The Impact of Mother's Education on Child Health and Nutrition in Developing Countries: Evidence from a Natural Experiment in Burkina Faso

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Abstract

Data from a natural experiment are used to demonstrate how a sudden change in education policy in Burkina Faso is useful in estimating the effect of maternal education on child health. Indeed, a major problem in estimating the effect of maternal education on child health is that unobserved factors may affect maternal education and child health simultaneously, causing endogeneity bias. Most studies on the relationship between maternal education and child health have used instrumental variables to address the endogeneity problem. Because it is very difficult to find instrumental variables that clearly satisfy the requirements of "correlation with maternal education" and "non- correlation to unobserved factors", instrumental variables do not guarantee a solution to the endogeneity problem. A way around this is the use of natural experiment as an identification strategy.
The results show that mother's education significantly and positively affects child weight-for-height (WHZ, an indicator of current malnutrition). The effect of mother's education on child height-for-age (HAZ, an indicator of chronic malnutrition) is positive but statistically insignificant, suggesting no direct effect of mother's education on child's HAZ. Per capita household expenditures seem to be the pathway through which mother's education affects children's HAZ. For WHZ, the mother's education variable was found to be significant even after including all pathways in the regression, indicating that mother's education, by itself, has a strong causal effect on child health or there are other pathways that the data used did not allow us to investigate. The threshold effects estimation indicate the largest impacts of mother's years of education at 13 years of education for WHZ and 12 years for HAZ. Thus, after taking costs into consideration, education policies targeted to girls should focus on trying to maintain them in school longer than the six years that has been the standard so far.

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JEL classification: I15, I25, I28

1) Introduction

a) Research problem

Health and nutrition have both intrinsic value and economic returns. Therefore, many countries have taken actions to promote both child health and nutrition, with varying degrees of success. More specifically, many countries have implemented health programs and projects (vaccination campaigns, building of hospitals, construction of sanitation facilities, etc.) with mixed results. These mixed results are reflected in high rates of malnutrition in many developing countries. De Onis et al. (2000) estimated that the prevalence rate of stunting (low height-for-age) in developing countries' preschool children was 33% in 2000. This rate masks regional disparities. The same authors estimated that the prevalence rates of stunting for Africa, Asia, and Latin America and the Caribbean were 35%, 34%, and 13%, respectively. Prevalence rates between 30 and 39% are considered high.

The focus of this paper is on child health outcomes in poor countries. There is a strong link between child health and child nutrition: malnourished children are more likely to develop illnesses that can have long lasting effects throughout their lives. Unfortunately, many children in developing countries are malnourished. Malnutrition is defined as inadequate intake of calories and nutrients, which can lead to illnesses that might cause death in the extreme case (Chen et. al., 1980). Three commonly used anthropometric indicators of nutritional status are weight-for-height (wasting), height-for-age (stunting) and weight-for-age (underweight). In Burkina Faso, the geographical focus of this research, the prevalence rate for stunting was 39% in 2003 (*Institut National de la Statistique et de la Démographie*, 2004).

Inadequate nutrition has consequences for the child and for the society in which the child lives. Proper nutrition during the first two years of life is crucial for child health, physical growth, and mental development. Poor nutrition for young children can lead to poor schooling outcomes, adversely affecting productivity later in life, which results in low economic growth (Glewwe and Miguel, 2008). There are also several costs of illnesses related to malnutrition, including physical suffering, time costs for both parents and children, and monetary costs. Parents will have to pay for healthcare and will also lose income by having to stay home and care for their sick children. Sick and malnourished children cannot develop properly and thus will not be able to learn as well as healthy children. In the long term, these individuals would also lose income as adults due to reduced learning.

Staying home to care for a sick child implies that parents will lose hours of work. The higher the number of parents who will have to miss work to care for sick children, the less production will take place in the economy. This might adversely affect economic growth. Children's nutritional status, therefore, not only reflects a country's level of development but also determines it in the long run (de Onis et. al, 2000). For developing countries, more research on child health and nutrition outcomes is needed to improve our understanding of the determinants of these outcomes. This would facilitate the design of better policies that contribute to enhancing child health and nutrition outcomes in the short run, improve education outcomes in the medium run, and labor market outcomes in the long run. In the very long run, this chain of events should lead to higher rates of sustained economic growth.

Children, especially at young ages, depend on their parents for nutrition, and mothers play a crucial role in children's nutrition. Therefore, mothers have a potentially great influence on children's health outcomes. The theoretical justification of the relationship between education and health goes back to Grossman's 1972 model of the demand for good health. His model predicts that if education increases the efficiency of gross investments in health, then more educated people would choose a higher optimal stock of health. This means that education positively affects health.

In most families, mothers spend more time than fathers taking care of children; that is, mothers play a more important role in decisions about child health and nutrition. This suggests that it is likely that mothers' education would matter more than fathers' education, after controlling for income (this is the rationale behind treating mothers' education as endogenous but not fathers'). Therefore, more educated mothers should have healthier, better nourished children.

A major problem in estimating the effect of maternal education on child health is that unobserved factors may affect maternal education and child health simultaneously. This problem, which may be called the endogeneity problem, means that the estimates of the effect of maternal education on child health may be biased. Most studies on the relationship between maternal education and child health have attempted to use instrumental variables (variables that are correlated with maternal education but are not correlated with unobserved factors that have a direct impact on child health status) to remove the bias caused by the endogeneity problem. Because it is very difficult to find instrumental variables that clearly satisfy these requirements, instrumental variables do not guarantee a solution to the endogeneity problem.

b) Objectives

This paper will examine how a sudden change in education policy in Burkina Faso can be used to construct good instrumental variables, which in turn can be used to consistently estimate the effect of maternal education on child health. More specifically, this research will attempt to:

(i) Verify whether a strong causal relationship exists

(ii) Understand the channels through which mother's education affects children's health

(iii) Investigate whether threshold effects exists, that is, whether specific years or levels of mother's education have unusually large impacts on children's health.

The quality of education could also matter in maternal education and child health relationship. However, given the nature of the data available for this study, it will not be possible to address this issue.

c) Background on Burkina Faso

Burkina Faso is located in the semi-arid Sahel region of West Africa. This landlocked country's area is 274,000 km^2 and its population was estimated at 15.2 million in 2008 (World Bank, 2009). The GNI per capita was US$480 in 2008.

The formal education system in Burkina Faso consists of 3 main levels: basic education (primary school, 6 years), secondary education (7 years), and higher education. In general, Burkina Faso's education system is characterized by low enrolment rates[1]. Data from the United Nations Educational, Scientific, and Cultural Organization (UNESCO) show that the gross enrolment rates in Burkina Faso were 73%, 18%, and 3% in 2008 for primary, secondary, and higher education, respectively. The net enrolment rates for primary and secondary education were 60 % and 14% in 2008, respectively. These low enrolment rates are due to a combination of the following factors: low parental income (81.2% of the population live on less than $2 per day, UNDP 2009); parents' negative beliefs about school (school would make children less obedient to parents, school does not really pay off well or soon enough, etc.); and a supply problem (lack of schools) in certain areas. Regarding low income, note that for public schools parents pay about 2000 FCFA ($4) per year for primary school fees and 15,000 to 25,000 FCFA ($35 to $50) per year for secondary school fees (and this does not include books and other school materials).

Gender disparities in school enrolment and school outcomes have long existed in Burkina Faso. Yet, the discrepancies are getting smaller. The parity index (female enrolment as proportion of male enrolment) increased from 0.68 in 2002 to 0.82 in 2005 for primary school enrolment and for secondary school enrolment it rose from 0.68 in 2001 to 0.70 in 2007 (*Ministère de l'Enseignement de Base et de l'Alphabétisation*, MEBA 2006 and *Ministère des Enseignements Secondaire, Supérieur, et de la Recherche Scientifique,* MESSRS *2008*). Yet given that females account for 52% of the country's population there is still much to do to reduce the gender gap in the primary and secondary school gross enrolment rates. Given the data available for this study, the focus will be on primary education.

d) Education Reform in Burkina Faso

Recognizing the gender disparity problem, the government of Burkina Faso decided in 1994 to take action. With the support of the United Nations Children's Fund (UNICEF), the

[1] The primary gross enrolment rate is defined as the total number of pupils enrolled in primary school, regardless of age, divided by the population in the theoretical age group for primary education. The net enrolment rate is defined as the total number of pupils in the theoretical age group for primary education who are enrolled in primary education divided by the total population in that age group. The net enrolment rate is useful because it focuses on pupils in the appropriate age range.

government, implemented a project called African Girls' Education Initiative (AGEI). One of the components of this project is the '*écoles satellites*' (ESs), 3-year primary schools built in the most remote areas of the country where there are no regular primary schools (6-year schools). After three years in an *école satellite*, children should go to the nearest regular primary school to complete their primary education, or the ES will be upgraded to a regular school. A 50% quota for girls' enrolment in the ESs was announced as a requirement of the program but it is not enforced.

This project was implemented in two phases. The first was an experimental phase, from 1995 to 1997, during which 30 ESs were built in 10 provinces. An expansion phase followed. Nineteen provinces out of 45 were chosen based on their low school enrolment rates and the availability of Non-Governmental Organizations (NGOs) that could give support to the project (and to education in general). In 2000, there were 204 ESs dispersed among 19 provinces (Tankono, 2000). In the year 2000, the ESs represented about 17 % of the total number of schools in these 19 provinces (1,191 schools), and about 5% of the 4,339 primary schools in Burkina Faso.[2] The ESs target children between 7 and 9 years old who have not yet been enrolled in primary school. On average, there are 40 children per class. The children are taught in their local language and in French. Since 1998, most of the ESs have been upgraded to six-class schools[3] or regular schools (Tankono, 2000). In the school year 2007-2008 there was a total of 308 ESs in Burkina Faso.

Two evaluations of this project have already been conducted, a joint evaluation by MEBA/UNICEF/World Bank in 1998 (MEBA is the ministry of basic education) and a joint evaluation by IRD (*Institut pour la Recherche et le Développement, Burkina Faso*) and the University of Ouagadougou in 1999. In general, both evaluations deemed the results of the reform to be satisfactory. The ESs have contributed to increase the enrolment rates in the provinces where they were built. For instance, between 1996-1997 and 2001-2002, the net enrolment rates for girls increased from 1.1% to 12.6% in the Komondjari province (Back,

[2] These percentages were computed based on the number of schools reported in the 2000 education statistics annual report

[3] Primary education lasts for six years in Burkina Faso.

Coulibaly, and Hickson, 2003). For Yagha province, primary school net enrolment rates for girls increased from 3.4% to 14.7% for the same period. In addition, the evaluations showed that there was strong participation from the people who live in the communities where ESs were built. In particular, the people contributed to the construction of the schools. The design of curricula and creation of textbooks specific to the ESs was highlighted as an important achievement of the project. Furthermore, tests scores in French and mathematics showed that the ES pupils performed better than the pupils in regular schools. Among the negative results pointed out by the evaluators, are: insufficient or inappropriate training in teaching methodology for the instructors, delays in provision of school and teaching materials, lack of school lunch programs, especially for children who live far away, and complaints from communities in which ESs have not been upgraded to 6-year schools.

Data on primary school enrolment rates from provinces with the program confirm the increase in girls' enrolment rates (boys enrolment rates also increased), but do not seem to show a reduction in the gender disparity. Figures 1 and 2 show the enrolment rates in primary school from 1989 to 1999 for five provinces with ESs and four without ESs provinces, respectively. There is a sharp jump in the enrolment rates in the provinces with immediately after the year the policies became effective (1995-1996). The enrolment rates for both boys and girls increased gradually in the provinces without ESs but the graph shows no significant jump after 1995-96. This suggests that the ES policy had an effect on girls schooling. This implies that it is possible to construct good instrumental variables (variables indicating whether mothers were affected by these reforms during their childhood) that will be used to identify the impact of mothers' education on children's health.

2) Literature Review

a) Theory on the Relationship between Education and Health

The relevant theories this work will draw upon have been developed by Becker (1965, 1981) and surveyed by Grossman (2006). In his 1965 paper, Becker developed a theory about how households allocate time to market and non-market activities. The main assumption of that paper that is related to this paper is that households produce non-market goods (e.g. health) using market goods and time.

Becker (1981) analyzed households' decisions on the quantity and quality of children. In his model, households derive utility from conventional goods as well as from the number of children and the quality of children (measured by expenditures per child). Quality of children could also be measured in terms of their healthiness. The model that will be developed in the next section follows Becker's model of the family, with child health as an argument in the household's utility function.

Grossman (2006) looked at the effects of education on nonmarket outcomes, namely, the causal effects of education and the channels through which it affects nonmarket outcomes. His work draws greatly on Becker's work on fertility, time allocation, the family, rational addiction and tastes. A survey of the empirical evidence on education and nonmarket outcomes reveals that education has causal effects on many nonmarket outcomes. Grossman predicts that an increase in parents' education will lead to an increase in children's well-being (measured by their health and cognitive development). However, Grossman's review of the literature does not find conclusive evidence on the mechanisms through which education operates.

b) Empirical Studies of the Impact of Maternal Education on Child Health

Regarding theoretical models, there seems to be an agreement among economists that parents' education positively affects child health (Rosenzweig and Schultz 1982, Behrman and Deolalikar 1988). However, the empirics provide another story. Some authors have found a significant effect of maternal education on child health status while others argue that there is little or no evidence of a causal relationship. For instance, Frongillo, de Onis, and Hanson (1997) ran cross-country OLS regressions of child height-for-age (stunting) and weight-for-height (wasting) on education variables, food security, geographic region and other variables. They found that the female literacy rate had a significantly negative effect on stunting. The main shortcoming of this study is that it did not address the heterogeneity in child health endowment and did not use instrumental variables methods to address the endogeneity of female literacy rate. Other studies that did not address the issues of heterogeneity in child health endowment and endogeneity of mother's education are, among others, Martorell, Leslie, and Moock (1984), Baya (1998) and Appoh and Krekling (2005). As mentioned above, the findings are inconsistent: Frongillo, de Onis, and Hanson (1997) and Appoh and Krekling (2005) found significant effects of mother's education whereas Martorell, Leslie, and Moock (1984) found no evidence of an impact of parents' education on child health outcomes. Baya (1998), using data from a town in Burkina Faso, found that after controlling for father's education, the effect of mother's education on child survival loses significance. He concludes that studies on parents' education and child health status should not focus on mother's education.

The next set of studies used natural experiments to identify mother's education-child health relationship. Breierova and Duflo (2004) used the 1995 intercensal survey of Indonesia and school data from the Sekolah Dasar program to investigate the impact of parents' education on fertility and child mortality. The results show a positive and significant effect of the school program on parents' education and a negative effect on fertility. Both father's and mother's education were found to reduce child mortality. The authors found little evidence to support the intuition that the mother's education effect is stronger than the father's. Similarly, using a natural experiment from Taiwan (a new compulsory education law), Chou et. al. found evidence of a causal relationship between parents' education and child health, but contrary to the previous study, mother's education was found to be stronger effect than father's education. No pathway investigation was attempted in either study.

Another set of past studies that are relevant to this research are those that address the pathways through which mother's education might affect child health outcomes. Using data from the 1986 Brazilian Demographic and Health Survey, Thomas, Strauss, and Henriques

(1991) examined three mechanisms through which mother's education might affect child health outcomes: income augmenting effects, information processing effects, and interactive effects with community services. They conclude that a mother's acquisition of information is the main pathway through which her education affects her children's health outcomes. The shortcomings of this study include treating parents' education as exogenous and not controlling for heterogeneity in the child's health endowment. Glewwe (1999) also suggests three pathways through which mother's education might affect child health outcomes: direct acquisition of basic health knowledge from schooling, health knowledge obtained through literacy and numeracy acquired in school, and exposure to modern society. Using data from Morocco, he found that mother's health knowledge is the main pathway through which mother's education affects child health outcomes. Glewwe treated mother's health knowledge, household income, and literacy and numeracy as endogenous. In addition, Glewwe controls for heterogeneity in the child's health endowment using parent's height. Although tests for the appropriateness of the instruments confirm that the instruments are valid, it is very hard to prove that the instruments have no predictive power for child's HAZ. The only way to get around that is to use natural experiment data or randomized experiment data which are very rare or expensive to collect in developing countries.

Handa (1999) examined six pathways through which mother's education might affect child health outcomes: income effects, interactions with household characteristics, interactions with community services, information processing, unobserved household heterogeneity[4], and intrahousehold bargaining power. Using data from Jamaica, Handa found that information processing is found to be a pathway through which mother's education affects child health outcomes. Handa argued that he was able to control for unobserved household heterogeneity. He used the fact that in Jamaican households there are usually children from different mothers, and women in the same household care for all children whether the children are their own or not. This is questionable because there is likely to be

[4] Correlation between mother's education and unobserved household characteristics. Possible sources of unobserved household heterogeneity: food preparation methods, knowledge of symptoms of ill health, different minimum levels of acceptable sanitation and cleanliness, and different tastes for child health.

mother heterogeneity. The other limitations of this study include treating parents' education as exogenous, and using unobserved household heterogeneity as a pathway; it is really an estimation problem, not a pathway.

Webb and Block (2004), using household survey data from Central Java, Indonesia, found that a mother's nutritional knowledge is a determinant of child short-term nutritional status (weight-for-height) whereas her schooling is a determinant of long-term nutritional status (height-for-age). These authors could not find plausible instrumental variables for maternal nutritional knowledge and household expenditures, so they used proxy variables to estimate reduced form equations for child nutritional status. Webb and Block did not account for the possibility of omitted variable bias that would result from the heterogeneity of child health endowment. Appoh and Krekling (2005), using data from the Volta Region in Ghana, found that mother's nutritional knowledge is more important than mother's schooling in determining child weight–for-age. However, these authors accounted neither for the simultaneity of inputs choices, nor the endogeneity of mother's health knowledge.

A common objection to many of the above studies is that the endogeneity of parents' education has not been considered. A major drawback for those studies who addressed it using instrumental variables methods is that one cannot prove that the instruments are not directly related to the outcome variable. Therefore, identification is not guaranteed. This paper goes beyond previous studies by using a natural experiment to investigate the relationship between maternal education and child health. To my knowledge, no other paper has used a change in policy to obtain identification in maternal education and child health relationships in an African country (this has been done for Indonesia, Taiwan, and the U.S.). It will be shown below how a change in policy is useful in identifying the effect of maternal education on child health.

3) Conceptual Framework

The analytical framework developed here draws on the work of Becker (1965, 1981), Rosenzweig and Schultz (1983), Glewwe (1999), Glewwe and Miguel (2008) and Grossman (2006). Becker (1965) posits that households derive utility from non-market or home produced goods. An example of such goods is child health. Child health is influenced by household decisions on resource allocation (Rosenzweig and Schultz, 1983). The model assumes that households maximize utility over market goods, child health (quantity and quality of children), and leisure. The utility function is assumed to have all the usual properties (quasi-concavity, continuity and differentiability). The household faces three constraints: a time constraint, a budget constraint, and a child health production function.

In equation format, the utility function is:

$$U = u(\mathbf{X}, H) \tag{1}$$

where **X** a vector of market goods and H is child health. Assume that leisure time is fixed, so it does not enter the utility function. Since parents use their time to produce children's health, time is costly and its price is the parents' wages (Glewwe and Miguel, 2008).

The child health production function can be depicted as follows:

$$H = h(\mathbf{I}, \mathbf{E}, \mu) \tag{2}$$

where **I** is a vector of health and nutritional inputs (food and calorie intake, medical care, etc.) that affect utility only through their effect on H, **E** is a vector of household characteristics and environmental variables that directly affect child health and μ is a child-specific health endowment. The child-specific health endowment is potentially known to the household but is not controlled by it; health inputs are in the household's choice set whereas environmental variables are not.

The budget constraint is:

$$p_1\mathbf{X} + p_2\mathbf{I} = M \tag{3}$$

where M is money income, and p_1, and p_2 are vectors of prices.

Estimation of equation (2) requires detailed information on health inputs, which is not feasible with the data available for this study. Yet one can maximize (1) subject to (2) and (3) to get reduced form demand functions for *X, I* and *H*:

$$\begin{aligned} X &= x(\mathbf{p},\mathbf{E},M,\mu) \\ I &= i(\mathbf{p},\mathbf{E},M,\mu) \\ H &= h(\mathbf{p},\mathbf{E},M,\mu) \end{aligned} \tag{4}$$

where **p**= (p_1, p_2, p_3).

The reduced form demand for child health is now a function of prices, income, household characteristics and environmental variables, and the child health endowment. The household characteristics include the child's characteristics (age, sex), parents' characteristics (education, age), type of dwelling, toilet facilities, water source, etc. and the environment variables include presence of health facilities in the area, availability of piped water, etc.

All the reduced form equations still contain the child health endowment (μ), which is not observed by the researcher. This is likely to cause two types of omitted variable bias (OMB). On one hand, a child's unobserved health endowment may be negatively correlated with parents' health knowledge in the sense that parents with sicker children would try to obtain more health knowledge than parents with healthier children. One can partially remove this bias by using parents' height to control for heterogeneity in child health endowment (Glewwe, 1999). On the other hand, as pointed out by Grossman (2006) bias would occur if there are unmeasured healthy behavior inputs (acceptable level of hygiene, healthy diet, etc.) that may be positively correlated with observed inputs (e.g. household income), which imply that one has to account for the possibility of household income being endogenous (in the econometric sense). Therefore household income may need to be instrumented. Given these two sources of possible bias, instrumental variable methods (two-stage least squares) are needed to estimate the reduced form demand for child health and for the endogenous inputs. Grossman (2006) suggests the use of mother's age at birth of the child as a proxy for genetic endowment to partially control for the child health endowment bias.

In this model, parental education is exogenous because their own parents made the decisions about their education (economic exogeneity). But because of possible correlation between parents' education and omitted variables (child innate healthiness is not observed) in the child health equation one should worry about econometric endogeneity (i.e. econometric exogeneity may not hold). Parents' education depends on their innate healthiness, which is passed on to their children. Therefore instrumental variable methods will be used to estimate the impact of parents' education on child health.

More specifically, consider the following equations:

$$H_i = h(CC_i, MS_i, FS_i, M_i, \mathbf{HEV_i}, \mu_i) \tag{5}$$

$$MS_i = f(\mathbf{EI}_{\mathrm{i}}, \mathrm{HA}_{\mathrm{i}}, \mathbf{HEV_i}, \epsilon_i) \tag{6}$$

where CC_i is child i's characteristics, MS_i and FS_i are child i's mother's and father's schooling respectively, M_i is household income, **HEV** is a vector of household environment variables, including community characteristics and region of residence, μ_i is a child's health endowment, $\mathbf{EI_i}$ is a vector of educational inputs, HA is mother's family household assets, and $\boldsymbol{\epsilon}_{\mathrm{i}}$ is a vector of maternal endowments (for example ethnic background, genetic makeup). Both μ and $\boldsymbol{\epsilon}$ are unobserved. Equation 5 is a more detailed version of equation 4. The (econometric) endogeneity of mother's schooling stems from potential correlation between μ_i and unobserved elements of $\boldsymbol{\epsilon}_{\mathrm{i}}$: family background may affect both mother's education and child health.

Among child health inputs, the one of most interest is mother's education because in most families in Burkina Faso mothers' spend more time caring for children than fathers. In addition Cleland (1990) postulates that education leads to behavioral changes that are child-health improving. Moreover, past studies have shown that fathers' education matters less than mothers' in child health production (Glewwe, 1999, Chou et.al., 2007). But exactly how does maternal education lead to better child health? Several pathways are suggested in the literature.

Information processing effect. Education makes mothers better able to process information (Thomas, Strauss and Henriques, 1991, and Glewwe, 1999). For example, educated mothers are able to read a medication label and give the proper dose to their children. Therefore, mother's education is likely to improve child health status.

Income effect. Educated mothers are more likely to have higher incomes (Thomas, Strauss and Henriques, 1991, and Handa, 1999). Thus educated mothers are likely to have access to more financial resources to invest in child health.

Health knowledge effect. Education leads to better health knowledge (Glewwe, 1999, Webb and Block, 2004, and Appoh and Krekling, 2005); hence, better educated mothers are more likely to know more about how to handle child health issues.

Bargaining power effect. Educated mothers have higher bargaining power over the household's resources (Handa, 1999). Therefore, they can positively impact their children's health.

Community services availability and interaction effects. Presence of health clinics, nutrition education, and availability of piped water in a community can help improve child health outcomes. In addition, education may interact with community services to improve child health outcomes (Thomas, Strauss and Henriques, 1991, and Handa, 1999). Some community services act as substitutes; others are complements to mother's education (Thomas, Strauss and Henriques, 1991).

Among the above-mentioned pathways, only four, income, health knowledge, bargaining power, and community services availability, will be investigated because of data limitations. The following hypotheses will be tested:

(1) Holding other variables (child's age and gender, mother's and father's age, father's education, and urban residence) constant, the higher the mother's education level, the better the child's health status.

(2) Income pathway in the conditional demand for child health, does including household income reduce or annul the mother's education effect?

(3) Health knowledge pathway in the conditional demand for child health, does including health knowledge reduce or annul the mother's education effect?

(4) Bargaining power pathway in the conditional demand for child health, does including bargaining power reduce or annul the mother's education effect?

(5) Community services availability pathway: Does including community services availability reduce or annul the mother's education effect? If the community services variable is statistically significant, does its impact on child health vary with her level of education?

Another interesting hypothesis to test is an empirical one: how many years of education are needed to see largest impacts on child health? In other words are there threshold effects of mother's education?

(6) A threshold of 6 years of school (primary school completed) for largest impacts is hypothesized (this is based on the fact that in the primary school curriculum in Burkina Faso, hygiene and health subjects are introduced during the last two years).

The estimation of the pathways can be done by incorporating the pathways into equation (5) as follows.

$$H_i = h(CC_i, MS_i, FS_i, HK_i(MS_i), BP_i(MS_i), M_i(MS_i), \mathbf{HEV_i}, \mu_i) \qquad (7)$$

where HK_i is mother's health knowledge, BP_i is mother's bargaining power, and M_i is household income. The mother's education effect can be decomposed as follows.

$$\frac{dH_i}{dMS_i} = \frac{\partial H_i}{\partial MS_i} + \frac{\partial H_i}{\partial HK_i}\frac{\partial HK_i}{\partial MS_i} + \frac{\partial H_i}{\partial BP_i}\frac{\partial BP_i}{\partial MS_i} + \frac{\partial H_i}{\partial M_i}\frac{\partial M_i}{\partial MS_i} \qquad (8)$$

If mother's education has a direct impact on child health, then the first term on the right hand side of equation 8 should be positive and statistically significant from zero. There are some endogeneity issues with some of the pathways (such as those for income and health knowledge); these will be addressed in the following section.

4) Data and Methods

A) Data

The data for this study come from three different sources. The main source is the Burkina Faso 2007 *Enquête Annuelle sur les Conditions de Vie des Ménages* (2007 EACVM). Additional data sources include the Ministry of Basic Education of Burkina Faso and an Internet distance calculator. In the remainder of this paper, the household survey data will be referred to as 2007 EACVM data, and the additional data will be referred to as education policy change data.

a) Household survey data

EACVM surveys collect nationally representative household survey data to assess poverty in Burkina Faso. The 2007 EACVM survey used a two-stage stratified sampling design. The primary sampling units (PSUs) are census tracts (*zones de dénombrement*) all of which are designated as rural or urban. In rural areas, census tracts consist of a village or a group of villages. The secondary sampling units are households from the PSUs. In the first stage, 425 PSUs were selected with probability proportional to size, so one need not use weights in statistical analyzes. In the second stage, 24 households were randomly selected with equal probability from each PSU. The systematic selection method was used, and the questionnaire was administered to 20 households, leaving 4 households for replacement. The total sample size is 8500 households, which together contained 6750 children age five and under. The EACVM data provide information on household assets, household demographics, education, health and nutrition, employment status, economic activities, housing, sanitation services, access to health and education services, and access to clean water.

b) Education policy change data

The education policy change data were collected from "*Projet Ecoles Satellites*", which is administered by the Ministry of Basic Education. The information collected includes the name of each *Ecoles Satellite* (ES), the location of each ES, number of students, year established, and province-level primary school enrolment rates.

Distance to school is an important determinant of school attendance, which in turn affects educational attainment (Vuri, 2008). The distance between household residence and the nearest ES was computed using an Internet distance calculator available at http://www.infoplease.com/atlas/calculate-distance.html. The distance is calculated from the center of the locality where the household resides to the center of the locality the school is located in. This information is used to construct instrumental variables for mother's education. The instrumental variables are a dummy variable indicating whether the mother lived within 5 km of an ES when she was school age, (between 6 and 10 years of age[5]) a dummy variable indicating whether the mother lived between 5 and 10 km of an ES when she was school age, the number of years an ES was available in the area during the years that she was 6 to 10 years old, and interactions terms between the dummy variables for distance to an ES and the number of years an ES was available. The rationale behind the interaction terms is that what may matter most is having both the school close by and how long the school has been available. In other words, the longer the ES has been around and the closer to the ES one lives, the more likely one is to have been affected by the program.

c) Data sample used in this study

The original sample size is 6,750 children ages five and under. The earliest start year of the *Ecoles Satellites* program is 1995, and children entering the ES schools are of ages between 6 and 10. Taking into account the school entrance age and the necessity to have mothers who were never exposed to the program in the sample, I restrict the sample to mothers born in 1978 or later. Restricting the sample to children of mothers born in 1978 or later reduces the sample size to 3,671 children.

Since the purpose of this study is to estimate the impact of parents' education on child health, 10 observations are dropped for children that passed away (because there are no

[5] The ES program targets children between 7 and 9 years of age. I allowed an additional year on each side of the age interval.

anthropometric measures for such children), and 263 observations are dropped for children whose father is not the household head (such children cannot be matched to their father in dataset for individuals living in the household).

Day and/or month of birth information is missing for 39% of the 3,671 children in the initial sample. Therefore, age in months was imputed for children with information on age at last birthday (age in months in this case is age in years multiplied by 12 plus 6 months) and children with month and year of birth information (day of birth missing). It is important to note that imputing age in months may introduce noise in the child age variables since in Burkina Faso, especially in rural areas, many children do not obtain a birth certificate until they are of school age (ages 6 and over), which means the age information collected is from parents' memories. Given the low literacy rate (25.3% in 2008, UNESCO) in the population, what parents recall as year, month, or day of birth of their children may be incorrect.

Distance information (between household residence and program schools) could not be obtained for 683 observations because the Internet distance calculator could not find the corresponding villages. In the process of computing child anthropometric measures (height-for-age and weight-for-height), 478 children with biologically implausible height (given their age) or weight measures (given their height) and 230 children with missing both HAZ and WHZ were dropped from the sample. The final sample size consists of 2,007 children ages zero to 59 months.

d) Descriptive Statistics

Child variables

The children in the sample used in this study were 59 months old or younger at the time of the survey. Table 1 presents descriptive statistics for the child characteristics. The average age in months (imputed) is 27.3, and 52.7% of the children are boys. This research focuses on two child health outcomes: height-for-age and weight-for-height. The prevalences of stunting (HAZ<-2) and wasting (WHZ<-2) are 47.6% and 20.7%, respectively. Severe stunting (wasting) is defined as HAZ<-3 (WHZ<-3). Based on this definition, 28.3% of the children in the data are severely stunted and 11.2 % are severely wasted. When HAZ (WHZ) is between -3 and -2 the child is said to be moderately stunted (wasted). In this sample, 19.4% of the children are moderately stunted whereas 9.5% are moderately wasted.

Child health outcomes by parents' education

For both health outcomes of the child, there is a positive correlation between them and both mothers' education and father's education. Looking at stunting status, there is a difference of about 14.6 percentage points in the percent of children that are stunted between educated mothers and non-educated mothers (Table 2, second column). The difference in the percent of children that are stunted by father's education is about 12.8 percentage points (Table 2, second column). For wasting status, there is a difference of about 4.0 percentage points in the percent of children that are stunted between educated mothers and non-educated mothers (Table 2, third column). The difference in the percent of children that are wasted by father's education is only 2.1 percentage points (Table 2, fourth column).

Parents and household variables

The parent and household characteristics that are used in the regression analysis below include mother's years of education, mother's age at child's birth, father's years of education, father's age, assets and income. Table 3 presents the descriptive statistics for the parent and household characteristics. About 7% of the households currently reside within five km of an *Ecole Satellite* (ES) and 10% reside between five and 10 km of an ES. The average education for mothers is 1.4 years (6.9 years for mothers with non-zero education) and 2.1 years for fathers (7.9 years for fathers with non-zero education). Mothers are 24 years old on average and fathers are 36 years old on average. On average, households spend 8,510 CFA francs per capita per month (about $17). Only 16% of households have electricity. For television and cell phone, the percentages are 20% and 25%. Bicycles are a common means of transportation in Burkina Faso: 87% of the households own a bicycle while motorcycles and cars are less common (38% and 2%, respectively). About 25% of households live in urban areas. On average mothers know correct answers to 4 questions (out of 8) about HIV transmission routes. Roughly 65% of mothers contribute to household expenses. About 92% of mothers reported no illness in the 15 days prior to the interview.

B) Methods

a) Empirical Model

From the maximization problem in the theoretical model, the reduced form demand for health was derived as a function of prices p, household characteristics and environmental variables HEV, the child's genetic health endowment μ, and money income M. The problem in estimating this reduced form equation is that the genetic health endowment is potentially known to the family, but is not observed by the researcher. Rosenzweig and Schultz (1983) showed that this will lead to biased estimates. For instance, the child health endowment might be correlated with observed variables such as mother's health knowledge, which would bias OLS estimates. In addition, mother's education may be correlated with unobserved variables (ethnicity, religion, etc.) that, if they directly affect child health, would result in omitted variable bias. In order to account for the likely endogeneity of mother's education, we need to estimate the health technology using a system of equations in order to avoid bias:

$$\begin{aligned} S_i &= \alpha + \lambda_k + \delta\mathbf{Z} + \gamma\mathbf{X} + \varepsilon_i \\ H_i &= \tau + \lambda_k + \beta S_i + \theta\mathbf{X} + \nu_i \end{aligned} \tag{9}$$

where S is parents' education, H is the health outcome, $\mathbf{X}$ is a vector of exogenous regressors, $\mathbf{Z}$ is a vector of instrumental variables for education , λ_k is province[6] fixed effects, δ, γ, θ, and β are parameters, α and τ are constants, and ε and ν are error terms.

The exogenous regressors include child age in months, the square of child age (in months), child gender, province of residence, father's education, and parents' age. To obtain identification of mother's education effects on child health, the changes in policy that occurred in the mid-1990s in Burkina Faso will be used as instrumental variables.

[6] The distance variable used as an IV is the same for households living in the same community, therefore community fixed effects cannot be used in the regressions.

b) Identification strategy

To determine whether a child's mother was affected by the education reform during her childhood, the age of a mother and her village or city of residence are used. The official age range for attending primary school in Burkina Faso is 6 to 12 years. However, both delayed entry into primary school and grade repetition in primary school are common. Education statistics from the Ministry of Basic Education show grade repetition rates of 17.1% and 11.7% for girls in primary school in 1997-1998 and 2004-2005, respectively. This means that it is likely that more girls might have been affected by the reform than one would infer based on age alone. Girls who entered "CP1" (first year of primary school) in the school year 1995-1996 (or later) would be affected by the reform (the program stated in 1995). Recall that the '*Ecoles Satellites*' enroll children between 7 and 9 years old who have not yet been in school. I allow for an additional year on each side of the interval [7, 9] because school age entry is not strictly enforced in Burkina Faso. This means that mothers born between 1985 and 1993 (the youngest mothers were 14 years old in 2007) would be potentially affected by the primary school policy change that occurred beginning in the school year 1995-1996.

Turning to the region of residence, the percentage of mothers in the sample who still live in the region where they were born ranges from 54.6% in *Centre* (Region 11) to 93.4% in *Centre Nord* (Region 6) with an average of 78.9% for all 13 regions. In only three regions is the percentage less than 75%. In those three regions (where the three largest urban areas are located) there are only 12 '*Ecoles Satellites*'. Therefore, the current city or village of residence will be used in computing the distance between the nearest '*Ecole Satellite*' and the household's residence. Province of birth is not observed in the data, only region of birth is. Previous evidence (Vuri, 2008) showed that distance to school is an important determinant of school attendance, which in turn affects educational attainment. An Internet distance calculator was used to compute the distance between household residence and the nearest ES, information that is used to construct instrumental variables for mother's education (described in section 4.1.2).

To determine the effect of the reform on educational attainment, the following regression equation will be estimated:

$$S_i = \alpha + \lambda_k + \delta\mathbf{Z} + \gamma\mathbf{X} + \varepsilon_i \tag{10}$$

where S_i is years of schooling of mother i, α is a constant, λ_k is a province fixed effect, $\mathbf{Z}$ is a vector of instrumental variables (described above), **X** is a vector of control variables, δ and γ are vectors of parameters, and ε_i is an error term.

Equation (10) is the first stage of a two-stage least squares (2SLS) estimation to determine the existence of a causal effect of mother's education on child health (hypothesis 1). The second stage equation is:

$$H_i = \tau + \lambda_k + \beta S_i + \theta\mathbf{X}_i + \nu_i \tag{11}$$

where H_i is the health of child i, τ is a constant, λ_k is a province fixed effect, S_i is mother's years of schooling, $\mathbf{X_i}$ is a vector of control variables, and v_i is an error term. The child anthropometric measures variables will serve as left-hand-side variables in this equation.

To test hypothesis 2 (the income pathway), household expenditures will be added to the vector of controls, **X**, to see what effect it has on the education coefficient. Household assets are often used as an instrument for household expenditures since the latter is endogenous: parents' decisions (especially a mother's decision) to participate in the workforce are jointly determined with child health. However, as pointed out by Thomas, Strauss and Henriques (1991), household assets will not remove all income-related effects from the education estimates: one would need data on wages to do so, but wage data are not available in the EACVM survey. Therefore, the wealth index (a composite index that is based on exogenous measures of household assets, on amenities, and on services) will be used to instrument with the caveat above-mentioned.

To test hypothesis 3 (the health knowledge pathway), one needs to add mother's health knowledge to the vector of controls, **X**. There is an endogeneity issue with mother's health knowledge, since there may be a negative correlation with the child's genetic health endowment (Glewwe, 1999). The mother's health knowledge variable is generated from the information on HIV transmission knowledge, which will be used as a proxy for mother's health knowledge. This is general health knowledge information; it does not pertain specifically to child health and nutrition, but unfortunately there are no other health knowledge questions in the questionnaire. Two advantages of using HIV/AIDS knowledge as an indicator of health knowledge are that the former is less likely to be endogenous, and that the direction of the bias is known (negative because of attenuation bias due to measurement error). Therefore a lower bound effect is what one would be estimating.

The EACVM 2007 survey includes information on whether women contribute financially to household expenses. This information is used to generate a proxy variable for women's bargaining power, which will be added to the regression equation to test hypothesis 4 (the bargaining power pathway).

To test hypothesis 5 (the community services availability pathway), interactions between the instrumental variables for mother's schooling and community services variables will be included in equation (11). Community services, such as clinics and piped water availability, could be viewed as complements to mother's education in the sense that more educated mothers would make more use of them. They could also be viewed as substitutes to mother's education since the least educated mothers may receive the largest benefit from these community services. So, if the sign of the estimated interaction coefficient is positive, then the community services are complements; if the sign is negative, they are substitutes.

For a long time, international organizations such as the World Bank have, supported education programs in developing countries that focus on basic (primary) education. This suggests a belief that six years of schooling (primary school completion) are sufficient to generate sizable returns to education. This is and the fact that in primary school curriculum in Burkina Faso, hygiene and health subjects are introduced during the last two years are behind hypothesis 6 (six years of schooling are needed to obtain large impacts). To determine whether threshold effects exist, nonparametric methods will be used to look at the bivariate relationship between maternal education and child health. If the resulting relationship is nonlinear, separate binary variables for three levels of mother's schooling will be used in the estimation of the child health production function.

5) Results

This section presents the estimation results. It begins with the estimation of the effect of mother's education on anthropometric indicators of child health. Then the results of the threshold effects estimation are presented. A basic model without any pathway variable is estimated (see appendix for results) but only the full model with pathways results are discussed.

A) Causal effect of mother's education

The dependent variables examined in this subsection are height-for-age (HAZ) and weight-for-height (WHZ) Z-scores. Both anthropometric measures are used as dependent variables as they measure long-term and short term malnutrition respectively. The estimation methods used are OLS with province fixed effects (FE)[7] and instrumental variables with province fixed effects (IV/FE). IV regressions are preferred to OLS, which produces biased estimates if mother's education is affected by unobserved variables that also affect child health. The direction of the bias depends on whether the correlation between mother's education and the unobservables is positive (upward bias) or negative (downward bias). In addition controlling for FE in the IV estimation can purge potential bias in the estimates from unobserved province level variables that may be correlated with the regressors, such as unobserved government health programs. Mother's age at birth of the child is included in all regressions to (partially) control for heterogeneity in the child's health endowment. Robust standard errors are computed for both

[7] Burkina Faso has 45 provinces. In the sample used here there are two provinces with less than 10 observations. Therefore the observations from those provinces were combined with those of neighboring provinces.

estimation methods to account for possible heteroskedasticity. In the remainder of this paper, the terms *Ecole Satellite* (ES) and program school will be used interchangeably.

Before presenting the parametric results, Figure 3 shows the bivariate relationship between HAZ (WHZ) and mother's education obtained by using semi-parametric regression. A local polynomial regression of HAZ (WHZ) on mother's education and its square is used to fit segments of the data. The method produces a smooth curve of the relationship along with 95% confidence interval curves. The graphs seem to indicate that HAZ is more sensitive to variations in mother's education.

Checking the explanatory power of mother's education on the pathway variables

Table 4 presents OLS results of the regressions of household per capita expenditures, mother's health knowledge and bargaining power on mother's education and other regressors. Mother's education has positive and strongly significant coefficient in the per capita expenditures and health knowledge regressions but it is negative and insignificant in the bargaining power regression.

Regression Results for Child Weight-for-height (WHZ)

Instrumental Variables Regressions: First Stage Regressions for WHZ

Table 5 presents the first stage results for WHZ. Mother's years of education and per capita household expenditures are treated as endogenous and are instrumented using distance from household residence to nearest program school, number of years a program school was available, interactions terms between distance to nearest *Ecole Satellite* and number of years a program school was available, and scores from the wealth index (constructed using household assets and housing characteristics).

In the mother's education equation the variables of interest are d_1 (a dummy variable indicating whether the distance between household residence and the nearest *Ecole Satellite* is between 0 and 5 km), d_2 (a dummy variable indicating whether the distance between household residence and the nearest *Ecole Satellite* is between 5 and 10 km), d_1**ESyears* (interactions terms between d_1 and the number of years a program school was available) *and* d_2**ESyears* (interactions terms between d_2 and the number of years a program school was available). The reference group for the distance variable is residence farther than 10 km from an ES. The variable *ESyears* is not expected to be significant since it captures the impact on having an ES available in the area for household residing farther than 10 km from the school. For the regression with mother's education as the dependent variable the results show that the coefficient on d_1 is negative and statistically insignificant. The coefficient of d_1**ESyears* is positive and significant at the 1% level. The coefficient for d_2 is positive and statistically significant. The coefficient for d_2**ESyears* is negative and statistically insignificant. The four coefficients suggest that for mothers who lived in an area where an ES was available for one year there is an increase of 0.8[8] years in their years of schooling. For mothers who were exposed to an ES for three years, there is an increase of 1.89 years. The F-statistics for the excluded instruments is 32.12 (p= 0.000) which passes the F > 10 test for good instruments.

Turning to the per capita household expenditures equation, the main variable of interest is the wealth index, whose coefficient estimate is positive and significant. The F-statistic for this regression is 27.05 (p= 0.000) for IV suggesting that the wealth index is a valid instrument for per capita expenditures.

Instrumental Variables Regressions: Second Stage Regressions for WHZ

Table 6 presents the results for the full model WHZ regressions. The mother's education coefficient is positive and strongly significant, and these impacts are about 10 times as large as those for the OLS regressions (Table A_1). The coefficient for the full model suggests an increase of 0.19 (evaluated at mean education= 6.9) to 0.9 (evaluated at mean education = 1.43) standard deviations in child's WHZ for each additional year of mother's education. The standard errors in the IV specification here are much larger than those of the OLS with province fixed effects

[8] This number is obtained from the following expression: $\frac{\partial logEduc}{\partial d_1} + \frac{\partial logEduc}{\partial d_2} = \beta_1 + \beta_4 * ESyears + \beta_2 + \beta_5 * ESyears$ where the mother's education equation is $logEduc = \beta_1 * d_1 + \beta_2 * d_2 + \beta_3 * ESyears + \beta_4 * d_1 * ESyears + \beta_5 * d_2 * ESyears + \delta\mathbf{X} + \varepsilon$

specification in Table A_1 (in appendix), again suggesting a loss of precision with IV estimation. Child age is significant but father's age and urban residence are not. Father's education is negative and significant which is still quite puzzling. Other estimates are also puzzling. Mother's bargaining power and per capita expenditures are negative and significant.

The endogeneity test produced a chi square statistic of 5.73 with a p-value of 0.06 confirming that IV methods should be preferred for WHZ estimation. The overidentification tests show that the value for the Hansen J statistic is 6.50 for the full model (p=0.16). Therefore the null hypothesis of IVs uncorrelated with error term cannot be rejected.

Regression Results for Child Height-for-age (HAZ)

The first stage results of IV estimation are similar to those of WHZ (see appendix). In the second stage results (in appendix), the endogeneity test results (chi square = 2.20, p-value = 0.33) suggest that mother's education and per capita expenditures are not endogenous in the HAZ equation. Therefore OLS with fixed effects results are interpreted. Table 7 shows that the coefficient of mother's education is positive but not significant when all pathway variables are included in the regression (last column) suggesting that mother's education does not have a direct impact on child HAZ. The coefficient of per capita expenditures is positive and significant at the 1% level which suggests that income is the pathway through which mother's education affects child HAZ.

Summary of Causal Effects Results

The first stage results showed that the construction of *Ecoles Satellites* had a significant impact of girls' educational attainment: there is an increase of 0.80 years of schooling as a result of a one year "exposure" to an ES. For a three-year exposure to a program school, mother's years of schooling is estimated to increase by 1.89 years. The impact of this program seems to extend to the next generation, namely the children of the mothers who benefited from the program when they were very young. Mother's education significantly impacts child WHZ (an increase of 0.9 standard deviations in WHZ for each year of mother's education) but not child HAZ after accounting for province fixed effects in the OLS regression (the preferred specification for HAZ). This difference of statistical significance between short term and long term malnutrition measures may be explained by the fact that child HAZ is set by 24 months of age (meaning HAZ does not vary much after 2 years of age) implying a smaller sample for HAZ. Therefore the program does not affect HAZ for children older than 24 months. In terms of the difference in the magnitude of the mother's education coefficient between OLS and IV regressions, one explanation may be measurement error in WHZ. Another explanation could be that the negative coefficient of mother's bargaining power in the WHZ suggests that mother's with more education (hence bargaining power) spend more time away from home. Lastly, IV regressions may be estimating something different than OLS regressions if there is variation in the treatment received. The children who attended ESs are taught in their local language and in French which would qualify as difference in treatment received.

B) Threshold effects of mother's education

To determine whether threshold effects exist, consider the bivariate relationship between maternal education and child WHZ using nonparametric methods shown in Figure 4. The relationship is nonlinear. Therefore separate binary variables for each year of mother's schooling are included in the child health regression results shown in Table 8. Mother's education has two large and statistically significant impacts at 6 years (coefficient = 0.547) and at 11 years (coefficient = 1.274), suggesting threshold effects exist. Although the largest significant impact is at 11 years of education, the coefficient at 6 years of education has a stronger statistical significance. Part a of Figure 4 (single dummy variables for each year of education) shows that the confidence interval for 11 years of education is much wider than the 6 years of education confidence interval. In part b of Figure 4 education years 1 to 5 and 7 to 10 were combined to try to obtain more precise estimates. The coefficient for 6 years of education still has the highest significance level and the coefficient for 11 years the largest magnitude but the coefficient for 13 years is more significant (p=0.053) than before and its magnitude is larger than that of 6 years of education. If the magnitude of the coefficient is used as the main criterion, these results suggest that 13 years should be the goal of education policies to target girls if one wants to maximize the impact on the next generation's health. However, going from 6 years to 13 years is costly, especially for low-income countries like Burkina Faso.

The relationship between mother's education and child's HAZ is also nonlinear as shown in Figure 5. Table 9 shows the regression of child HAZ on dummy variables for each year of mother's schooling. The coefficient at three years of education is negative and strongly significant suggesting these are students with low innate ability. The largest positive and statistically significant impact is at 12 years (coefficient = 0.878) suggesting that should it should be the goal education policies targeting girls for maximum impact on the child's health. This is similar to the WHZ threshold of 11 years. Again, the cost of going from 6 to 12 years of education needs to be taken into account. Figure 5 indicates that the most precisely estimated coefficient is the coefficient for 7 years of education when dummy variables for single years of education are included in the regression. If education years 1 to 5 and 7 to 10 are combined the most precisely estimated coefficient is that of 12 years of education which also has the largest magnitude.

6) Conclusion

This paper has examined the impact of mother's education on child health in Burkina Faso for children age 59 months and younger. A change in education policy in primary school (construction of schools in areas with low enrollment rates, with a 50% quota for girls' admission in the first year) was used to attempt to purge endogeneity bias from the estimates of mother's education. The results show that mother's education significantly and positively affects child weight-for-height (which measures wasting, an indicator of current malnutrition). The effect of mother's education on child height-for-age (which measures stunting, an indicator of chronic malnutrition) is positive but statistically insignificant, suggesting no direct effect of mother's education on child's HAZ. Per capita household expenditures and mother's bargaining power seem to be pathways through which mother's education affects children's HAZ. For WHZ, the mother's education variable was found to be significant even after including all pathways in the regression, indicating that mother's education, by itself, has a strong causal effect on child health or there are other pathways that the data used did not allow us to investigate. The threshold effects estimation indicate the largest impacts of mother's years of education at 13 years of education for WHZ and 12 years for HAZ. Thus, after taking costs into consideration, education policies targeted to girls should focus on trying to maintain them in school longer than the six years that has been the standard so far. Per capita expenditures being a pathway for mother education-child health relationship and education being positively correlated with income reinforces the recommendation of keeping girls in school as long as possible. This would increase their chances at better paying jobs which in turn would positively affect the health outcomes of their future children. Although health knowledge variable did not prove significant in either regression, nutrition education programs targeted at girls while in school and later when they become mothers would help improve children's nutritional status. Given the impact of the ES program on girls' educational attainment, this program should be scaled up, improved (e.g. provide school lunches) and the bilingual nature of the schools should be maintained as it seems to make a difference in test scores compared to regular schools.

Despite a thorough attempt to provide unbiased estimates of the impact of mother's education on child health, the estimates still may be biased and the IV estimates suffer from imprecision (standard errors increase sharply from OLS with FE to IV with FE and F-statistic of excluded instruments passes the test of F >10 only when both mother's education and household expenditures are instrumented). Omitted variable bias may still be a problem because religion and ethnicity are not available in the data used, and data quality (especially health knowledge and bargaining power information) may be an issue here. Another limitation of this study could be addressed in future studies by looking at the mother’s education-child health relationships using longitudinal data.

Figures

Figure 1: Primary School Enrolment Rates for Five Provinces with ESs

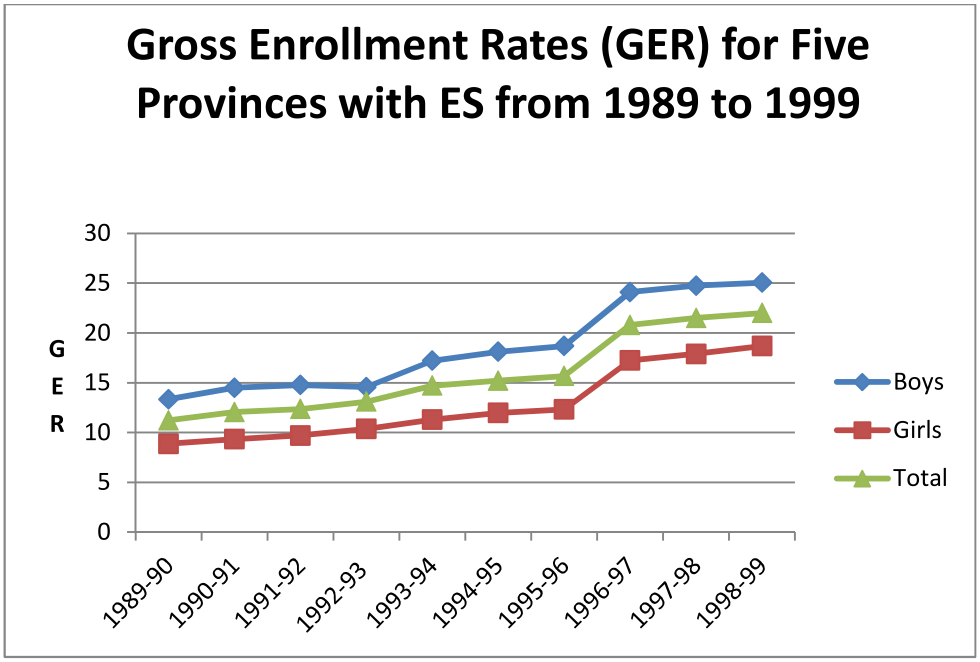
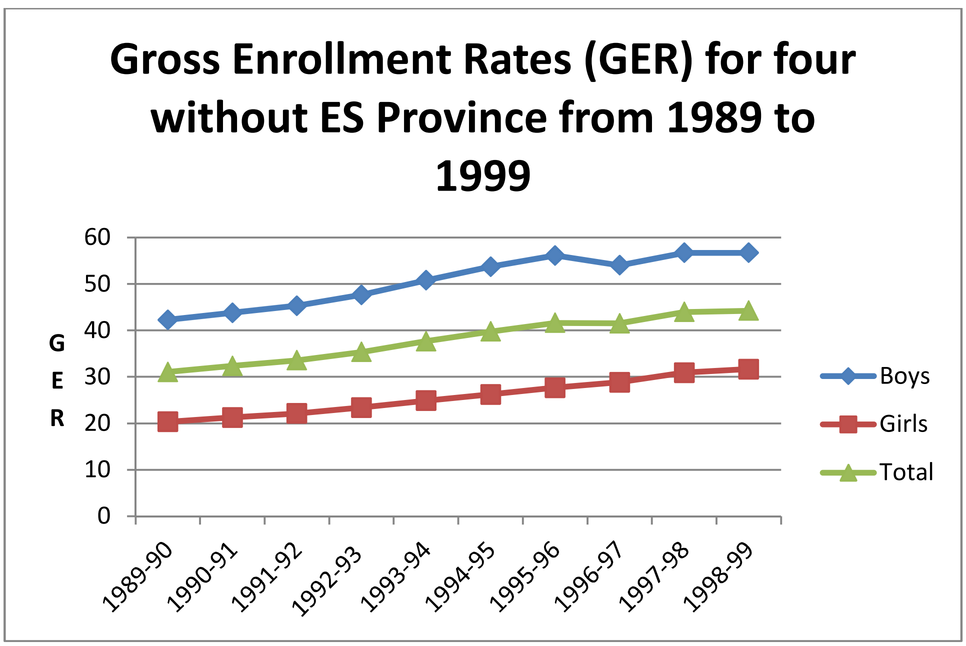
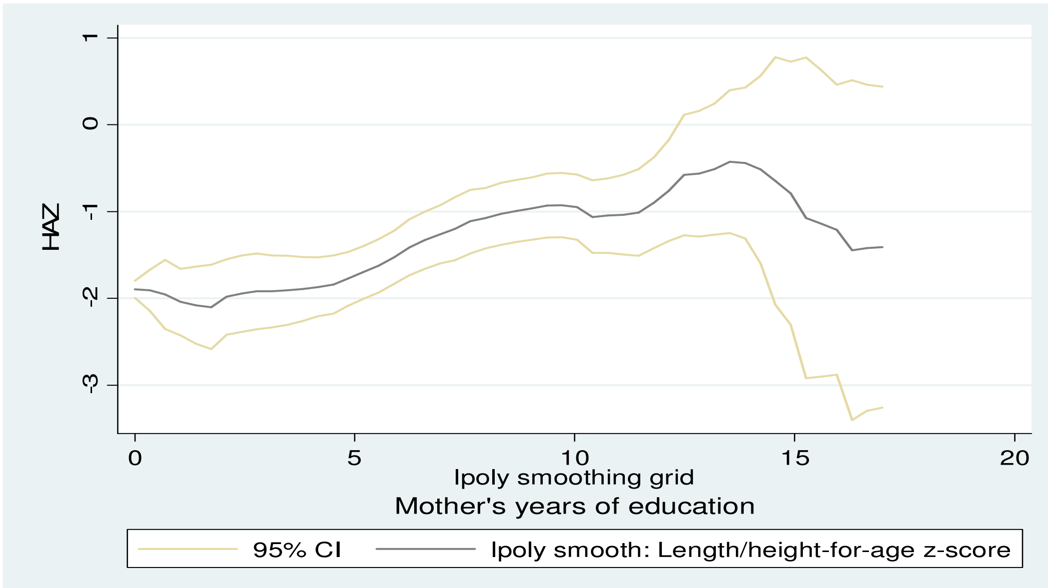


Figure 2: Primary School Enrolment Rates for Four Provinces without ESs



Data source: Statistiques de l'éducation de base, 1989-1999, MEBA, Burkina Faso

Figure 3: Semi-parametric Regressions of HAZ and WHZ on Mother's Years of Education



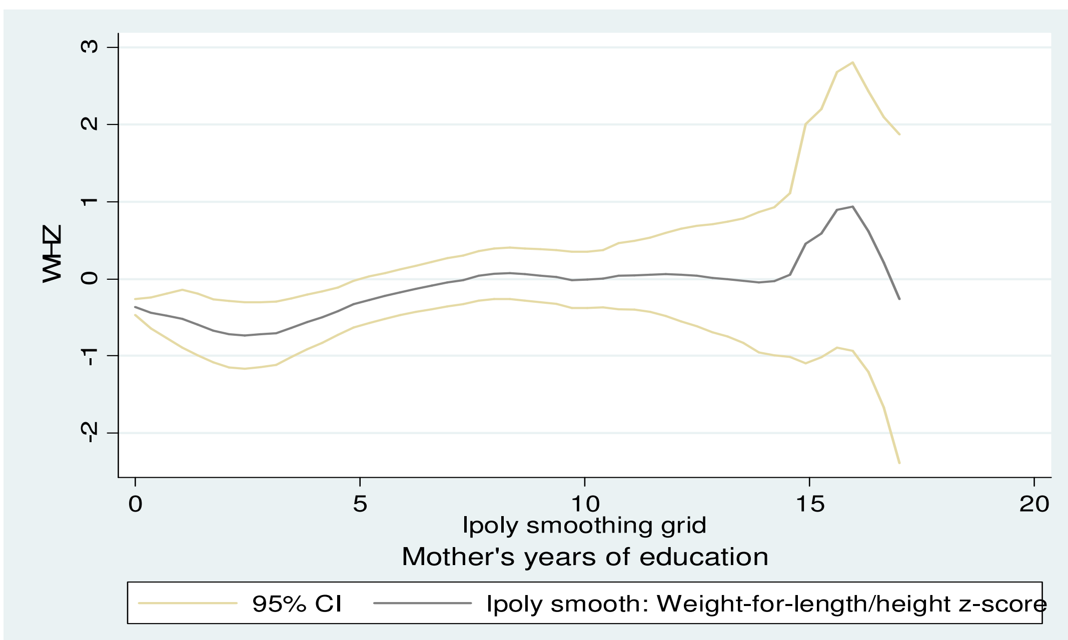
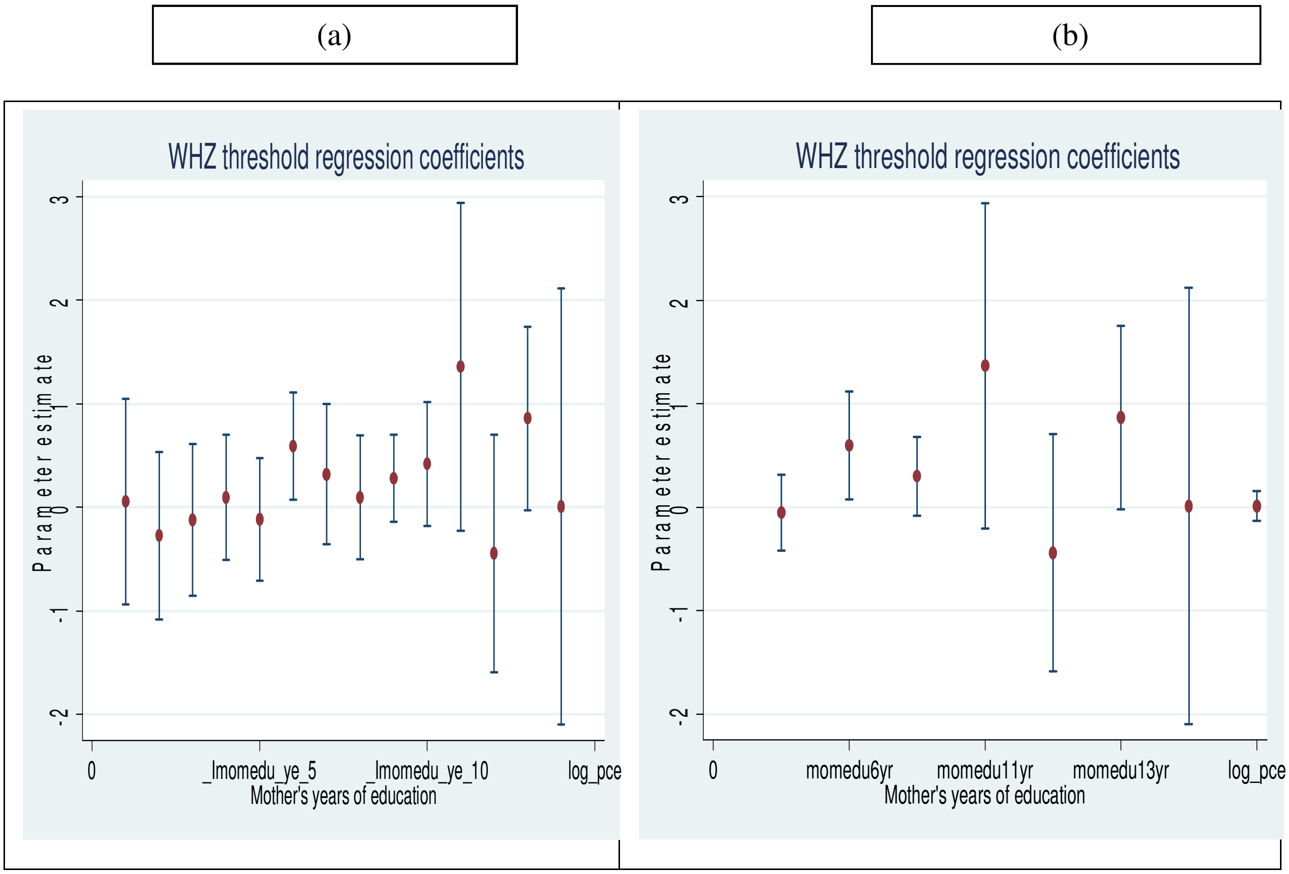


Figure 4: Graphs of the WHZ Regression Coefficients and their Confidence Intervals

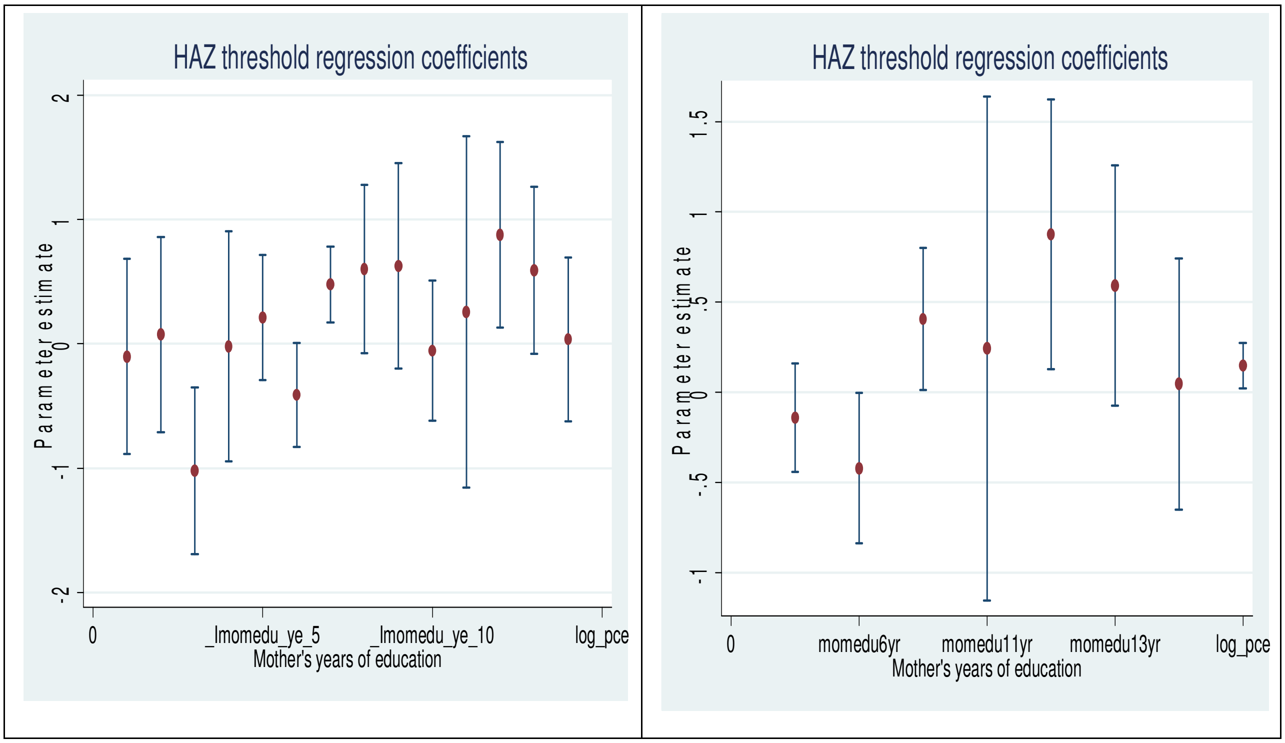


a) Dummy Variables for Each Year of Mother's Education

b) Dummy Variables Combining Years 1 to 5, Years 7 to 10 and the Rest in Single Years

Figure 5: Graph of the HAZ Regression Coefficients and their Confidence Intervals

(a) (b)



a) Dummy Variables for Each Year of Mother's Education

b) Dummy Variables Combining Years 1 to 5, Years 7 to 10 and the Rest in Single Years

Tables

Table 1: Child Health Outcomes and Child characteristics

Variable	Obs	Mean	Std. Dev.	Min	Max
Child's age	2003	2.1	1.40	0	5
Child's age in months	2003	27.3	16.8	0	59
Male	2007	52.7%	0.50	0	1
HAZ	2003	-1.8	2.05	-5.98	5.8
Stunting	2003	47.6%	0.50	0	1
Moderate stunting	2003	19.4%	0.40	0	1
Severe stunting	2003	28.3%	0.45	0	1
WHZ	1932	-0.3	2.04	-4.96	5
Wasting	1932	20.7%	0.40	0	1
Moderate wasting	1932	9.5%	0.29	0	1
Severe wasting	1932	11.2%	0.32	0	1

Table 2: Child health Outcomes by Parents' Education

	Stunting	**Wasting**
Mother schooling		
No schooling	50.7%	21.5%
Some schooling	36.1%	17.5%
Father's schooling		
No schooling	51.2%	21.2%
Some schooling	38.4%	19.2%
Total	47.6%	20.7%

Table 3: Parents and Household Characteristics

Variable	Obs	Mean	Std. Dev.	Min	Max
Zero to 5km of program school (ES)	2007	6.9%	0.25	0	1
Five to 10km of program school (ES)	2007	10.1%	0.30	0	1
Number of years ES was available	2007	0.4	1.05	0	5
Mother’s years of education	2007	1.4	3.12	0	17
Mother’s age	2007	24.3	3.29	14	29
Mother’s age at birth of the child	2003	22.1	3.33	10	29
Father’s years of education	2007	2.1	4.15	0	17
Father’s age	2004	35.7	11.44	15	97
Per capita expenditures (monthly, 1,000 FCFA)	2005	8.2	12.44	0	225
Wealth index (scores)	2007	0.2	1.13	-1.10	4.02
Urban residence	2007	24.5%	0.43	0	1
Television	2007	20.1%	0.40	0	1
Radio	2007	74.9%	0.43	0	1
Refrigerator	2007	5.4%	0.23	0	1
Bicycle	2007	86.8%	0.34	0	1
Moped	2007	38.5%	0.49	0	1
Car	2007	2.4%	0.15	0	1
Electricity	2007	15.8%	0.37	0	1
Cell phone	2007	25.0%	0.43	0	1
Mother’s health knowledge	2007	3.7	1.80	0	8
Mother’s bargaining power	2007	65.4%	0.48	0	1

Table 4: OLS Estimates of Mother's Health Knowledge, Bargaining Power, and Household Expenditures on Mother's Education and other Variables

VARIABLES	OLS Per capita expenditures	OLS Health knowledge	OLS Bargain power
Mother's education (log)	0.300***	0.541***	-0.023
	(0.031)	(0.064)	(0.018)
Per capita expenditures (log)		0.084*	-0.022
		(0.049)	(0.014)
Mother's age	-0.001	0.041***	0.018***
	(0.007)	(0.013)	(0.004)
Father's education (log)	-0.125***	-0.158***	-0.028**
	(0.021)	(0.043)	(0.013)
Father's age	-0.007***	-0.001	-0.000
	(0.002)	(0.004)	(0.001)
Urban residence	0.370***	0.499***	-0.137***
	(0.052)	(0.117)	(0.037)
Has a television		0.225*	-0.064
		(0.128)	(0.041)
Has a radio		0.416***	-0.016
		(0.094)	(0.026)
Electricity		0.017	-0.005
		(0.149)	(0.049)
Constant	1.781***	1.973***	0.341***
	(0.162)	(0.336)	(0.095)
Observations	1934	1934	1934
R-squared	0.164	0.173	0.056

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5: First stage regression for child weight-for-height (WHZ)

VARIABLES	Basic model **Logarithm of mother's education**	Full model **Logarithm of mother's education**	Full model **Logarithm of per capita expenditures**
Zero to 5km of ES (d1)	-0.041	-0.008	0.068
	(0.066)	(0.049)	(0.092)
Five to 10km of ES (d2)	0.157**	0.163**	0.010
	(0.076)	(0.071)	(0.079)
Number of years ES was available (ESyears)	-0.016	-0.003	0.007
	(0.020)	(0.019)	(0.027)
Interaction d1*ESyears	0.349***	0.407***	-0.168**
	(0.107)	(0.124)	(0.066)
Interaction d2*ESyears	-0.049	-0.020	0.048
	(0.045)	(0.042)	(0.045)
Child's age (months)	-0.002	-0.001	-0.002*
	(0.001)	(0.001)	(0.001)
Male	0.010	0.002	0.042
	(0.030)	(0.027)	(0.038)
Mother's age at birth	0.005	0.003	-0.004
	(0.006)	(0.005)	(0.007)
Father's education	0.003	0.024	0.009
	(0.020)	(0.019)	(0.024)
Father's age	-0.004***	-0.003**	-0.006***
	(0.001)	(0.001)	(0.002)
Urban residence	0.675***	-0.012	0.145**
	(0.067)	(0.072)	(0.072)
Health knowledge		0.072***	0.028**
		(0.010)	(0.013)
Bargaining power		-0.023	-0.035
		(0.030)	(0.044)
Within 30 minutes of a health clinic		0.031	-0.007
		(0.035)	(0.041)
Wealth index		0.368***	0.320***
		(0.027)	(0.026)
Observations	1925	1923	1923
R-squared	0.117	0.299	0.161

Table 6: Second Stage IV Regressions for Child Weight-for-Height (WHZ)

VARIABLES	Basic model WHZ	Full model WHZ
Mother's education (log)	1.735***	1.287***
	(0.579)	(0.326)
Age in months	0.016***	0.012***
	(0.004)	(0.004)
Male	-0.164	-0.125
	(0.109)	(0.111)
Mother age at birth	0.009	0.017
	(0.018)	(0.017)
Father's education	-0.163**	-0.177**
	(0.071)	(0.070)
Father's age	0.014**	0.003
	(0.006)	(0.005)
Urban residence	-0.919**	0.196
	(0.434)	(0.254)
Health knowledge		-0.065
		(0.040)
Bargaining power		-0.287**
		(0.126)
Within 30 minutes of a health clinic		-0.033
		(0.130)
Per capita expenditures (log)		-1.113***
		(0.394)
Observations	1925	1923
R-squared	-0.244	-0.227
Number of provinces	43	43

Table 7: Reduced Form Estimates for Child Height-for-Age (HAZ): Pathways Added

VARIABLES	Base FE HAZ	Income HAZ	Health Knowledge HAZ	Bargainin g power HAZ	Communit y services HAZ	All pathways HAZ
Mother's education (log)	0.133**	0.083	0.123*	0.139**	0.130*	0.079
	(0.064)	(0.061)	(0.064)	(0.065)	(0.065)	(0.062)
Child's age (months)	-0.204***	-0.203***	-0.204***	-0.204***	-0.203***	-0.203***
	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)
Age square	0.542***	0.541***	0.543***	0.542***	0.541***	0.541***
	(0.129)	(0.131)	(0.129)	(0.130)	(0.129)	(0.132)
Age cube	-0.044***	-0.044***	-0.044***	-0.044***	-0.044***	-0.044***
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
Male	-0.135	-0.140	-0.135	-0.129	-0.136	-0.133
	(0.091)	(0.091)	(0.091)	(0.090)	(0.091)	(0.090)
Mother's age at birth	-0.008	-0.006	-0.008	-0.010	-0.008	-0.009
	(0.013)	(0.013)	(0.014)	(0.013)	(0.013)	(0.013)
Father's education	-0.008	-0.005	-0.008	-0.006	-0.008	-0.004
	(0.053)	(0.054)	(0.053)	(0.053)	(0.054)	(0.054)
Father's age	0.001	0.002	0.001	0.001	0.001	0.002
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Urban residence	0.193	0.107	0.184	0.214	0.183	0.114
	(0.189)	(0.192)	(0.195)	(0.190)	(0.190)	(0.198)
Per capita expenditures (log)		0.169***				0.170***
		(0.060)				(0.061)
Health knowledge			0.017			0.012
			(0.027)			(0.027)
Bargaining power				0.143		0.152
				(0.122)		(0.119)
Within 30 minutes of a health clinic					0.044	0.035
					(0.107)	(0.105)
Constant	0.238	-0.074	0.195	0.176	0.230	-0.178
	(0.382)	(0.433)	(0.371)	(0.409)	(0.379)	(0.454)
Observations	2000	1998	2000	2000	2000	1998
R-squared	0.101	0.104	0.101	0.102	0.101	0.105
Number of provinces	43	43	43	43	43	43

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 8: Threshold Effects Estimation Results for WHZ

VARIABLES	OLS/FE WHZ
Mother's education 1 year	0.057
	(0.493)
Mother's education 2 years	-0.277
	(0.397)
Mother's education 3 years	-0.120
	(0.359)
Mother's education 4 years	0.095
	(0.292)
Mother's education 5 years	-0.115
	(0.288)
Mother's education 6 years	0.592**
	(0.254)
Mother's education 7 years	0.322
	(0.330)
Mother's education 8 years	0.096
	(0.295)
Mother's education 9 years	0.280
	(0.208)
Mother's education 10 years	0.416
	(0.292)
Mother's education 11 years	1.358*
	(0.766)
Mother's education 12 years	-0.442
	(0.565)
Mother's education 13 years	0.861*
	(0.431)
Mother's education 17 years	0.005
	(1.039)
Observations	1923
R-squared	0.027
Number of provinces	43

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
All variables in the full model are included in the regression but not shown here.

Table 9: Threshold Effects Estimation Results for HAZ

VARIABLES	OLS/FE HAZ
Mother's education 1 year	-0.102
	(0.384)
Mother's education 2 years	0.075
	(0.385)
Mother's education 3 years	-1.021***
	(0.328)
Mother's education 4 years	-0.021
	(0.454)
Mother's education 5 years	0.211
	(0.246)
Mother's education 6 years	-0.413*
	(0.205)
Mother's education 7 years	0.477***
	(0.150)
Mother's education 8 years	0.601*
	(0.331)
Mother's education 9 years	0.626
	(0.406)
Mother's education 10 years	-0.056
	(0.276)
Mother's education 11 years	0.254
	(0.693)
Mother's education 12 years	0.878**
	(0.365)
Mother's education 13 years	0.593*
	(0.330)
Mother's education 17 years	0.035
	(0.322)
Observations	1998
R-squared	0.119
Number of provinces	43

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
All variables in the full model are included in the regression but not shown here.

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Appendix

Table A1: Reduced Form Estimates for Child Weight-for-Height (WHZ): OLS and Fixed Effects

VARIABLES	OLS **WHZ**	Fixed Effects **WHZ**
Mother's education (log)	0.120*	0.164*
	(0.069)	(0.086)
Child's age (months)	0.012***	0.011***
	(0.003)	(0.003)
Male	-0.155*	-0.126
	(0.093)	(0.103)
Mother's age at birth	0.014	0.019
	(0.015)	(0.015)
Father's education	-0.166***	-0.140**
	(0.050)	(0.058)
Father's age	0.007*	0.008
	(0.004)	(0.005)
Urban residence	0.109	0.215
	(0.119)	(0.169)
Constant	-1.107***	-1.307***
	(0.358)	(0.342)
Observations	1925	1925
R-squared	0.020	0.020
Number of provinces		43

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A_2: Reduced Form Estimates for Child Height-for-Age (HAZ): OLS and Fixed Effects

VARIABLES	OLS **HAZ**	Fixed Effects **HAZ**
Mother's education (log)	0.186***	0.133**
	(0.065)	(0.064)
Child's age (months)	-0.205***	-0.204***
	(0.028)	(0.035)
Age square	0.554***	0.542***
	(0.108)	(0.129)
Age cube	-0.046***	-0.044***
	(0.012)	(0.014)
Male	-0.102	-0.135
	(0.088)	(0.091)
Mother's age at birth	-0.004	-0.008
	(0.014)	(0.013)
Father's education (log)	-0.009	-0.008
	(0.049)	(0.053)
Father's age	0.001	0.001
	(0.004)	(0.004)
Urban residence	0.423***	0.193
	(0.113)	(0.189)
Constant	0.101	0.238
	(0.390)	(0.382)
Observations	2000	2000
R-squared	0.111	0.101
Number of provinces		43

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A3: First stage regression for Child Height-for-Age (HAZ) with province fixed effects

VARIABLES	Basic model **Logarithm of mother's education**	Full model **Logarithm of mother's education**	Full model **Logarithm of per capita expenditures**
Zero to 5km of ES (d1)	-0.045	-0.006	0.025
	(0.063)	(0.047)	(0.091)
Five to 10km of ES (d2)	0.155**	0.156**	0.023
	(0.074)	(0.069)	(0.076)
Number of years ES was available (ESyears)	-0.013	-0.001	0.001
	(0.020)	(0.019)	(0.027)
Interaction d1*ESyears	0.326***	0.380***	-0.165**
	(0.106)	(0.123)	(0.067)
Interaction d2*ESyears	-0.051	-0.019	0.049
	(0.044)	(0.042)	(0.045)
Child's age (months)	-0.004	0.000	-0.005
	(0.010)	(0.009)	(0.010)
Age square	0.008	-0.005	0.016
	(0.038)	(0.034)	(0.041)
Age cube	-0.001	0.001	-0.002
	(0.004)	(0.004)	(0.005)
Male	0.011	0.000	0.045
	(0.029)	(0.026)	(0.038)
Mother's age at birth	0.006	0.004	-0.005
	(0.006)	(0.005)	(0.007)
Father's education	0.000	0.022	0.015

	(0.019)	(0.018)	(0.024)
Father's age	-0.005***	-0.003**	-0.006***
	(0.001)	(0.001)	(0.002)
Urban residence	0.678***	0.004	0.169**
	(0.066)	(0.071)	(0.072)
Health knowledge		0.070***	0.030**
		(0.010)	(0.013)
Bargaining power		-0.026	-0.029
		(0.030)	(0.044)
Within 30 minutes of a health clinic		0.030	-0.004
		(0.034)	(0.040)
Wealth index		0.362***	0.314***
		(0.027)	(0.026)
Observations	2000	1998	1998
R-squared	0.116	0.296	0.157
F (test of excluded instruments)	3.11	32.45	27.03
P-value of F-test	0.008	0.000	0.000
Number of provinces	43	43	43

Table A_4: Second Stage IV Regressions for Child Height-for-Age (HAZ)

VARIABLES	Basic model HAZ	Full model HAZ
Mother's education (log)	-0.637	-0.355
	(0.514)	(0.301)
Child's age (months)	-0.206***	-0.199***
	(0.029)	(0.028)
Age square	0.535***	0.515***
	(0.111)	(0.110)
Age cube	-0.042***	-0.040***
	(0.012)	(0.012)
Male	-0.126	-0.153
	(0.091)	(0.094)
Mother's age at birth	0.001	-0.004
	(0.015)	(0.015)
Father's education	0.028	0.034
	(0.061)	(0.061)
Father's age	-0.002	0.005
	(0.005)	(0.004)
Urban residence	0.726*	0.030
	(0.387)	(0.204)
Health knowledge		0.020
		(0.034)
Bargaining power		0.217**
		(0.106)
Within 30 minutes of a health clinic		0.030
		(0.111)
Per capita expenditures (log)		0.713*
		(0.364)
Observations	2000	1998
R-squared	0.047	0.054
Number of provinces	43	43