spouses' Overweight Status at the Survey Time | | | | | | | |
| Twins' Education | −0.026* | −0.027** | −0.055** | −0.053** | −0.035** | −0.038** | −0.053** | −0.049** |
| | (0.015) | (0.013) | (0.024) | (0.023) | (0.017) | (0.015) | (0.023) | (0.022) |
| Spousal Working Status | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Spousal Occupation | No | Yes | No | Yes | No | Yes | No | Yes |
| | Panel B. Dependent Variable: Twins' Spouses' Number of Chronic Diseases at the Survey Time | | | | | | | |
| Twins' Education | 0.008 | 0.009 | −0.089* | −0.092* | −0.007 | −0.009 | −0.086* | −0.088* |
| | (0.052) | (0.052) | (0.051) | (0.054) | (0.051) | (0.052) | (0.051) | (0.052) |
| Spousal Working Status | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Spousal Occupation | No | Yes | No | Yes | No | Yes | No | Yes |
| No. of Twin Pairs | 263 | 263 | 262 | 262 | 263 | 263 | 262 | 262 |

Note: All regressions control for twins' birth weight, spousal age, spousal schooling years, and spousal labor force participation status. Additionally, Columns (2), (4), (6), and (8) control for spousal occupational categories. Columns (1)–(2) and Columns (3)–(4) report IVFE-1 estimates for female and male samples, respectively. Columns (5)–(6) and Columns (7)–(8) report IVFE-2 estimates for female and male samples, respectively. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

## References


Almond, Douglas, Chay, Kenneth Y., Lee, David S., 2005. The costs of low birth weight. Q. J. Econ. 120 (3), 1031–1083.

Ashenfelter, Orley, Krueger, Alan, 1994. Estimates of the economic return to schooling from a new sample of twins. Am. Econ. Rev. 84 (5), 1157–1173.

Ashenfelter, Orley, Rouse, Cecilia, 1998. Income, schooling, and ability: evidence from a new sample of identical twins. Q. J. Econ. 113 (1), 253–284.

Barba, Corazon, Cavalli-Sforza, Tommaso, Cutter, Jeffery, Darnton-Hill, Ian, et al., 2004. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet 363 (9403), 157.

Becker, Gary S., 1973. A theory of marriage: Part I. J. Polit. Econ. 81 (4), 813–846.

Behrman, Jere R., Kohler, Hans-Peter, Jensen, Vibeke Myrup, Pedersen, Dorthe, Petersen, Inge, Bingley, Paul, Christensen, Kaare, 2011. Does more schooling reduce hospitalization and delay mortality? New evidence based on Danish twins. Demography 48 (4), 1347–1375.

Behrman, Jere R., Rosenzweig, Mark R., 2004. Returns to birthweight. Rev. Econ. Stat. 86 (2), 586–601.

Behrman, Jere R., Xiong, Yanyan, Zhang, Junsen, 2015. Cross-sectional schooling-health associations misrepresented causal schooling effects on adult health and health-related behaviors: evidence from the Chinese Adults Twins Survey. Soc. Sci. Med. 127, 190–197.

Bound, John, Solon, Gary, 1999. Double trouble: on the value of twins-based estimation of the return to schooling. Econ. Educ. Rev. 18 (2), 169–182.

Brown, Dustin C., Hummer, Robert A., Hayward, Mark D., 2014. The importance of spousal education for the self-rated health of married adults in the United States. Popul. Res. Pol. Rev. 33 (1), 127–151.

Card, David, 1999. The causal effect of education on earnings. In: Handbook of Labor Economics, vol. 3. Elsevier, pp. 1801–1863.

Carrell, Scott E., Fullerton, Richard L., West, James E., 2009. Does your cohort matter? Measuring peer effects in college achievement. J. Labor Econ. 27 (3), 439–464.

Chevalier, Arnaud, Harmon, Colm, O'Sullivan, Vincent, Walker, Ian, 2013. The impact of parental income and education on the schooling of their children. J. Labor Econ. 2 (1), 8.

Chiappori, Pierre-André, Oreffice, Sonia, Quintana-Domeque, Climent, 2012. Fatter attraction: anthropometric and socioeconomic matching on the marriage market. J. Polit. Econ. 120 (4), 659–695.
Chiappori, Pierre-André, Oreffice, Sonia, Quintana-Domeque, Climent, 2017. Bidimensional matching with heterogeneous preferences: education and smoking in the marriage market. J. Eur. Econ. Assoc. 16 (1), 161–198.
Clark, Damon, Roayer, Heather, 2013. The effect of education on adult mortality and health: evidence from Britain. Am. Econ. Rev. 103 (6), 2087–2120.
Currie, Janet, Moretti, Enrico, 2003. Mother's education and the intergenerational transmission of human capital: evidence from college openings. Q. J. Econ. 118 (4), 1495–1532.
Cutler, David, Lleras-Muney, Adriana, House, J., Schoeni, R., Kaplan, G., Pollack, H., 2008. Education and Health: Evaluating Theories and evidence. Making Americans Healthier: Social and Economic Policy as Health Policy. .
Cutler, David M., Lleras-Muney, Adriana, 2010. Understanding differences in health behaviors by education. J. Health Econ. 29 (1), 1–28.
Deaton, Angus, 2007. Height, health, and development. Proc. Natl. Acad. Sci. Unit. States Am. 104 (33), 13232–13237.
Deaton, Angus, 2008. Height, health, and inequality: the distribution of adult heights in India. Am. Econ. Rev. 98 (2), 468–474.
Eika, Lasse, Mogstad, Magne, Zafar, Basit, 2018. Educational assortative mating and household income inequality. J. Polit. Econ. (forthcoming).
Fan, Yi, Yi, Junjian, Zhang, Junsen, 2020. Rising intergenerational income persistence in China. Am. Econ. J. Econ. Pol. (forthcoming).
Fang, Hai, Eggleston, Karen N., Rizzo, John A., Rozelle, Scott, Zeckhauser, Richard J., 2012. The Returns to Education in China: Evidence from the 1986 Compulsory Education Law. National Bureau of Economic Research.
Figlio, David, Guryan, Jonathan, Karbownik, Krzysztof, Roth, Jeffrey, 2014. The effects of poor neonatal health on children's cognitive development. Am. Econ. Rev. 104 (12), 3921–3955.
Grossman, Michael, 1972. On the concept of health capital and the demand for health. J. Polit. Econ. 80 (2), 223–255.
Grossman, Michael, 2006. Education and nonmarket outcomes. In: Handbook of the Economics of Education, vol. 1, pp. 577–633.
Holmlund, Helena, Lindahl, Mikael, Plug, Erik, 2011. The causal effect of parents' schooling on children's schooling: a comparison of estimation methods. J. Econ. Lit. 49 (3), 615–651.
Hoxby, Caroline, 2000. Peer Effects in the Classroom: Learning from Gender and Race Variation. National Bureau of Economic Research.
Huang, Chong, Li, Hongbin, Liu, Pak Wai, Zhang, Junsen, 2009. Why does spousal education matter for earnings? Assortative mating and cross-productivity. J. Labor Econ. 27 (4), 633–652.
Huang, Fali, Jin, Ginger Zhe, Xu, Lixin Colin, 2017. Love, money, and parental goods: does parental matchmaking matter? J. Comp. Econ. 45 (2), 224–245.
Huang, Wei, 2015. Understanding the Effects of Education on Health: Evidence from China. IZA Discussion Paper 9225. .
Huang, Wei, Lei, Xiaoyan, Zhao, Yaohui, 2016. One-child policy and the rise of man-made twins. Rev. Econ. Stat. 98 (3), 467–476.
Kemptner, Daniel, Jürges, Hendrik, Reinhold, Steffen, 2011. Changes in compulsory schooling and the causal effect of education on health: evidence from Germany. J. Health Econ. 30 (2), 340–354.
Li, Yang, Fu, Hua, Zhao, Fang, Luo, Jianfeng, Kawachi, Ichiro, 2013. Influence of spousal education on partner's self-rated health: cross-sectional study among 1382 married couples in Shanghai, China. Asia Pac. J. Publ. Health 25 (5), 398–408.
Lipowicz, Anna, 2003. Effect of husbands' education on fatness of wives. Am. J. Hum. Biol. 15 (1), 1–7.
Lleras-Muney, Adriana, 2005. The relationship between education and adult mortality in the United States. Rev. Econ. Stud. 72 (1), 189–221.
Lucas Jr., Robert E., 1988. On the mechanics of economic development. J. Monetary Econ. 22 (1), 3–42.
McCrary, Justin, Royer, Heather, 2011. The effect of female education on fertility and infant health: evidence from school entry policies using exact date of birth. Am. Econ. Rev. 101 (1), 158–195.
Moretti, Enrico, 2004. Workers' education, spillovers, and productivity: evidence from plant-level production functions. Am. Econ. Rev. 94 (3), 656–690.
Neumark, David, 1999. Biases in twin estimates of the return to schooling. Econ. Educ. Rev. 18 (2), 143–148.
Rosenzweig, Mark R., Wolpin, Kenneth I., 1980. Testing the quantity-quality fertility model: the use of twins as a natural experiment. Econometrica 227–240.
Stommel, Manfred, Schoenborn, Charlotte A., 2010. Variations in BMI and prevalence of health risks in diverse racial and ethnic populations. Obesity 18 (9), 1821–1826.
Wantchekon, Leonard, Klašnja, Marko, Novta, Natalija, 2014. Education and human capital externalities: evidence from colonial Benin. Q. J. Econ. 130 (2), 703–757.
Yi, Junjian, Heckman, James J., Zhang, Junsen, Conti, Gabriella, 2015. Early health shocks, intra-household resource allocation and child outcomes. Econ. J. 125 (588), F347–F371.