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Mother's education and child health: Is there a nurturing effect?

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ABSTRACT

In this paper, we examine the effect of maternal education on the health of young children by using a large sample of adopted children from China. As adopted children are genetically unrelated to the nurturing parents, the educational effect on them is most likely to be the nurturing effect. We find that the mother's education is an important determinant of the health of adopted children even after we control for income, the number of siblings, health environments, and other socioeconomic variables. Moreover, the effect of the mother's education on the adoptee sample is similar to that on the own birth sample, which suggests that the main effect of the mother's education on child health is in post-natal nurturing. We also find suggestive evidence that the effect is causal. Our work provides new evidence to the general literature that examines the determinants of health and that examines the intergenerational immobility of socioeconomic status.

1. Introduction

Child health has become a key indicator of economic development. Among the eight Millennium Development Goals (MDGs) that were adopted by the 189 members of the United Nations (UN) in 2000, at least four are directly related to child health or nutritional status (Todaro and Smith, 2005).[2] In addition to being a development indicator itself, child health is also closely associated with other development indicators, such as adult health, educational attainment, productivity, and income (Currie and Hyson, 1999; Currie and Madrian, 1999; Persico et al., 2004; Case et al., 2002, 2005; Behrman and Rosenzweig, 2004). Despite its importance, however, little is known about the causes of good or poor child health.

Among the potential determinants of child health, the mother's education has been the focus of economists. More educated mothers may have healthier children because they have better knowledge about health care and nutrition, have healthier behavior, and provide more sanitary and safer environments for their children (Behrman and Deolalikar, 1988, 1990; Strauss, 1990; Thomas et al., 1990, 1991; Desai and Alva, 1998; Glewwe, 1999; Currie and Moretti, 2003). In addition to the nurturing effect, nature could also play an important role. More educated mothers are more likely to have better health, which

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[2] These four goals are to reduce child mortality, improve the mother's health, combat diseases such as AIDS and malaria, and eradicate hunger.

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genetically leads to better health for their children (Behrman and Wolfe, 1987; Wolfe and Behrman, 1987). Unfortunately, to the best of our knowledge, very few previous studies have separated the nature effect from the nurturing effect.[3]

An understanding of how the mother's education affects child health will help us to evaluate a very important development policy in the world today: the improvement of women's education. In fact, two additional goals of the MDGs are to directly target the education of women.[4] Raising the education of girls is also the priority of the World Bank.[5] According to the World Bank, one primary reason for this priority is that raising the education of women can greatly improve the health of the next generation. However, to justify the policy priority, one needs to show that the mother's education has a nurturing effect on child health. If the mother's education matters mainly because of nature, then policy interventions that increase it will not have any intergenerational effect on child health.

Our goal in this paper is to empirically separate the nature effect from the nurturing effect. This is achieved by analyzing a sample of 2140 adopted children aged between 0 and 4 years from China, which is the largest developing country in the world. As adopted children are genetically unrelated to the nurturing parents, the educational effect on them is most likely to be the true post-natal nurturing effect.

Our empirical work shows that the mother's education indeed has a nurturing effect. Following the literature (Thomas et al., 1991; Strauss and Thomas, 1998), we use the height-for-age *z*-score as our measure of child health. As argued by Thomas et al. (1991), Strauss and Thomas (1998) and Behrman and Rosenzweig (2002), height is a measure of both short run and long run health status. We find that the mother's education is an important determinant of the height-for-age *z*-score for adopted children even after we control for income, the number of siblings, health environment, and other socioeconomic variables. Moreover, the effect of the mother's education for the adoptee sample is only slightly smaller than that for the own birth sample, which suggests that the main effect of the mother's education on child health is through post-natal nurturing. Finally, we find that mother's education affects child health only when they are the main caregivers, suggesting that this effect is causal. Our finding suggests that the policies of the United Nations and of the World Bank, and of governments of both developed and developing nations that target the education of women will have a strong influence on economic development.

We also conduct sensitivity analyses to address several potential problems with the adoptee sample. First, adoptees are different from own birth children, and thus the role of the mother's education may be different for adopted children and own birth children. Following Sacerdote (2000), Plug and Vijverberg (2003, 2005), and Plug (2004), we conduct a series of sensitivity tests, and do not find evidence that the difference between adoptees (and adoptive families) and own birth children (and families) affect our estimations. Second, the mother's education may still pick up some of the selection effect if more educated mothers adopt children of better quality. Generally, there is no way to perfectly address this issue because our data do not include any information on the birth parents or the health of the children at the time of adoption.[6] However, selection may be less of an issue in the case of adoptions in China because most adopted girls have been abandoned, and thus adoptive parents cannot select children based on information about the birth parents. Moreover, it is generally difficult to select a child because the adoption rules (described in the next section) are designed to prevent child selection.

This paper not only adds to the literature on the contributing factors to child health but also sheds light on the growing literature that examines the intergenerational immobility of socioeconomic status. Research shows that people who grow up in wealthier and more educated families are healthier, more educated, and perform better in the job market (Behrman and Rosenzweig, 2002; Case et al., 2002; Plug, 2004; Black et al., 2005). This intergenerational transfer of economic status starts as early as childhood (Case et al., 2002; Currie and Moretti, 2003; Currie and Stabile, 2003) or even in the womb (Case et al., 2005; Almond, 2006). In this paper, we focus on a particular aspect of the intergenerational transfer: the effect of the mother's education on the health of young children. To the best of our knowledge, this is the first use of adoptees to examine the effect of parental education on child health. Generally, economic studies that use adoptees are rare,[7] and our sample is large.

The structure of this paper is as follows. Section 2 describes infant abandonment and adoption in China. Section 3 lays out a simple empirical model. Section 4 describes the data and variables. Section 5 empirically tests the effect of the mother's education on child health, and Section 6 presents sensitivity tests. Section 7 concludes the paper.

2. Infant abandonment and adoption in China

China possibly has the most adoptees in the world. Although there are no formal statistics, some government agencies estimate that there are between 100,000 and 160,000 adoption cases every year (Liu, 1993; People's Daily, May 10, 1995).

[3] One exception is a recent paper by Currie and Moretti (2003) that uses school openings as an instrumental variable to identify the causal effect of the mother's education on child health.

[4] They are universal primary education and the elimination of the gender gap in education.

[5] See the official statement of the World Bank at http://www.wordbank.org.

[6] Only two recent studies, de Walque (2005) and Bjorklund et al. (2006), have information on the birth parents.

[7] Recently, there have been a few papers that use samples of adoptees to study the intergenerational transfer of education, such as those of Sacerdote (2000, 2002, 2004), Plug and Vijverberg (2003, 2005), Plug (2004) and Bjorklund et al. (2006). Case et al. (2002) use adoptees to conduct a sensitivity test for their study of the effect of parental income on child health.

Although child adoption is a universal phenomenon, it has many unique features in China because of the strong sex preference and the one-child policy. The preference for sons is deeply rooted both economically and culturally. A son is necessary for most Chinese parents, especially in rural areas, because few people have social security and it is customary for the son to support and care for aging parents. In addition, it is culturally important for the son to carry on the family name. In rural areas, households that do not have a son are discriminated against by friends and relatives because failure to carry on the family name is a serious sign of disrespect to one's ancestors.[8]

Since the one-child policy came into effect in 1979 the sex preference for boys has resulted in the widespread abandonment of girls. Under China's one-child policy, each household is allowed to have only one child. Later, the policy was relaxed in some rural areas to allow a second child if the first child is a girl. Households are given birth quotas, and births outside this quota, or "above-quota births," are heavily fined. Because of the one-child policy, parents who have a strong preference for boys may abandon their first or second girl and have another child without penalty. Thus, abandonment of female babies has resulted in a large number of girl adoptees. In addition to abandonment, children are put up for adoption if they are orphaned or their parents are unable to raise them. For these children, there is a balanced sex ratio.

Adoptions of children in China normally happen in a Children's Welfare Institute (CWI), to which most abandoned children or orphans are sent.[9] Potential parents can only adopt a child from the CWI of the district or city of their residence, unless referred elsewhere by the local CWI. To adopt a child, a couple (person) must provide documents to prove their marital status, their number of children and the sex of each child, and their annual income, etc.[10] Qualified parents can then file an application, which specifies their preferences for the age, sex, and health status of the child. Most Chinese prefer young babies with good health status, which is understandable. However, they are normally advised not to select the sex of the baby because the majority of abandoned children are girls. After receiving the application, the CWI sends staff to visit the applicants' home and employer to verify details of the application. It then arranges a meeting of the potential parents with a child according to their preferences. Unless the child has health problems, the potential parents are expected to adopt the child. If they pass up the opportunity by without good reason, then the CWI will normally not consider future applications from the same parents. Finally, the potential parents sign formal documents and take the child home. Normally, if potential parents do not prefer a boy, then the whole process can be finished in 1–2 months because there are many healthy girls waiting to be adopted.

To summarize, child adoption in China has unique features due to China's economic and cultural status. First, most adoptees are girls. According to surveys by Johansson and Nygren (1991), Greenhalgh and Li (1995) and Johnson et al. (1998), around 90% of abandoned infants are girls and around 80% of the adoptees are girls. Second, because abandonment is illegal and above-quota births are heavily fined, parents usually travel a long distance to abandon their children. They normally leave their children in a crowded public place, such as a train station, a hospital, or somewhere near an orphanage, with a thank-you note and some basic information about the child, such as birth date, a bottle of milk, some clothes, and sometimes money. Children that are picked up from these public places usually end up in a CWI. Finally, most children are abandoned and adopted at a very early age. In addition, most adoptive parents prefer to adopt young infants. For this reason and also to avoid being caught for having above-quota births, most parents abandon their children at a very early age. According to Johnson et al. (1998), the majority of parents abandon their children in the first 3 months of age and the majority of these children are adopted in the first 6 months of age.

3. Empirical model

We examine the relationship between child health and the mother's education with the following equation:

$$\mathrm{HAZ}_i = \beta_0 + \beta_1\,\mathrm{medu}_i + X_i\beta_2 + \epsilon_i \tag{1}$$

where HAZ, to be defined next, is a measure of child health, medu is the mother's education, X are other control variables, β_0, β_1 and β_2 are the corresponding vectors of coefficients, and ϵ is the residual. The subscript i denotes child i. We hypothesize that β_1 is greater than zero, or the mother's education has a positive effect on child health.

Following the literature (Thomas et al., 1991; Strauss and Thomas, 1998), we use the height-for-age *z*-score (HAZ) as a measurement of child health. Child anthropometric measurements, such as height-for-age, provide useful information for child health status, are easy to obtain, and are comparable across different ages and sexes. HAZ is a particularly good health indicator as it is a measure of both short- and long-term health status (Thomas et al., 1991; Strauss and Thomas, 1998;

[8] There is a succinct saying in Chinese that describes this vividly: "There are three ways to disrespect one's ancestors and not carrying on the family name is the biggest one" (bu xiao you san, wu hou wei da). Discrimination is also addressed in two other Chinese expressions: "no sons, no grandsons" (duan zi jue sun) and "extinction of descendants" (jue hou). All of these are extremely negative.

[9] See Johnson (1993), Johnson et al. (1998) and Deng (2006), and the CWI of Tianjin (2006) for details of the child adoption procedure in China.

[10] To supplement the one-child policy and to legally protect adoptees and adoptive parents, the government passed its first adoption law in April 1992. The law restricts the adoption of healthy foundlings to parents who are childless and over 35 years of age. The age limit is to prevent adoptive parents from subsequently having their own birth children. However, in most areas neither restriction applies because of the large number of abandoned children who are waiting to be adopted. The law has little impact on our study as our data were collected in June 1992.

Behrman and Rosenzweig, 2002). The height-for-age z-score is defined as follows.

$$\text{HAZ}_i = \frac{h_{ij} - \bar{h}_j}{\sigma_j},$$

where h_{ij} is the observed height of child i in group j, where a group is defined according to child sex and the birth month. $\bar{h}_j$ and σ_j are the median and standard deviation of the height in group j, using American children as the reference population.[11]

4. Data

In this paper, we use the Chinese Children Survey that was conducted by the National Bureau of Statistics of China in June 1992. The survey was funded and supported by the United Nations Children's Fund, the Ministry of Education of China, the Ministry of Health of China, and the All Women's Federation of China. The purpose of the survey was to learn about the welfare of children aged 0–14 years. The survey includes a simple health form for children aged 0–4 years, and an education form for children aged 5–14 years. The survey randomly sampled 560,000 households and two million individuals (including children, their parents, and other family members) throughout China. This is probably the largest dataset for the study of child welfare in China. Most respondents (76%) of the survey were mothers of children, 14% were fathers, and the rest were other caregivers of the children.

In this paper, we focus on a sample of children aged 0–4 years, for whom we observe their health measures. The sample's total is 129,858 children. The heights (or lengths) of children of 24 months or younger were measured while they were lying down and those of older children were measured while they were standing up. Immunization history, including vaccination for BCG (bacillus calmette guerin), poliomyelitis, pertussis-diphtheria-tetanus, and measles was reported by the respondents.

The health status of Chinese children was poor when compared with international standards. Note that the average z-score was −1.376, which suggests that Chinese children were more than one standard deviation shorter than American children in the same reference group. According to the standardized welfare indicators for children that are defined by the World Bank, children with a HAZ below two standard deviation points from the median of the reference population are considered stunt. In 1992, 32.5% of Chinese children were stunt. Moreover, many children had not been immunized. About 14 percent of the children had not received the BCG vaccine, 14% had not received the poliomyelitis vaccine, 18% had not received the pertussis-diphtheria-tetanus vaccine, and 25% had not received the measles vaccine. Only about half of the children had received all four vaccines in 1992.

In addition to health measures, the survey also provides detailed family and other socioeconomic variables. In particular, there is one question on the relationship between the child and his or her parents: 1 = both birth parents, 2 = one birth parent, 3 = adopted from relatives, and 4 = other adoptions. In the sample, 97.98% of the children have both birth parents, 0.37% have one birth parent, 0.13% were adopted from relatives, and 1.52% were adopted outside bloodlines. In total, we have 2140 adoptees aged between 0 and 4 in our sample and around 1700 adoptees with complete information. This is probably the largest adoptee sample ever used in economics. The information on parents includes their education, family income, family size, and the family structure. The survey reported the final diploma or degree obtained by a parent, and we use this to construct the year of schooling, our main education variable.[12] Moreover, the survey also provides some environmental variables, such as whether the household has running water, their own water supply, and a flushing toilet.

Similar to adoptee samples from other countries (see e.g. Plug and Vijverberg, 2003; Plug, 2004), the adoptee sample differs from the own birth sample in many characteristics. In particular, adoptees have poorer health on average than the own birth children. The average HAZ is −1.678 for the adoptee sample, but it is 0.307 greater for the own birth sample. Adoptive mothers are also less educated than other parents, with a difference of 1.412 years of schooling. There are also two particular characteristics of the Chinese adoptee sample that differ from adoptee samples from most other countries. First, the sex ratio of the adoptee sample is very low, with less than 20% being boys.[13] This reflects the one-child policy and the son preference in China. Second, adoptive parents are about 7 years older than other parents, which reflects the fact that most Chinese parents adopt children only after failing to have their own for many years.

5. Mother's education and child health

In this section, we report the regression results. We first examine the effect of the mother's education on the health of adopted children and then examine the impact of the father's education. As a comparison, we also estimate the same child health equations by using the own birth sample.

[11] Onis and Yip (1996) suggest that although there are some variations in the growth patterns of children from different races and/or ethnic backgrounds in developing countries, we can use the American (or international) reference population, as the variations are relatively minor. The use of a common reference population has its advantages, as the population can be compared locally and with other countries. Onis and Yip also argue that it is not appropriate to develop a local reference or standard, as children who come from less developed areas may have poor health and nutrition. If we use these children as a reference, then the screening value for the investigation of health and nutritional status is lower.

[12] Years of schooling is constructed as follows: primary school = 6, junior high school = 9, high school/technical school = 12, 2-year college = 14, college = 16. We also use the education level dummies in the sensitivity tests.

[13] The adoptee sample from Korea collected by Sacerdote (2000) also has an unbalanced sex ratio.

5.1. Health of adopted children

In this section, we examine the effect of the mother's education on child health by using the adoptee sample. The dependent variable for all regressions is the HAZ. The choice of independent variables follows that of Case et al. (2002), Plug and Vijverberg (2003) and Plug (2004). We employ ordinary least squares regressions and report standard errors that are robust to heteroscadesticity and clustering at the family level.

The first column in Table 2 reports a baseline specification with the mother's education, age, age squared, and sex as independent variables. This simple regression shows that the mother's education has a large positive effect on child health. The variable, mother's education, has a positive coefficient and it is significant at the 1% percent level. An additional year of education for the mother increases HAZ by 0.064: that is, 0.064 standard deviations of the height for children of the same age and sex. More intuitively, compared to an illiterate woman, a woman with primary school education (6 years) has children who are about 0.4 standard deviations taller, and a high school graduate (12) has children who are about 0.8 standard deviations taller.

Other variables have the expected signs. Boys have a 0.176 standard deviations advantage in terms of height over that of girls, and there is a convex relationship between HAZ and age. The height advantage of boys suggests that compared to international standards, Chinese boys have a smaller disadvantage in terms of height than girls. The negative coefficient of age and the positive coefficient of age squared are both significant at the 1% level, suggesting that HAZ decreases with age but with a decreasing slope. HAZ is worse for older children either because the height disadvantage of Chinese children relative to the international standard increases over time, or because earlier birth cohorts are worse off in terms of health.

In addition to education, another important determinant of child health is parental income. Wealthier parents can afford better medical care and more nutritious food, and can provide a better environment so that their children are healthier (Smith, 1999; Case et al., 2002). When we add log per capita household income in the second column, the effect of the mother's education on child HAZ remains significant at the 1% level. The estimated coefficient decreases only marginally, which suggests that the main effect of the mother's education on child health is not through income. The newly added log income also has the expected positive sign, and is significant at the 1% level.

In column 3, we add another important variable, the number of siblings, as a control. The number of siblings can affect child health because with more children, the parents have less time and money for each child and as a result each of them may have poorer health (Becker and Lewis, 1973). Thus, we should expect the number of siblings to have a negative sign. Indeed, the number of siblings has a negative coefficient and is significant at the 1% level. One more sibling reduces the HAZ by 0.238 standard deviations. When controlling for the number of siblings, the effect of the mother's education is reduced only marginally. This suggests that educated mothers tend to have a smaller family size, but most of the effect of the mother's education on child health is not through the effect of family size.

We next test whether the mother's education affects child health because highly educated mothers tend to live in a more hygienic environment. Improvements in domestic water supplies and facilities for disposal of excreta benefit the health of children, as they can reduce exposure to pathogens. Better education may therefore affect child health by providing a household with better sanitation, such as running water or flushing toilets ((Strauss, 1990; Horton, 1998; Case, 2001). We have three measures for health environment: a dummy for whether the household has running water, a dummy for whether the household has its own water source, and a dummy for whether the household has a flushing toilet. Although these are standard household facilities in developed countries, they were far less common in a developing country like China in the 1990s. As shown in column 1 of Table 1, only about 30% of the children in our sample live in places with running water, and as few as 10% of the children use a flushing toilet. Interestingly, these measures for health environment have a large influence on the effect of the mother's education. The coefficient on the mother's education is reduced to 0.033 in column 4, but remains significant at the 1% level. Moreover, the three health environment variables are jointly significant at the 1% level, which suggests that children are indeed healthier in better environments. Together, these results suggest that better educated mothers do, in fact, raise their children in more hygienic environments and thus have healthier children.

Finally, in columns 5 and 6, we include the rural and regional dummies. If we include these location dummies they can control for any unobserved difference between localities that might affect child health. For example, it may be that children in certain parts of China are genetically taller than children in other parts. Controlling for these dummies reduces the estimated coefficient on the mother's education, but it remains significant at the 1% level. After including all these controls, the remaining effect of the mother's education is 0.022 in column 5 and 0.032 in column 6. Note also that children in rural areas have a disadvantage as great as 0.528–0.874 standard deviations.

To summarize, we find that the mother's education has a positive effect on the health of adopted children. The effect is robust to different regression specifications that control for other variables that affect child health. The findings suggest that the mother's education has an important nurturing effect on child health. We also find that this nurturing effect of mother's education may also be attributed to greater income, fewer children, and better environments.

In the interpretation of results associated with columns 2–5, we exercise some caution. All of the newly added variables, such as income, the number of siblings, and health environments can be endogenous. For example, the number of children and child quality (health) are simultaneously chosen as in the model of Becker and Lewis (1973). Income can also be endogenous because ill children may affect parents' labor supply and income negatively. However, resolving the endogeneity of these variables is not our current focus. We are mainly interested in examining whether the mother's education affects child health through genetic inheritance, or through post-natal nurturing, such as greater income, fewer children, and healthier

Table 1
Summary statistics of variables for children under 4 years.

	Whole sample (1)	Adoptees (2)	Own birth children (3)	Difference (4) = (2)–(3)
Number of observations	129,858	2,140	127,718	–
Height	82.675 (11.841)	82.838 (11.082)	82.672 (11.853)	0.167 (0.258)
HAZ	−1.376 (1.641)	−1.678 (1.662)	−1.371 (1.640)	−0.307 (0.036)***
Age (months)	27.563 (13.795)	29.171 (13.049)	27.537 (13.806)	1.634 (0.301)
Male	0.538 (0.499)	0.195 (0.397)	0.544 (0.498)	−0.349 (0.011)***
Mother's age	27.616 (4.499)	34.222 (7.619)	27.522 (4.367)	6.700 (0.106)***
Father's age	29.545 (5.408)	36.699 (8.961)	29.444 (5.272)	7.255 (0.130)***
Mother's education	6.753 (3.833)	5.361 (4.135)	6.773 (3.825)	−1.412 (0.091)***
Father's education	8.352 (3.076)	7.588 (3.359)	8.363 (3.071)	−0.775 (0.075)***
Average parents' education	7.527 (3.016)	6.458 (3.184)	7.542 (3.011)	−1.084 (0.073)***
Maximum parents' education	8.755 (2.961)	8.035 (3.260)	8.765 (2.955)	−0.729 (0.072)***
Mother being the main caregiver	0.861 (0.346)	0.803 (0.398)	0.862 (0.345)	−0.058 (0.008)***
Per capita income	839.725 (715.224)	794.099 (505.890)	840.489 (718.188)	−46.390 (15.589)***
Log of per capita income	6.514 (0.672)	6.507 (6.031)	6.514 (0.673)	−0.007 (0.015)
Number of siblings	0.784 (0.902)	0.726 (0.897)	0.785 (0.902)	−0.056 (0.020)***
Have running water	0.304 (0.460)	0.262 (0.440)	0.305 (0.460)	−0.043 (0.010)***
Have own water supply	0.477 (0.499)	0.485 (0.500)	0.477 (0.499)	0.008 (0.011)
Have a flushing toilet	0.102 (0.302)	0.061 (0.240)	0.103 (0.303)	−0.041 (0.007)***
Rural household	0.819 (0.384)	0.877 (0.328)	0.819 (0.385)	0.058 (0.008)***
Have BCG vaccine	0.857 (0.350)	0.809 (0.393)	0.858 (0.349)	−0.049 (0.010)***
Have poliomyelitis vaccine	0.858 (0.349)	0.822 (0.382)	0.858 (0.348)	−0.036 (0.010)***
Have pertussis-diphtheria-tetanus vaccine	0.818 (0.386)	0.778 (0.416)	0.819 (0.385)	−0.041 (0.011)***
Have measles vaccine	0.745 (0.436)	0.727 (0.446)	0.746 (0.435)	−0.019 (0.014)

Note: columns 1–3 report mean and standard deviations (in parentheses); column 4 reports the *t*-test of the difference between columns 2 and 3 with standard errors in parentheses;*significant at 10%;**significant at 5%.
*** Significant at 1%.

environments. We find that income, the number of siblings, and environments are all important, but education may also affect child health through other non-genetic mechanisms.

5.2. Parental education

In addition to the mother's education, the father's education can also be important for child health. Although the literature has provided overwhelming evidence that the mother's education is more important, few studies have examined the relationship between the father's education and child health (Case et al., 2002). This may be due to the fact that fathers devote less time to childcare, and thus the relationship between the father's education and child health may not be immediate. However, in China, the father's education can be important because generally fathers have more education than mothers. In our sample, fathers have about two more years of education than mothers. If the highest level of education achieved in a family matters, then the father's education could be even more important than the mother's education in China.

To test whether the father's education, or more generally, parental education matters, we try a few specifications that use different measures of parental education in the last four columns in Table 2. Two features of these regressions are noteworthy. First, the mother's education is more important than the father's education for child health, though the difference is small. Second, the average of the two parents' education has the largest effect among all measures of the parental education that is followed by the maximum of the two parents' education.

5.3. Health of own birth children

In this subsection, we repeat the same regressions by using the sample of own birth children. As the estimated coefficients of the mother's education for the own birth sample contains the effect of both nature and nurture, comparing the results of the own birth sample with those of the adoptee sample is a way to assess the importance of the nurturing effect.

The regression results reported in Table 3 suggest that the main role of the mother's education is the post-natal nurturing effect. For example, the estimate is 0.032 for adoptees (column 6, Table 2), but it is 0.044 for the own birth sample using the same specification (column 6, Table 3). This suggests that 73% of the impact is due to nurture, and the remaining 27% is due to nature.[14] Similar conclusions can be reached if we compare other specifications of the two tables.

[14] One assumption we have made in the above calculation is that the education of biological mother and the education of the adopting mother is not correlated. This assumption is supported by de Walque (2005), who observes the education of both the biological mother and the adopting mother in his sample. Interestingly, he finds that the correlation between the two may not pose a serious bias on the estimated nurture effect. When he controls for the education of the biological parents, the effects of the education of adopting mother only change slightly.

Table 2
Ordinary least squares estimates of the effect of mother's education on the health of adopted children (dependent variable: HAZ).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Mother's education	0.064 *** (0.009)	0.057 *** (0.010)	0.053 *** (0.009)	0.033 *** (0.010)	0.022 ** (0.010)	0.032 *** (0.010)		0.028 *** (0.010)		
Father's education							0.023 * (0.013)	0.010 (0.013)		
Parental education (mean)									0.040 *** (0.014)	
Parental education (max)										0.028 ** (0.013)
Age (months)	−0.055 *** (0.014)	−0.057 *** (0.014)	−0.054 *** (0.014)	−0.053 ***	−0.057 *** (0.014)	−0.057 *** (0.014)	−0.061 *** (0.014)	−0.061 *** (0.015)	−0.061 *** (0.015)	−0.061 *** (0.014)
Age squared	0.001 *** (0.000)	0.001 *** (0.000)	0.001 *** (0.000)	0.001 *** (0.000)	0.001 *** (0.000)	0.001 *** (0.000)	0.001 *** (0.000)	0.001 *** (0.000)	0.001 *** (0.000)	0.001 *** (0.000)
Male	0.176 * (0.101)	0.165 (0.102)	0.200 * (0.102)	0.176 * (0.102)	0.121 (0.101)	0.116 (0.099)	0.137 (0.101)	0.136 (0.101)	0.138 (0.101)	0.136 (0.101)
Log per capita household income		0.221 *** (0.069)	0.167 ** (0.069)	0.055 (0.072)	0.118 (0.075)					
The number of siblings			−0.238 *** (0.043)	−0.202 *** (0.043)	−0.160 *** (0.043)					
Have running water				0.502 *** (0.110)	0.288 ** (0.119)					
Have own water supply				0.142 (0.090)	0.071 (0.090)					
Have a flushing toilet				0.252 (0.166)	0.108 (0.179)					
Rural					−0.528 *** (0.157)	−0.874 *** (0.109)	−1.002 *** (0.110)	−0.915 *** (0.115)	−0.925 *** (0.115)	−0.982 *** (0.112)
Observations	1781	1775	1775	1775	1775	1781	1701	1697	1697	1701
R-squared	0.04	0.04	0.06	0.08	0.12	0.10	0.10	0.11	0.11	0.10

Note: standard errors in parentheses are robust to heteroscadesticity and clustering at the family level; columns (5)–(10) control for regional dummies.

* Significant at 10%.

** Significant at 5%.

*** Significant at 1%.

Table 3
Ordinary least squares estimates of the effect of mother's education on the health of own birth children (dependent variable: HAZ).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Mother's education	0.091 *** (0.002)	0.066 *** (0.002)	0.059 *** (0.002)	0.038 *** (0.002)	0.028 *** (0.002)	0.044 *** (0.001)		0.036 *** (0.002)		
Father's education							0.039 *** (0.002)	0.021 *** (0.002)		
Parental education (mean)									0.059 *** (0.002)	
Parental education (max)										0.046 *** (0.002)
Age (months)	−0.047 *** (0.002)	−0.048 *** (0.002)	−0.046 *** (0.002)	−0.046 *** (0.002)	−0.046 *** (0.002)	−0.047 *** (0.001)	−0.048 *** (0.001)	−0.047 *** (0.001)	−0.047 *** (0.001)	−0.048 *** (0.001)
Age squared	0.001 *** (0.000)	0.001 *** (0.000)	0.001 *** (0.000)	0.001 *** (0.000)	0.001 *** (0.000)	0.001 *** (0.000)	0.001 *** (0.000)	0.001 *** (0.000)	0.001 *** (0.000)	0.001 *** (0.000)
Male	0.033 *** (0.009)	0.032 *** (0.009)	0.039 *** (0.009)	0.045 *** (0.009)	0.048 *** (0.009)	0.044 *** (0.009)	0.045 *** (0.009)	0.045 *** (0.009)	0.044 *** (0.009)	0.045 *** (0.009)
Log per capita household income		0.346 *** (0.013)	0.293 *** (0.013)	0.175 *** (0.013)	0.145 *** (0.013)					
The number of siblings			−0.153 *** (0.008)	−0.116 *** (0.008)	−0.102 *** (0.007)					
Have running water				0.321 *** (0.021)	0.111 *** (0.022)					
Have own water supply				0.237 *** (0.016)	0.145 *** (0.015)					
Have a flushing toilet				0.354 *** (0.025)	0.154 *** (0.025)					
Rural					−0.524 *** (0.027)	−0.825 *** (0.012)	−0.885 *** (0.012)	−0.785 *** (0.013)	−0.787 *** (0.013)	−0.855 *** (0.012)
Observations	125,749	125,588	125,588	125,588	125,588	125,749	121,848	121,848	121,848	121,848
R-squared	0.06	0.08	0.08	0.11	0.13	0.12	0.11	0.12	0.12	0.11

Note: standard errors in parentheses are robust to heteroscadesticity and clustering at the family level; columns (5)–(10) control for regional dummies;*significant at 10%;**significant at 5%.
*** Significant at 1%.

Other variables in regressions for the own birth sample behave similarly. The father's education has a positive effect but this effect is generally smaller than that of the mother's education. Moreover, the father or parents' education have a very similar effect on the health of own birth children to that of adoptees. These results confirm our early findings that the parents' education is mainly the nurturing effect. Age has a negative and convex effect on the HAZ of children, and boys also have an advantage for own birth children. Income has a large effect on health and it remains significant in all specifications. Health environment also has a large and significant effect on the health of children. Finally, children in rural areas have a similar disadvantage to that of the adoptee sample.

6. Sensitivity analysis

As in other studies that use adoptees, there are two potential problems that may prevent us from making a strong statistical inference. First, adoptees may be different from own birth children, adoptive mothers may be different from other mothers, and parents may treat adopted children differently. Thus, it may be questionable to generalize findings from adoptees to all children. In other words, the results that use adoptees may not be directly comparable to those that use own birth samples. Second, using adoptees cannot completely remove the nature effect. If more educated mothers choose healthier children, then the mother's education will still pick up some of the nature (or selection) effect.

In the following analysis, we conduct a series of sensitivity tests. Generally, there is no perfect way to deal with these problems unless adoptees and adoptive mothers are randomly selected from the population and they are also randomly matched. However, we can still apply some tests designed by Plug and Vijverberg (2003, 2005) and Plug (2004) to illustrate how serious these problems are for our study. We also test whether the effect of the mother's education is causal and whether our results are sensitive to different measures of health. In all the sensitivity tests, we focus on specification 6 in Tables 2 and 3. The results are very similar if we use other specifications.

6.1. Non-linear effect of education

First, we test whether the mother's education has a non-linear effect. As shown in Table 1, adoptees differ from own birth children in most of the variables we observe. In particular, adoptees have poorer health and their mothers have fewer years of education than own birth children. Can the effect of the mother's education also differ for the two samples? For example, if the effect of the mother's education is nonlinear, then the estimated effects of the two samples are not directly comparable because they measure the return to education at different levels.

To test whether the effect of the mother's education is non-linear, we use the mother's education levels – that is, primary school, junior high school, and high school or above dummies (the base group is the illiterate group) – rather than a continuous education variable in our specifications. Regression results are reported in the first two columns of Table 4. The coefficients of all three education level dummies are positive and significant for the own birth sample. The magnitude of the coefficient also increases with education level as expected. For the adoptee sample, all three education dummies have positive coefficients, and those of junior high school and high school dummies are significant at the 1% level. The magnitudes of the coefficients are smaller for the adoptee sample. Overall, the results using these education dummies are similar to those using the year of schooling as a measure for education.

6.2. Are adoptees treated differently?

We next test if the way mothers treat their children affects our estimation. Adoptive parents may treat adopted children poorly when they realize that the personality or intelligence of adoptees is different from their own. Many adoptive parents also have own birth children and it may be that adoptive parents treat their own birth children differently than adoptees. Some adoptive parents have their own children after adoption and may favor their own children for genetic or emotional reasons (Case et al., 2000; Case and Paxon, 2001). Sometimes, people may adopt a girl to "lead in" their own birth boy. If they get their own boy, the adopted girl may be less highly regarded and thus may be treated poorly. Adoptive parents may also treat adoptees better because they worry about the negative psychological effects of being adoptees among peers. Adoptive parents may also want to compensate for adoptees' early misfortunes (Johnson et al., 1998).

In our first test, we directly examine whether adoptees are treated differently in a way that is related to the mother's education. In particular, we estimate the effect of the mother's education on the likelihood of a child receiving immunizations. Although immunization against diseases such as BCG, poliomyelitis, pertussis-diphtheria-tetanus, and measles are common in developed countries, it was less so in China in the 1990s. About half of the children in our sample had not received one out of four of the vaccines. Our regression results show that adoptive mothers do not differ from other mothers in health care. Columns 3 and 4 of Table 4 report regressions that use own and adoptee samples respectively. The dependent variable is a dummy for having received all four vaccines (1 = having received all four vaccines, 0 = missing at least one of them). The effect of the mother's education is very similar for the two samples.

In our second test, we examine a sample of adoptees that live in families with own birth children. If adoptees are treated differently in these families, then the mother's education has a different effect on child health. The regression reported in column 5 shows that the mother's education has an almost identical effect on health for this sub-sample of adoptees as for other adoptees. Thus, there is no evidence to suggest that adoptees that are raised in families with own

Table 4
Ordinary least squares estimates of the effect of mother's education on the health of children: various specifications.

Sample and specification	(1) Own birth	(2) Adoptees	(3) Own birth	(4) Adoptees	(5) Adoptees with own birth siblings	(6) Own birth with adopted siblings	(7) Adoptees with no bloodlines	(8) Adoptees mother is caregiver	(9) Adoptees Mother is not caregiver
Dependent variable	HAZ	HAZ	Vaccine	Vaccine	HAZ	HAZ	HAZ	HAZ	HAZ
Mother's education			0.011 ***(0.000)	0.010 ***(0.004)	0.033 **(0.014)	0.057 ***(0.015)	0.035 ***(0.010)	0.034 ***(0.011)	0.005 (0.026)
Mother's education dummies									
Primary	0.139 ***(0.014)	0.029 (0.097)							
Junior high	0.353 ***(0.014)	0.344 ***(0.106)							
High school	0.565 ***(0.019)	0.380 ***(0.136)							
Age (months)	−0.047 ***(0.001)	−0.058 ***(0.014)	0.057 ***(0.000)	0.054 ***(0.004)	−0.039 *(0.021)	−0.029 *(0.017)	−0.065 ***(0.014)	−0.054 ***(0.016)	−0.092 **(0.042)
Age squared	0.001 ***(0.000)	0.001 ***(0.000)	−0.001 ***(0.000)	−0.001 ***(0.000)	0.001 *(0.000)	0.000 (0.000)	0.001 ***(0.000)	0.001 ***(0.000)	0.001 *(0.001)
Male	0.045 ***(0.009)	0.117 (0.099)	0.006 **(0.003)	0.024 (0.033)	0.286 **(0.141)	−0.087 (0.117)	0.054 (0.101)	0.165 (0.111)	0.082 (0.257)
Rural	−0.777 ***(0.013)	−0.844 ***(0.110)	−0.072 ***(0.003)	0.003 (0.039)	−0.644 ***(0.192)	−0.295 (0.189)	−0.862 ***(0.112)	−0.941 ***(0.127)	−0.640 **(0.247)
Observations	125,749	1785	96,839	1118	922	775	1666	1472	235
R-squared	0.12	0.10	0.28	0.17	0.08	0.07	0.11	0.11	0.10

Note: standard errors in parentheses are robust to heteroscadesticity and clustering at the family level; all regressions control for regional dummies.

* Significant at 10%.

** Significant at 5%.

*** Significant at 1%.

birth children are treated differently in a way that influences the estimated effect of the mother's education on child health.

6.3. Are adoptive parents different?

It is also possible that adoptive parents have better parenting skills and this is why they adopt children. If this is true, then the effect of the mother's education that is estimated using adoptees is over-stated when an inference is made for the rest of the population. To test whether adoptive parents are better parents, we follow Plug (2004) and use a sample of own birth children in adoptive families. If adoptive families are different, then we should be able to see that the effect of the mother's education for this sample is different from the sample of own birth children. The regression reported in column 6 of Table 4 shows that the effect of the mother's education is not significantly different from that of the sample of all own birth children (column 6 of Table 3).

6.4. Selection effect

There may still be some selection or nature effect with the adoptee sample. Some families may adopt children from relatives (called guo ji in Chinese). This may happen if the natural parents are unable to raise all of their own children and it may also happen if natural parents want to have more children, especially boys, but do not want to pay the fertility fine. By excluding bloodline adoptions from the sample, we can examine whether, and by how much, this kind of adoption has biased our estimates of the nurturing effect. Specifically, we estimate the child health equation by using only adoptees without bloodlines. The regression reported in column 7 of Table 4 continues to show that the mother's education has a positive and significant effect on the health of adoptees who do not share a bloodline with the nurturing parents. Moreover, the magnitude of the effect is very similar to that of all adoptees (column 6 of Table 2).

Even for adoptees without bloodlines, there may still be a selection effect. If better educated mothers tend to adopt healthier children, then the mother's education will still pick up some of the nature effect. For example, better educated mothers may live closer to an orphanage with high-quality abandoned children. Or perhaps, better educated mothers care more about child height, or are better able to assess the health status of a child. Generally, there is no perfect way to evaluate selection of this sort due to the limitations of our data.[15]

Although we do not have a good econometric test for the selection effect, we provide a few reasons as to why selection may not be an issue in China. First, most adoptees in China are illegally abandoned girls. Thus, birth parents cannot select the adoptive parents and adoptive parents cannot select children based on the information of the birth parents. Second, all parents want to adopt healthy children and it may not be true that well educated mothers tend to pick taller or healthier children. The opposite may be true. Less educated mothers may select taller children if the return to height increases for low-skilled jobs.[16]

6.5. Is the effect causal?

The above analysis suggests that mother's education has a nurturing effect on the health of young children, but it cannot prove causality. Although there is no genetic link between the education of the adopting mother and the adopted child, there could be other unobserved environmental variables that are correlated with both mother's education and child health. For example, many of the children live in extended families, in which there are adults other than parents. It could be that the childcare skills of these adults are correlated with the education of mothers. In this example, mother's education has picked up the nurturing skills of other adults in a household.

Although this kind of omitted variable bias is very difficult to deal with, we can provide some plausible tests. The mother's time available for parenting is an important determinant in raising healthy children, and thus mother's education should have a larger effect when the mother herself is a main caregiver of the child. We test this hypothesis by dividing the adoptee sample into two, depending on whether or not the mother is the main caregiver. Regression results reported in columns 8 and 9 of Table 4 are consistent with the hypothesis that mother's education has a causal effect. When mothers are the main caregivers (column 8), mother's education has a positive impact on child health and the magnitude is comparable to the baseline estimate. In contrast, when mothers are not the main caregivers, mother's education has no effect. These results suggest that mother's education matters for child health only when they are the main caregivers.

6.6. An alternative health measure

Besides height, weight is another important anthropometric measure for child health. In this section, we examine whether similar results hold when we use the weight-for-age z-score as the health measure. As being over-weight and under-weight

[15] Ideally, these problems could be solved if we observe the information about the children's birth parents and about the children themselves before they were adopted.

[16] The return to height may decrease with education if height is valued more for low-skilled jobs. See, for example, Thomas and Strauss (1997) and Strauss and Thomas (1998) for detailed arguments.

Table 5
Ordinary least squares estimates of the effect of mother's education on the health of children (dependent variable: a dummy equal to 1 if −WAZ−<2, equal to 0 otherwise).

	(1) Adoptee	(2) Adoptee	(3) Adoptee	(4) Own birth	(5) Own birth	(6) Own birth
Mother's education	0.0047 *(0.0027)	0.0065 **(0.0026)	0.0047 (0.0029)	0.0049 ***(0.0004)	0.0071 ***(0.0004)	0.0056 ***(0.0004)
Father's education			0.0056 (0.0035)			0.0046 ***(0.0005)
Age (months)	0.0020 (0.0034)	0.0023 (0.0034)	0.0036 (0.0004)	−0.0003	−0.0004 (0.0004)	−0.0006 (0.0004)
Age squared	0.0000 (0.0001)	0.0000 (0.0001)	−0.0000 (0.0001)	0.0000 **(0.0000)	0.0000 **(0.0000)	0.0000 ***(0.0000)
Male	0.0232 (0.0258)	0.0218 (0.0256)	0.0242 (0.0262)	0.0088 ***(0.0023)	0.0081 ***(0.0023)	0.0079 ***(0.0024)
Log per capita household income	0.0606 ***(0.0196)			0.0224 ***(0.0023)		
The number of siblings	−0.0406 ***(0.0121)			−0.0179 ***(0.0016)		
Have running water	0.0490 *(0.0277)			0.0184 ***(0.0035)		
Have own water supply	0.0074 (0.0227)			0.0231 ***(0.0028)		
Have a flushing toilet	−0.0852 **(0.0394)			−0.0050 (0.0043)		
Rural	−0.1063 ***(0.0344)	−0.1484 ***(0.0262)	−0.1403 ***(0.0279)	−0.0525 ***(0.0043)	−0.0884 ***(0.0031)	−0.0805 ***(0.0032)
Observations	1,757	1,763	1,679	125,588	125,749	121,848
R-squared	0.06	0.04	0.05	0.04	0.04	0.04

Note: standard errors in parentheses are robust to heteroscadesticity and clustering at the family level; all regressions control for regional dummies.

* Significant at 10%.

** Significant at 5%.

*** Significant at 1%.

are both unhealthy, we define a dummy variable for normal weight (equal to 1 if the absolute value of the *z*-score is less than 2, and 0 otherwise) as the dependent variable. Indeed, the regression results reported in Table 5 show that mother's education has a nurturing impact on child weight. Although the coefficients of mother's education are slightly smaller for the adoptee sample (columns 1–3) than those for the own birth sample (columns 4–6), they are all positive and are significant at the 10% level in two cases. These results suggest that our main findings are not sensitive to the health measure we use.

7. Conclusions

In this paper, we have examined the effect of the mother's education on the health of young children by using a large sample of adopted children from China. As adopted children are genetically unrelated to the nurturing parents, the education effect for them is most likely the nurturing effect. We find that the mother's education is an important determinant of the health of adopted children even after we control for income, the number of siblings, health environments, and other socioeconomic variables. Moreover, the effect of the mother's education for the adoptee sample is similar to that for the own birth sample, which suggests that the main effect of the mother's education on child health is in post-natal nurturing. Our sensitivity tests do not show any evidence that the difference of adoptees from own birth children affects the estimated effect of the mother's education on child health, and we find suggestive evidence that the estimated effect is causal. Although using a sample of adoptees cannot solve all econometric issues, such as selection, the empirical results suggest that the mother's education has a nurturing effect. Our work also provides new evidence for the general literature that examines the intergenerational immobility of capital, human capital, and health capital.

Our finding that the mother's education has a nurturing effect on child health may shed light on public policies in developing countries. First, our finding that an important part of the health capital is accumulated through nurturing suggests that the health of the poor can be improved and the inequality of health can be reduced by public policies, such as the improvement of women's education. Second, there are many policies that may improve the health status of a country, but few empirical studies have shown that any of these policies have a causal effect on health. To this end, our finding that the educational level of women has a causal effect on the health of the next generation provides strong support for the policies adopted by the United Nations and the World Bank.

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