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Mother's Education and Children's Nutrition Outcomes in Burkina Faso:

Is there a Strong Causal Relationship?

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About the Authors

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Abstract

This paper examines the relationship between mothers' education and children's nutrition outcomes, specifically child stunting (low height for age) and wasting (low weight for height), using data from the 2010 Demographic and Health Survey. Pathways through which mothers' education impacts children's nutrition outcomes are investigated, as are threshold effects of maternal education. We employ instrumental variable methods to account for the potential endogeneity of mother's education, mother's health knowledge, mother's bargaining power, and household wealth; none of these variables appear endogenous so we then use fixed effects OLS regressions. The findings show that a mother's education has a positive and significant effect on her children's Height-for-Age Z score; no statistically significant impact on Weight-for-Height Z score was found. Mother's health knowledge, mother's bargaining power, and household wealth are the pathways through which maternal education affects children's health. The impact of maternal education is largest at a threshold of 12 years of education.

Résumé

Ce document examine la relation entre l'éducation des mères et la nutrition des enfants, en particulier retards de croissance (taille insuffisante pour l'âge) et l'émaciation (faible poids pour la taille), en utilisant les données de l'Enquête démographique et de santé 2010. Les voies par lesquelles l'éducation des mères affecte le statu nutritionnel des enfants sont examinées, de même que les effets de seuil de l'éducation maternelle. Nous employons des méthodes de variables instrumentales pour tenir compte de l'endogénéité potentielle de l'éducation de la mère, des connaissances en santé de la mère, du pouvoir de négociation de la mère dans le ménage, et de la richesse des ménages; aucune de ces variables ne semblent être endogènes donc nous avons utilisé des régressions de Moindres Carrés Ordinaires avec effets fixes. Les résultats montrent que l'éducation de la mère a un effet positif et significatif sur le score de la taille-pour-âge de ses enfants; aucune incidence statistiquement significative sur le score poids-taille a été trouvé. Les connaissances en santé de la mère, le pouvoir de négociation de la mère, et la richesse des ménages sont les voies par lesquelles l'éducation maternelle affecte la santé des enfants. L'impact de l'éducation maternelle est le plus grand à un seuil de 12 années de scolarité.

1. Introduction

Proper nutrition during the first two years of life is crucial for overall health, physical growth, and mental development. Poor nutrition early on can lead to poor schooling outcomes, adversely affecting productivity and income later in life and resulting in low economic growth (Glewwe and Miguel, 2008). Malnutrition-related illnesses also lead to physical suffering, time costs for both parents and children, and monetary costs.

Unfortunately, many children in developing countries are malnourished and suffer from child stunting (low height-for-age). De Onis et al. (2000) estimates that the prevalence of stunting (low height-for-age) among developing countries' preschool children (children 5 years old or below) was 33% in 2000. In Burkina Faso, the prevalence rate for stunting was 35% in 2010 (Institut National de la Statistique et de la Démographie et ICF International, 2012).

Young children depend on their parents for nutrition; mothers in particular can have a potentially strong influence on children's nutrition outcomes because in most families, mothers spend more time taking care of children than do fathers. This suggests that mothers' education would likely matter more than fathers' education, after controlling for income. Hence, it is reasonable to assume that more educated mothers should have healthier, better nourished children.

In theory, there is general agreement that education leads to better health (Grossman, 1972 and Becker, 1981). However, the empirical findings are inconsistent. Some authors find that maternal education has a significant effect on children's health status (Glewwe, 1999), while others find little or no evidence of a causal relationship (Desai and Alva, 1998). One major problem in estimating the effect of maternal education on children's health is that unobserved factors may affect both maternal education and children's health simultaneously. This endogeneity problem means that the estimates of the effect of maternal education on children's health may be biased.

Most studies on the relationship between maternal education and children's 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 children's 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, however, instrumental variables do not guarantee a solution to the endogeneity problem. This paper will examine how a sudden change in educational 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 children's nutrition.

More specifically, the paper will to (1) verify whether a strong causal relationship exists between maternal education and children's nutrition status; (2) identify the channels (mechanisms) through which a mother's education affects her children's nutrition status; and (3) investigate whether threshold effects exist (that is, whether specific levels or years of a mother's education have unusually large impacts on her children's nutrition). Children's nutrition is measured in two ways: height-for-age (stunting), a long-term indicator, and weight-for-height (wasting), a short-term measure.

The rest of this paper is organized as follows. Section 2 reviews previous literature. Section 3 lays out the empirical strategy and Section 4 describes the data. Section 5 presents the results and the verification of the robustness of the results. Section 6 concludes.

2. Literature Review

2.1 Theory on the Relationship between Education and Health

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

Becker (1981) analyzes households' decisions regarding the number and health of their 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 and children's health. The model we use in the next section follows Becker's model of the family, with children's health as an argument in the household's utility function.

Grossman (2006) looks at the effects of education on non-market outcomes, namely, the causal effects of education and the channels through which it affects non-market outcomes. Grossman develops a framework in which education has productive efficiency effects and allocative efficiency effects. Productive efficiency effects imply that increases in schooling lead to increased efficiency in non-market-sector production process; for a given amount of inputs, more educated people produce a larger health output than less educated people. Allocative efficiency means that more educated people choose a different combination of inputs to produce non-market goods than do less educated people because the former have a better understanding of how to optimally use health technology. 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.

Regarding theoretical models, there seems to be an agreement among economists that parents' education positively affects children's health (Rosenzweig and Schultz, 1982; Behrman and Deolalikar, 1988). However, the empirical evidence provides another story. Some authors find a significant effect of maternal education on children's health status, while others argue that there is little or no evidence of a causal relationship. In addition, both the relationships estimated (production function, reduced form demand function for child health) and the methods used (OLS regressions, logistic models, instrumental variables approach, difference-in-differences approach, regression discontinuity, etc.) vary greatly. This paper will focus on analyzing the mechanisms (e.g. information processing, income, health knowledge, etc.) through which mothers' education affects children's health and nutrition outcomes. Past studies on the pathways through which maternal education affects child health outcomes have not produced clear findings, as discussed in the following sub-section.

2.2 Studies without Natural Experiments

To estimate a health production function, one needs data regarding many health inputs (duration of breastfeeding, age at introduction of solid foods and the types of foods introduced, calorie and protein intake, morbidity, use of clean water, sanitary and health practices, etc.), as explained by Thomas and Strauss (1992). A child health production function depends on a variety of health inputs that are endogenous to the production process (e.g. food intake, decision to vaccinate children, sanitary and health practices). The economic theory of the household (Becker, 1965 and 1981) states that both children's health and children's nutrition inputs (e.g. duration of breastfeeding, calorie intake) are jointly chosen by households. This implies that to avoid simultaneity bias, one needs to use instrumental variables when estimating a child health production function or estimating reduced form demand functions. Omitted variable bias, which occurs when an important explanatory variable is not included in the model, can affect these estimates; for instance, if household income is considered as important in determining children's health, omitting household income from child health regressions will bias the estimates. However, the kind of data described above is usually not available, and thus most researchers are forced to estimate reduced form demand functions.

A reduced form demand for children's health is a function of variables that are exogenous, such as income, prices, and the child's health endowment. This takes care of the problem of simultaneity bias. However, omitted variable bias is still possible and a further estimation issue arises from the fact that the child health endowment may be known to the family but cannot be observed by researchers (Rosenzweig and Schultz, 1983). Thus, an instrumental variables approach is needed to address any omitted variable bias.

Another estimation issue arises from how to treat mothers' education in the econometric estimation. To answer this question, one needs to distinguish between economic endogeneity and econometric endogeneity. In terms of the economic model, a mother's education is exogenous because decisions about her education were made by her own parents. However, in terms of the econometric model, endogeneity issues arise when a mother's education is correlated with unobserved variables (e.g. parents' innate healthiness) that affect both the child's health and the mother's education. If this is the case, treating the mother's education as exogenous in the estimation could lead to biased results. Here also, an instrumental variables approach is needed to address the endogeneity bias.

Frongillo, de Onis, and Hanson (1997) run cross-country OLS regressions of children's stunting and wasting on educational variables, food security, geographic region, and other variables. They find that the female literacy rate had a significantly negative effect on stunting. Similarly, Appoh and Krekling (2005) find that mother's education has significant effects; however, Martorell, Leslie, and Moock (1984) find no evidence that parents' education has an impact on children's health outcomes. Using data from a town in Burkina Faso, Baya (1998) finds that after controlling for fathers' education, the effect of mothers' education on children's survival loses significance. He concludes that studies on parents' education and children's health status should not focus on mothers' education.

2.3 Studies with Natural Experiments

Breierova and Duflo (2004) use Indonesia's 1995 intercensal survey 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 fathers' and mothers' education were found to reduce child mortality. However, the authors find little evidence to support the theory that mothers' education has a stronger effect than is fathers'.

Using a natural experiment from Taiwan looking at a new compulsory education law, Chou et. al. (2007) study the relationship between parents' education and children's health. They find that the new education law has a positive and significant effect on parents' educational attainment, but there is a weak instrument problem in the father's education equation if an F-test > 10 in the first stage regression is used as a criterion for a sufficiently strong instrument. The authors find evidence of a causal relationship between parents' education and children's health, with a stronger effect for mothers' education. A decline of 11% in child mortality was estimated as a result of the increase in schooling due to the reform.

2.4 Studies with Pathways

Another set of past studies that are relevant to this research are those that address the pathways through which a mother's education might affect her children's health outcomes. Thomas, Strauss, and Henriques (1991) examine three such mechanisms: income-augmenting effects, information-processing effects, and interactive effects with community services. They use household data from the 1986 Brazilian Demographic and Health Survey to estimate conditional child height functions (obtained by fixing all health inputs at their utility maximizing level, allowing one to see how small variations in the optimal levels of the inputs affect parents' demand for children's health). Thomas, Strauss, and Henriques condition the demand function on income and the mother's choice to watch television, listen to a radio, and read newspapers, all of which were treated as endogenous. The authors instrument income using household assets and instrument information access indicators (if mother listens to radio, watches television, or reads newspaper) using binary variables indicating the presence of these media in the community. They conclude that a mother's acquisition of information is the main pathway through which her education affects her children's health outcomes.

Glewwe (1999) also suggests three pathways through which a mother's education might affect her children's 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. He uses data from Morocco to estimate reduced form and conditional demand functions for children's health and finds that health knowledge acquired using literacy and numeracy skills from schooling is the main pathway through which maternal education affects children's health outcomes. Glewwe treats a mother's health knowledge, household income, and literacy and numeracy as endogenous and instruments them using the education of the mother's parents, number of the mother's sisters who have children, household assets, and the availability of media in the community. In addition, he controls for heterogeneity in the child's health endowment using parents' height.

Handa (1999) examines six pathways through which mothers' education might affect children's health outcomes: income effects, interactions with household characteristics, interactions with community services, information processing, unobserved household heterogeneity[1], and intrahousehold bargaining power. Using data from Jamaica, Handa estimates reduced form demand equations for child stunting. He concludes that controlling for unobserved household heterogeneity nullifies the effect of mothers' education; rather, information processing is found to be the pathway through which maternal education affects children's health outcomes. Handa treats household expenditures as endogenous and uses the type of dwelling, the main material of outer walls, the value of household durable goods, the household's demographic composition, the presence of a telephone, and income earned from property as instruments. Handa argues that he was able to control for unobserved household heterogeneity (e.g. tastes for child health, food preparation methods, etc.) using the fact that Jamaican households usually include children from different mothers and that women in the same household care for all children whether the children are their own or not.

Webb and Block (2004), using household survey data from Central Java, Indonesia, find that a mother's nutritional knowledge is a determinant of her children's short-term nutritional status (weight-for-height), whereas her schooling is a determinant of long-term nutritional status (height-for-age). They do not find

[1] 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.

plausible instrumental variables for maternal nutritional knowledge and household expenditures, so they use proxy variables to estimate reduced form equations for child nutritional status.

Appoh and Krekling (2005), using data from the Volta Region in Ghana, find that mothers' nutritional knowledge is more important than mothers' schooling in determining child wasting.

Burchi (2010) investigates the role of maternal schooling on child HAZ in Mozambique, focusing on a mother's nutritional knowledge. He finds large direct effects of maternal knowledge on child HAZ, but this impact reduces as maternal education levels rise because more educated women face time constraints at their jobs. Using instrumental variable quantile regression, he finds that the mother's nutrition knowledge strongly impacts the most deprived children, while the mother's education and household wealth have the greatest impact for children who are relatively better off.

All of these papers estimate reduced form equations and it should be noted that reduced form relationships still have the child's genetic health endowment as an argument. However, this genetic health endowment, which might be known (at least to some extent) by the family, cannot be observed by the researcher, which raises the possibility of omitted variable bias. This is likely to cause two types of omitted variable bias. On one hand, a child's unobserved health endowment may be negatively correlated with parents' health knowledge (which can be obtained through education) 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 children's health endowment (Glewwe, 1999). In other words, parental education is exogenous because their own parents made decisions about their education (economic exogeneity). However, because of possible correlations between parents' education and omitted variables (i.e., children's innate healthiness is not observed) in the child health equation, one should worry about endogeneity (i.e. econometric exogeneity may not hold true). Parents' education depends on their innate healthiness, which is passed on to their children.

On the other hand, as pointed out by Grossman (2006), bias will 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); this implies that one has to account for the possibility of household income being endogenous. Therefore, household income may need to be instrumented. Given these two sources of possible bias, simultaneous equations methods (two-stage least squares) are needed to estimate the reduced form demand for children's health and the endogenous inputs. Grossman (2006) suggests the use of the mother's age at the birth of the child as a proxy for genetic endowment to partially control for the children's health endowment bias.

In light of all of these abovementioned issues, this paper will use instrumental variables methods to get around the omitted variable bias problem. This paper goes beyond previous studies by using a natural experiment to investigate the relationship between maternal education and child health and by testing for the endogeneity of mothers' education. To the author's knowledge, no other paper has used a change in policy to obtain information regarding maternal education and child health relationships in an African country, although this has been done for Indonesia, Taiwan, and the U.S.

3. Conceptual Framework and Empirical Strategy

To avoid simultaneity bias, I use a reduced form demand function to estimate the child health production function. As mentioned in the previous section, the reduced form demand for child health is a function of prices, income, household characteristics and environmental variables, and the child's health endowment. The household characteristics include the child's characteristics (age, sex), parents' characteristics (education, age), type of dwelling, toilet facilities, water source, etc.; the environment variables include presence of health facilities in the area, availability of piped water, etc.

Consider the following equations:

$$H_i = h(CC_i, MS_i, FS_i, M_i, \boldsymbol{HEV}, \mu_i) \quad (1)$$

$$MS_i = f(\boldsymbol{EI}_i, HA_i, \boldsymbol{HEV}, \epsilon_i) \quad (2)$$

where H_i is child's health, CC_i is child's i characteristics, MS_i and FS_i are mother's i and father's i schooling, respectively, M_i stands for 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 household assets, and $\boldsymbol{\epsilon}_i$ is a vector of maternal endowments (for example, ethnic background, genetic makeup). The reduced form equations contain the child health endowment (μ), which is not observed by the researcher. The endogeneity of mother's schooling stems from potential correlation between μ_i and $\boldsymbol{\epsilon}_i$: family background may affect both the mother's education and the child's health.

I use a model that links maternal education and children's health. More specifically, the model posits that children's health is determined by their mother's education, controlling for various child and household characteristics. Because mothers' education and children's health may be affected by many unobserved factors, the modeling strategy will include netting out the effect of these unobserved factors in the estimation process.

Causal Impact of Mothers' Education on Children's Health: To determine whether there is a causal relationship between maternal education and children's health and nutrition outcomes, I use a two-stage least squares instrumental variables methods to estimate the model and test for the endogeneity of mothers' education.

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

$$S_i = \alpha + \lambda_k + \delta Z + \gamma X + \varepsilon_i \qquad (3)$$

where S_i is years of maternal schooling i, α is a constant, λ_k is province fixed effects, **Z** is a vector of instrumental variables (described above), **X** is a vector of control variables, δ and γ are parameters, and ε_i is an error term.

The instrumental variables created from the natural experiment will be used to estimate Equation (3) and obtain predicted values which are free from any direct link with child health outcomes. Equation (3) is the first stage of a two-stage least squares estimation to determine the existence of a causal effect of maternal education on children's health (hypothesis 1). The second stage equation is:

$$H_i = \tau + \lambda_k + \beta S_i + \theta \boldsymbol{X} + \nu_i \qquad (4)$$

where Hi is the health of the child i, τ is a constant, λk is region fixed effects respectively, Si is the mother's years of schooling, X is a vector of control variables, and νi is an error term. The child's anthropometric measures (height-for-age and weight-for-height) will serve as left-hand-side variables in Equation (4) above. The predicted values from the first stage estimation are used to replace maternal education in Equation (4) and estimate the model to obtain unbiased estimates of maternal education on children's health given that the predicted values are uncorrelated with the error term in Equation (4).

Understanding the Channels: Among child health inputs, the one of most interest is the mother's education because in most families in Burkina Faso, mothers spend more time caring for children than do fathers. Cleland (1990) postulates that maternal education leads to behavioral changes that improve child health. Moreover, past studies have shown that fathers' education matters less than mothers' in children's health outcomes (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; Glewwe, 1999). For example, educated mothers are able to read a medication label and give the proper dosage to their children. Therefore, mothers' education is likely to improve children's health status.

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

Health knowledge effect. Education leads to better health knowledge (Glewwe, 1999, Webb, and Block, 2004; Appoh and Krekling, 2005); hence, better educated mothers are more likely to know how to deal with their children's health issues.

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

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

Among the above-mentioned pathways, income, health knowledge, and bargaining power will be investigated in this paper. To do so, variables that capture income effects, mothers' health knowledge effects, mothers' bargaining power effects, and predicted values from the education equation will be added to the child health production function. Information on these household characteristics and on community characteristics are available in the 2010 Burkina Faso Demographic and Health Survey (DHS).

The estimation of these pathways entails the use of conditional demand for children's health (conditioned on income, health knowledge, etc.). The conditional demand function is obtained by incorporating the pathways into Equation 1 as follows.

$$H_i = h(CC_i, FS_i, HKA_i(MS_i), BP_i(MS_i), M_i(MS_i), MS_i\boldsymbol{HEV_i}, \mu_i) \qquad (5)$$

where CC_i is child's characteristics, FS_i is father's schooling, HKA_i is mother's health knowledge availability, BP_i is mother's bargaining power, M_i is household income, **HEV** is a vector of household environment variables, and μ_i is child-specific health endowment. The mother's education effect can be decomposed as follows.

$$\frac{dH_i}{dMS_i} = \frac{\partial H_i}{\partial MS_i} + \frac{\partial H_i}{\partial HKA_i}\frac{\partial HKA_i}{\partial MS_i} + \frac{\partial H_i}{\partial BP_i}\frac{\partial BP_i}{\partial MS_i} + \frac{\partial H_i}{\partial M_i}\frac{\partial M_i}{\partial MS_i} \qquad (6)$$

If the allocative efficiency hypothesis holds true, then the last term of Equation 6 should not be statistically significant from zero, whereas the other terms should be significantly different from zero. There are potential endogeneity issues with these pathways (income, health knowledge, bargaining power). The household's assets were used to construct a wealth index which help get around the endogeneity problem in terms of income; however, given the lack of guarantee that household assets are exogenous, I also test for the endogeneity of the wealth index and the endogeneity of health knowledge and bargaining power.

Threshold Effects: To determine whether threshold effects exist, I will first use non-parametric methods to look at the bivariate relationship between maternal education and children's health. If the resulting relationship is nonlinear, I will include separate binary variables for different years of mothers' schooling in the estimation of the child health production function.

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, is it true that the higher the mother's education level, the better her child's health status?
2. Income pathway: conditional demand for child health, conditioning on household income. Does including household income reduce or annul the maternal education effect?
3. Health knowledge pathway: conditional demand for child health, conditioning on health knowledge. Does including health knowledge reduce or annul the maternal education effect?
4. Bargaining power pathway: conditional demand for child health, conditioning on bargaining power. Does including bargaining power reduce or annul the maternal education effect?

Testing the above hypotheses implies testing for the allocative efficiency hypothesis, which postulates that education has no direct effect on child health (see Grossman, 2006).

Another interesting hypothesis to test is an empirical one: how many years of education are needed to see the largest impacts on child health? In other words, are there threshold effects of mothers' education? A threshold of 6 years of primary school 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 next section describes the data and their suitability for implementing the empirical strategy.

4. Data and Descriptive Statistics

4.1 Data Sources

The main source of data is the 2010 Burkina Faso Demographic and Health Survey (DHS); this is accessible free of charge on the Measure DHS website (www.measuredhs.com) but registration is required. The DHS is a large, nationally representative household survey (14,424 households) conducted for the purpose of evaluating population, health, and nutrition outcomes. The second source is documentary review of reports and published statistics from the Ministry of Education. These reports and statistics will provide time series data on enrollment rates, new school construction, and school location.

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.

4.2 Education Policy Change Data

Gender disparities in school enrollment and school outcomes have long existed in Burkina Faso. These discrepancies are getting smaller, but 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 enrollment rates. The parity index (female to male) increased from 0.68 in 2002 to 0.82 in 2005 for primary school enrollment; for secondary school enrollment, it rose from 0.68 in 2001 to 0.70 in 2007 (*Ministère de l'enseignement de base et de l'alphabétisation* (MEBA), 2006; *Ministère des Enseignements Secondaire, Supérieur, et de la Recherche Scientifique, 2008*).

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 government implemented a project called African Girls' Education Initiative (AGEI). One of the components of this project is the '*écoles satellites*' (ESs), three-year primary schools built in the most remote areas of the country where there are no regular primary schools (six-year schools). After three years in an *école satellite*, children should go to the nearest regular primary school to complete their education, or the ES will be upgraded to a regular school.

This project was implemented in two phases. The first was an experimental phase, conducted from 1995 to 1997, during which 30 ESs were built in 10 provinces. An expansion phase followed. Nineteen out of 45 provinces were chosen for this phase based on their low school enrollment rates and the availability of Non-Governmental Organizations (NGOs) that could give support to the project (and to education in general). In 2000, 204 ESs were dispersed among 19 provinces (Tankono, 2000); 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 and children taught in both their local language and French. Since 1998, most of the ESs have been upgraded to six-class schools or regular schools (Tankono, 2000). In the 2007-2008 school year, there were a total of 307 ESs in Burkina Faso.

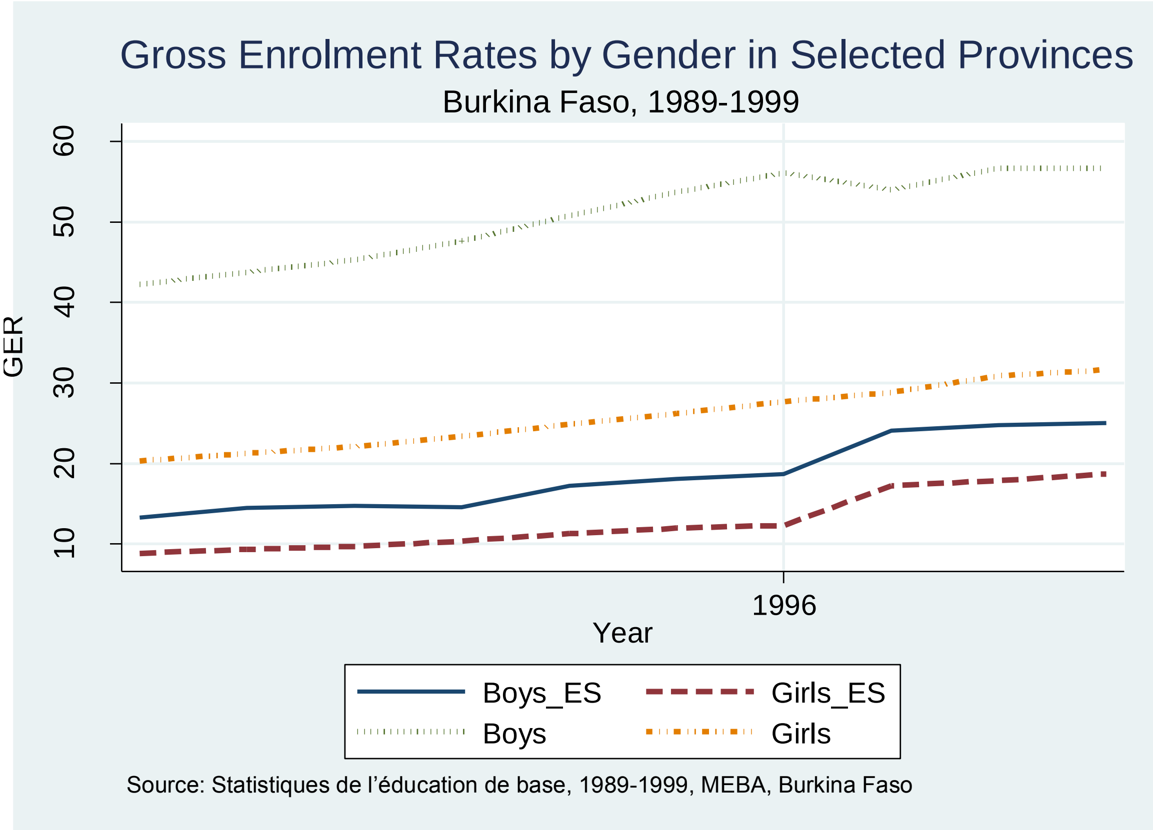
Two evaluations of this project have already been conducted: a joint evaluation by MEBA/UNICEF/World Bank in 1998 (MEBA is the ministry of basic education) and a joint evaluation by IRD (*Institut pour la Recherche et le Développement, Burkina Faso*) and the University of Ouagadougou in 1999. In general, both evaluations deemed the results of the reform satisfactory. The ESs have contributed to an increase in enrollment rates in the provinces where they were built. For instance, between 1996-1997 and 2001-2002, the net enrollment rates for girls increased from 1.1% to 12.6% in the Komondjari province (Back, Coulibaly, and Hickson, 2003). For the Yagha province during the same period, primary school net enrollment rates for girls increased from 3.4% to 14.7%. In addition, the evaluations showed that there was strong community participation in provinces where ESs were built. In particular, local populations helped in the construction of the schools. Design of curricula and creation of textbooks specific to the ESs was highlighted as another important achievement of the project. Furthermore, tests scores in French and mathematics showed that the ES pupils performed better than pupils from regular schools. On the other hand, the negative results pointed out by the evaluators include: 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 six-year schools.

Data on primary school enrollment rates from provinces with the program confirm the increase in girls' enrollment rates (boys enrollment rates increased also), but do not seem to show a reduction in the gender disparity. Figures 1 and 2 show the enrollment rates in primary school from 1989 to 1999 for Gourma province (which has ESs) and Yatenga province (which does not), respectively. There is an important jump in enrollment rates in Gourma province around the year the policies became effective (1995-1996). While enrollment rates for both boys and girls increase in the Yatenga province, the graph shows no significant jump. This suggests that the policy had an effect on girls' schooling, implying that it is possible to construct

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

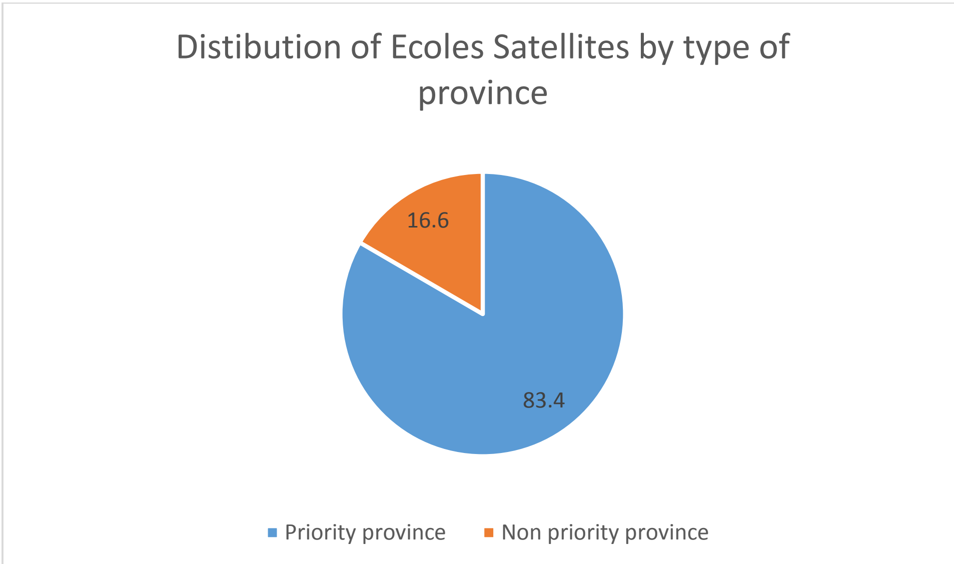
good instrumental variables (variables indicating whether mothers were affected by these reforms during their childhood) that will be used to identify the impact of mothers' education on children's health.

Figure 1: Primary school enrollment rates for provinces with and without ESs



In terms of placement of the schools, 83.4% of the ESs are located in 20 priority provinces defined by the Ministry of Education. These priority provinces are provinces that are lagging in terms of school enrollment, especially for girls. Therefore, in line with the objectives of the African Girls' Education Initiative, the ESs were placed in areas where gender disparities in enrollment are high and availability of schools low.

Figure 2: Distribution of ESs in priority and non-priority provinces between 1995 and 2007.



4.3 Descriptive Statistics

A child is said to be stunted if his height-for-age z-score (HAZ) is below two standard deviations of the HAZ of a child from a healthy population (from developed countries). In other words, a child's HAZ is obtained by subtracting the height of the child of interest from that of a child from a healthy population and dividing the result by the standard deviation of the height of the healthy child, provided that the children are of the same age. Child weight-for-height z-score is obtained in a similar manner.

Table 1 presents the descriptive statistics for all regressors included in the model. On average, Burkinabe children are 1.39 standard deviations below the HAZ of children from the population of reference. For WHZ, on average, Burkinabe children are 0.65 standard deviations below the reference. The average child in the sample is 29 months old and 51% of the children are male.

Mothers are 29 years old on average and fathers are 40 years old; 94% of women in the sample are in a committed relationship. Educational attainment is very low for both men and women, with averages of 1.15 years and 1.02 years, respectively. For the sub-sample of people with some educational levels, the average years of education attained is 5.89 years for women and 6.33 for men.

Mother's HAZ, WHZ, and body mass index (BMI) average -0.34, 0.89, and 21.30, respectively. Information from several variables in the DHS survey was used to construct an index of mothers' health/nutrition knowledge and two indices for mothers' bargaining power using factor analysis. These indices were standardized to have zero mean and standard deviation of 1. Knowledge of ovulation, breast cancer, and oral rehydration rates, as well as whether children under five years of age sleep under a bed net, whether children receive vitamin A, and how the mother disposes of the stools of the youngest child that is not yet using the toilet are used to construct the index of mothers' health/nutrition knowledge. The mother's say in decisions about her own health, visits to her relatives, large household purchases, and whether she agrees with the belief that men should beat their wife if she neglects the children, burns the food, goes out without telling her husband, argues with her husband, or refuse to have sex with her husband are used to construct the bargaining power indices.

About 62% of mothers are Muslim; 22% are Catholic and 9% are of traditional religion. Most mothers (51%) are from the Mossi ethnic group. The average household has 8 people, and 78% of households reside in rural areas.

Table 1: Descriptive statistics

Variable	Mean	Std. Dev.	Min	Max	N
HAZ	-1.39	1.59	-5.99	5.99	6,477
WHZ	-0.65	1.39	-4.92	4.99	6,477
Child age in months	28.56	17.05	0	59	6,477
Child gender (male)	0.51	0.50	0	1	6,477
Children under 5	2.35	1.27	1	10	6,477
Mother's age	29.46	6.91	15	49	6,477
Father's age	40.48	11.01	19	88	6,234
Marital status	0.94	0.24	0	1	6,475
Mother's years of education	1.02	2.54	0	18	6,477
Father's years of education	1.15	2.80	0	18	6,359
Mother's HAZ	-0.34	0.97	-4.96	4.73	6,458
Mother's WHZ	0.89	0.94	-3.79	4.21	6,454
Mother's BMI	21.30	3.12	14.4	59.82	6,458
Mother's health knowledge	0.00	1.00	-2.43	1.94	6,393
Mother's bargaining power 1	0.00	1.00	-1.94	1.69	6,273
Mother's bargaining power 2	0.00	1.00	-1.19	3.57	6,273
Mother listens to radio once a week	0.43	0.50	0	1	6,470
Mother's religion					
No religion	0.01	0.10	0	1	6,477
Muslim	0.62	0.48	0	1	6,477
Catholic	0.22	0.41	0	1	6,477
Protestant	0.06	0.24	0	1	6,477
Traditional	0.09	0.29	0	1	6,477

Table 1: Con't

Variable	Mean	Std. Dev.	Min	Max	N
Mother's ethnicity					
Bobo	0.04	0.20	0	1	6,477
Dioula	0.01	0.08	0	1	6,477
Peul	0.09	0.28	0	1	6,477
Gourmantche	0.07	0.26	0	1	6,477
Gourounsi	0.04	0.20	0	1	6,477
Lobi	0.04	0.19	0	1	6,477
Mossi	0.51	0.50	0	1	6,477
Senoufo	0.06	0.23	0	1	6,477
Bella	0.02	0.13	0	1	6,477
Dagara	0.03	0.16	0	1	6,477
Bissa	0.04	0.20	0	1	6,477
Wealth index quintiles	2.93	1.36	1	5	6,477
Rural	0.78	0.41	0	1	6,477
Household size	7.69	3.82	2	49	6,477

Table 2 presents the averages of children's HAZ, WHZ, and mothers' education by region. Maternal education is lowest in the Sahel region, averaging only 0.41 years in the sample. The worst outcome for child HAZ is also found in the Sahel region, where the average child HAZ is 1.71 standard deviations below the HAZ of a child from a healthy population. The best outcomes for both mothers' education and children's HAZ are found in the Centre region, with averages of 3.02 years of education and 0.91 standard deviations below the reference for HAZ. This performance could be explained by the fact that that the capital city of Ouagadougou is located in this region.

Turning to WHZ, the Centre-Est region performs worst, with an average of 0.90 standard deviations below the reference; the Cascades region performs best, with an average of 0.26 standard deviations below the reference. Note that unlike the case of HAZ, educational performance for Cascades and Centre–Est are not that far off in terms of magnitude, with 1.37 years and 1.04 years, respectively. These results suggest a stronger relationship between mothers' education and children's HAZ than between mothers' education and children's WHZ.

Table 2: Children's HAZ, WHZ, and Mothers' Education by Region

Region	**Child HAZ**	**Child WHZ**	**Mothers' schooling (years)**	**Number of observations**
Sahel	**-1.71**	-0.87	**0.41**	495
Est	-1.64	-0.74	0.57	594
Sud-Ouest	-1.57	-0.47	0.81	443
Centre-Ouest	-1.51	-0.63	1.06	580
Plateau Central	-1.50	-0.55	0.74	451
Cascades	-1.50	***-0.26***	***1.37***	391
Nord	-1.43	-0.79	0.75	544
Centre-Est	-1.36	***-0.90***	***1.04***	512
Boucle du Mouhoun	-1.29	-0.58	0.99	604
Hauts-Bassins	-1.25	-0.49	1.37	572
Centre-Sud	-1.19	-0.54	0.95	404
Centre-Nord	-0.98	-0.89	0.75	527
Centre	**-0.98**	-0.59	**3.02**	360
Countrywide	-1.39	-0.65	1.02	6,477

The histograms of HAZ and WHZ are skewed to the left, indicating the high prevalence of stunting (34.3% of children) and, to a lesser extent, of wasting (15.2%) among children under five years of age in Burkina Faso. Prevalence rates between 30 and 39% are considered high. On the left-hand panel of Figure 3, moderate stunting (-3 < HAZ < -2) and severe stunting (HAZ >= -3) are represented and reach 20.2 % and 13.9% respectively. Moderate wasting and severe wasting are defined similarly to their stunting counterparts. On the right-hand panel of Figure 3, moderate wasting and severe wasting are shown; their magnitudes are 9.4% and 5.7%.

Figure 3: Histograms of child HAZ and child WHZ

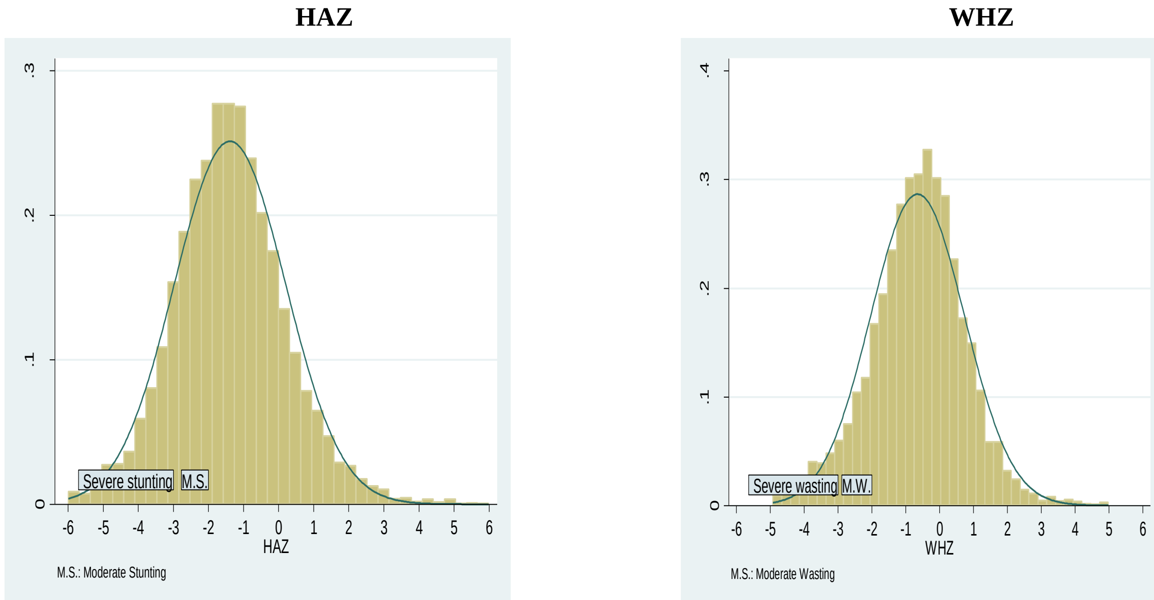


Table 3 presents the prevalence of stunting and wasting by mother's schooling status. The results show that there is a difference of 13.3 percentage points in the prevalence of low height-for-age between educated and non-educated mothers, suggesting a positive correlation between a mother's education and her child's HAZ. A much lower difference is found for WHZ - only 2.88 percentage points difference in the prevalence of wasting between children from educated mothers and children from non-educated mothers.

Table 3: Child Stunting and Wasting Prevalence by Mother's Schooling

	Stunting	**Wasting**
Mother's schooling		
No schooling	36.65%	15.69%
Some schooling	23.31%	12.81%
Total	34.4%	15.19%

4.4. Identification Strategy

To estimate the impact of the school construction program on education, I compare the difference in the numbers of years of education attained between a young cohort (ages 6 to 10) exposed to the program and an older one not exposed to the program (ages 14 to19) to the difference between two older cohorts (14-19 versus 20-25) not exposed to the program. This is done to get my counterfactual, that is, what would have happened in the absence of the program. The difference in these two differences is the causal effect of the program, provided that in the absence of the program the increase in educational attainment would not have systematically differed between high and low intensity program provinces. The assumption of no systematic difference between high and low intensity provinces in the absence of the program is important because it could be that the pattern of increases in education could be systematically different across regions which may lead to mean reversion (Duflo, 2001). Table 4 presents the average years of education for these cohorts by program intensity in the region where the mother currently resides.

One shortcoming of the 2010 DHS data for Burkina Faso is that mothers' childhood regions of residence are not collected. However, in the past, DHS had collected this information; the 2003 DHS data for Burkina Faso, the percentage of mothers in the sample that still lived in the region where they were born ranged 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. The percentage less than 75% in only three regions. In those three regions (where the three largest urban areas are located), there are only 12 '*Ecoles Satellites*'. Therefore, assuming the 2010 data reflects the pattern in 2003, I use the province of residence to compute the intensity of the school construction program. Following Duflo (2001), a province is a high program intensity one if the residual from a regression of the number of schools constructed on the youth population (60% of the total population) is positive.

In the top part of Table 4, the results suggest that a girl from the young cohort who lived in high program intensity province received on average 0.05 years more years of education than a girl from the same cohort in a low program intensity province. For both high and low program intensity provinces, the older cohorts have lower educational attainment than the younger cohorts. One can also note that educational attainment increased more in areas with more schools (0.31 versus 0.26).

In the bottom part of Table 4, the results suggest that the difference-in-differences is negative and strongly significant, which violates the identification assumption that increases in between cohorts of the older age group should not differ systematically across provinces. Therefore, identification cannot be obtained using the difference-in-differences method.

Table 4: Program intensity by province of residence

Program intensity in province of residence			
With program	**High**	**Low**	**Difference**
Age 6-10	1.38	1.70	-0.32
	(0.137)	(0.228)	(0.266)
Age 14-19	1.07	1.44	-0.37
	(0.106)	(0.135)	(0.172)
Difference	0.31	0.26	**0.05**
	(0.173)	(0.265)	**(0.012)**
Without the program	**High**	**Low**	**Difference**
Age 14-19	1.07	1.44	-0.37
	(0.106)	(0.135)	(0.172)
Age 20-25	1.03	0.95	0.08
	(0.117)	(0.111)	(0.161)
Difference	0.04	0.49	-0.45
	(0.158)	(0.175)	(0.007)

Given the problem with the identification assumption of the difference-in-differences method, instrumental variable methods will be used to estimate the child health equation. Mothers' education, health knowledge, bargaining power, and household wealth are all assumed to be endogenous.

The instrumental variables include a dummy variable indicating whether the mother lived in a province with high school construction intensity when she was school age (between 6 and 10 years of age[3]), the number of years in which an ES was available in the area during the years that she was of school age, and interaction terms between the two variables. The rationale behind the interaction terms is that what may matter most is both having the school close by and having the school has been available for a longer time period. A mother's health knowledge is instrumented using information on the frequency with which she listens to the radio and whether she has a living sister from whom she can gather information. Patel et. al. (2007) suggests the difference in education, expenditure, weight-for-age z score, and height-for-age z score between fathers and mothers, the proportion of household assets owned by the mother, her share of total household expenditures in the last two weeks, and expenditure on durable goods in the last year as instruments for household power structure. Among these variables, only the difference in parents' education can be constructed using the data available for this study. However, given that mothers' education is one of our main variables in the child health function, collinearity issues are highly likely. Therefore we will use the number of co-wives as an instrument for bargaining power within the household, as one would expect polygamy to influence the bargaining power of women within a household. Maternal work status over the past 12 months and average wealth index for the community in which the household resides are used as instruments for the wealth index.

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

5. Regression Results

5.1 Causal Relationship and Pathway Results

I first tested the correlation between the instrumental variables and the child health outcomes. Table 5 presents the results of OLS regressions of child HAZ and WHZ on the instrumental variables for mothers' education, health knowledge, bargaining power, and household wealth, as well as all other exogenous variables included in the full model. The WHZ results show that none of the instrumental variables have explanatory power for WHZ (Column 4). In the HAZ results in Column 1, the mean community wealth index has a strong positive coefficient. This result suggests that this instrument is not adequate for use in the wealth index-child HAZ relationship. Column 2 presents the results of the same regression as in Column 1 but without the community wealth index variable. The new results show that the variable that captures high program intensity is now significant at the 10% level. I exclude this variable from the regression, and the results in Column 3 show that no instrumental variable is statistically significant when this specification is used. In sum, for WHZ, the full instrument set will be used while for HAZ, the average community wealth index and high program intensity will be excluded from the instrument set.

Table 5: Test of the adequacy of the instrumental variables using OLS regression

VARIABLES	(1) HAZ	(2) HAZ	(3) HAZ	(4) WHZ
Young cohort	0.137	0.133	0.170	-0.007
	(0.121)	(0.121)	(0.119)	(0.113)
High intensity province	-0.087	-0.093*		0.035
	(0.055)	(0.055)		(0.051)
Young cohort *high intensity	-0.110	-0.120	-0.165	0.035
	(0.143)	(0.144)	(0.141)	(0.134)
Mother listens to radio at least once/week	-0.007	0.005	0.002	-0.042
	(0.038)	(0.038)	(0.038)	(0.035)
Mother has living sister	-0.009	-0.009	-0.007	0.062
	(0.063)	(0.063)	(0.063)	(0.059)
Number of other wives	0.012	0.018	0.018	-0.036
	(0.029)	(0.029)	(0.029)	(0.027)
Mother _worked in past 12 months	0.083	0.058	0.062	-0.076
	(0.054)	(0.053)	(0.053)	(0.050)
Mean community wealth index	0.002***			0.001
	(0.000)			(0.000)
Child age (months)	-0.119***	-0.119***	-0.119***	0.023***
	(0.004)	(0.004)	(0.004)	(0.004)
Squared child age	0.002***	0.002***	0.002***	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Gender (male=1)	-0.180***	-0.179***	-0.179***	-0.051

Table 5: Con't

VARIABLES	(1) HAZ	(2) HAZ	(3) HAZ	(4) WHZ
	(0.036)	(0.036)	(0.036)	(0.034)
Children under 5	-0.042**	-0.046***	-0.046***	-0.002
	(0.017)	(0.017)	(0.017)	(0.016)
Mother's _age	0.007**	0.007**	0.007**	0.014***
	(0.003)	(0.003)	(0.003)	(0.003)
Father's years of education	0.065	0.106**	0.104*	0.029
	(0.054)	(0.053)	(0.053)	(0.050)
Mother's marital status (married=1)	0.141	0.111	0.113	-0.118
	(0.111)	(0.111)	(0.111)	(0.104)
Mother's _HAZ	0.252***	0.253***	0.253***	0.326***
	(0.019)	(0.019)	(0.019)	(0.059)
Mother's _BMI	0.046***	0.050***	0.050***	-0.029
	(0.006)	(0.006)	(0.006)	(0.018)
Rural residence	-0.011	-0.203***	-0.211***	0.181***
	(0.067)	(0.052)	(0.052)	(0.063)
Constant	-0.980***	-0.886***	-0.966***	-0.406
	(0.300)	(0.300)	(0.297)	(0.453)
Observations	6,211	6,211	6,211	6,208
R-squared	0.206	0.203	0.203	0.096

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Next, I run instrumental variables regressions with the mother's education, her health knowledge and bargaining power, and household wealth as endogenous regressors. I consider two cases: (i) all endogenous regressors are included in the model (IV regression with multiple endogenous regressors) and (ii) the endogenous regressors are added one at a time.

The first-stage HAZ regression results of the multiple endogenous regressors' case are presented in Table 6, with information for conducting tests on the instrumental variables at the bottom of the table. The F test for the relevance of the instrument indicates failure to meet the threshold of 10 in the mother's education and bargaining power regressions. The instruments for these two variables are weak. The instruments for mother's health knowledge and household wealth are relevant as the F statistics exceed 10 (62.8 and 27.5). The Sargan statistic p-value is 0.275, which implies that the null hypothesis cannot be rejected. The joint null hypothesis is that the instruments are valid instruments, i.e., uncorrelated with the error term, and that the excluded instruments are correctly excluded from the estimated equation. Therefore, though some of the instruments are weak, the instrumental variables are all valid.

The Durbin-Wu-Hausman test allows one to determine whether the regressors assumed to be endogenous are indeed endogenous. The null hypothesis assumes that the regressor is exogenous. The p-values on all five cases exceed 0.05, indicating that all five regressors are not endogenous.

Similar conclusions regarding both the instruments and the endogenous regressors are reached when the endogenous regressors are considered individually (i.e. in separate regressions).

Table 6: First stage-regressions for HAZ IV regressions

VARIABLES	**(1) Education**	**(2) Health knowledge**	**(3) Bargaining power 1**	**(4) Bargaining power 2**	**(5) Wealth index**
Child age (months)	0.005	0.002	-0.001	0.000	-0.069
	(0.006)	(0.002)	(0.003)	(0.003)	(0.150)
Squared child age	-0.000	-0.000	0.000	0.000	0.001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)
Gender (male=1)	0.026	0.032	-0.021	0.027	2.421*
	(0.050)	(0.021)	(0.024)	(0.024)	(1.289)
Children under 5	-0.085***	-0.024**	-0.028**	-0.003	-2.741***
	(0.024)	(0.010)	(0.012)	(0.012)	(0.624)
Mother's _age	-0.016***	0.002	0.002	0.003	-0.179*
	(0.004)	(0.002)	(0.002)	(0.002)	(0.106)
Mother's marital status (married=1)	-1.028***	0.049	-0.081	0.002	-8.861**
	(0.152)	(0.064)	(0.073)	(0.074)	(3.932)
Father's years of education	0.349***	0.065***	0.041***	0.017***	9.708***
	(0.010)	(0.004)	(0.005)	(0.005)	(0.268)
Mother's _HAZ	0.120***	0.041***	-0.006	0.009	3.015***
	(0.026)	(0.011)	(0.012)	(0.013)	(0.675)
Mother's _BMI	0.074***	0.025***	0.013***	0.007	3.984***
	(0.009)	(0.004)	(0.004)	(0.004)	(0.228)
Rural residence	-0.908***	-0.622***	-0.063*	0.024	-74.711***
	(0.073)	(0.030)	(0.035)	(0.035)	(1.870)
Young cohort	0.084	-0.164**	0.014	-0.083	-7.878*
	(0.167)	(0.070)	(0.080)	(0.081)	(4.311)
High intensity province	-0.009	-0.006	-0.100***	-0.117***	-3.425*
	(0.076)	(0.032)	(0.036)	(0.037)	(1.961)
Young cohort *high intensity	-0.445**	0.191**	-0.072	0.145	-0.510
	(0.198)	(0.083)	(0.094)	(0.096)	(5.117)
Mother listens to radio at least once/week	0.279***	0.401***	-0.065***	0.033	10.057***
	(0.052)	(0.022)	(0.025)	(0.025)	(1.339)
Mother has living sister	-0.013	0.063*	-0.047	-0.044	-0.449
	(0.087)	(0.036)	(0.041)	(0.042)	(2.233)
Number of other wives	0.001	-0.007	-0.053***	-0.059***	9.501***

Table 6: Con't

VARIABLES	(1) Education	(2) Health knowledge	(3) Bargaining power 1	(4) Bargaining power 2	(5) Wealth index
	(0.040)	(0.017)	(0.019)	(0.020)	(1.044)
Mother _worked in past 12 months	-0.306***	0.284***	0.145***	0.051	-11.758***
	(0.073)	(0.031)	(0.035)	(0.036)	(1.895)
Constant	1.680***	-0.540***	-0.041	0.069	-25.801**
	(0.413)	(0.173)	(0.196)	(0.201)	(10.641)
Observations	6,131	6,131	6,131	6,131	6,131
R-squared	0.361	0.330	0.143	0.104	0.587
F test of joint significance of IVs	8.04	62.8	6.38	3.55	27.5
p-value	0.000	0.000	0.000	0.001	0.000
Sargan statistic	2.579	2.579	2.579	2.579	2.579
p-value	0.275	0.275	0.275	0.275	0.275
DWH test	0.195	0.254	1.025	0.046	0.855
p-value	0.659	0.614	0.311	0.829	0.355

*** p<0.01, ** p<0.05, * p<0.1

Similarly, the first-stage results for WHZ (see Table A1 in Appendix) lead to the conclusion that while the instruments are weak for mother's bargaining power, all instruments are valid (Sargan test) and none of the regressors assumed to be endogenous are endogenous.

Given that none of the five potential endogenous variables are in fact endogenous, I ran OLS with fixed effects (OLS/FE) as the preferred method of estimation. My interpretation will focus on OLS/FE, but second-stage IV regressions are presented for comparison purposes.

For HAZ, regressions using OLS/FE without the pathway variables (Column 1), OLS/FE (Columns 2-6), and IV (Column 7) with the pathway variables results are summarized in Table 7. All regressions also include dummy variables for mother's religion and ethnicity. The coefficient of mother's education on child health is positive and strongly significant in the OLS/FE without pathways. When mother's health knowledge is included as the sole pathway, there is a reduction in magnitude and significance of the mother's education coefficient, suggesting health knowledge as a channel through which maternal education impacts child health. Including the bargaining power indices as lone pathways (Columns 3 and 4) does not change the significance and magnitude of the mother's education coefficient, suggesting that bargaining power is not a strong pathway. The mother's education coefficient loses significance when the wealth index is added to the regression as the sole pathway (Column 5), suggesting that maternal education works through household wealth to impact children's health. When all the pathway variables are included in the regression at once (Column 6), the mother's education no longer has a direct impact on child HAZ. All these results suggest that a mother's education seems to impact her children's HAZ through health/nutrition knowledge, bargaining power, and household wealth. Children's age and gender, the number of children under five years of age in a household, and maternal age, HAZ, BMI, health knowledge, bargaining power, and household wealth are strongly significant and have the expected sign.

Table 7: OLS/FE and IV Regressions for HAZ

VARIABLES	**(1) OLS/FE HAZ**	**(2) OLS/FE HAZ**	**(3) OLS/FE HAZ**	**(4) OLS/FE HAZ**	**(5) OLS/FE HAZ**	**(6) OLS/FE HAZ**	**(7) IV HAZ**
Mother's years of education	0.020**	0.015*	0.020**	0.021**	0.010	0.007	-0.160
	(0.009)	(0.009)	(0.008)	(0.009)	(0.010)	(0.010)	(0.500)
Mother's health knowledge		0.065**				0.047*	0.113
		(0.028)				(0.028)	(0.559)
Mother's bargaining power index 1			0.042*			0.045**	-0.151
			(0.022)			(0.022)	(1.494)
Mother's bargaining power index 2				0.010		0.021	0.278
				(0.023)		(0.022)	(3.100)
Wealth index					0.001***	0.001***	0.003
					(0.000)	(0.000)	(0.014)
Child age (months)	-0.118***	-0.118***	-0.119***	-0.119***	-0.118***	-0.118***	-0.118***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Squared child age	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Gender (male=1)	-0.179***	-0.195***	-0.181***	-0.181***	-0.183***	-0.199***	-0.210*
	(0.030)	(0.030)	(0.031)	(0.031)	(0.030)	(0.031)	(0.126)
Children under 5	-0.048***	-0.047**	-0.047**	-0.048***	-0.049***	-0.047***	-0.065
	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.017)	(0.058)
Mother's _age	0.007**	0.006**	0.007**	0.007**	0.006**	0.006*	0.002
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)
Mother's marital status (married=1)	-0.016	-0.029	0.154	0.156	-0.025	0.142	0.008
	(0.082)	(0.081)	(0.107)	(0.107)	(0.081)	(0.100)	(0.797)

Table 7: Con't

VARIABLES	(1) OLS/FE HAZ	(2) OLS/FE HAZ	(3) OLS/FE HAZ	(4) OLS/FE HAZ	(5) OLS/FE HAZ	(6) OLS/FE HAZ	(7) IV HAZ
Father's years of education	0.014*	0.010	0.013*	0.014**	0.004	0.001	0.042
	(0.007)	(0.008)	(0.007)	(0.007)	(0.008)	(0.008)	(0.250)
Mother's _HAZ	0.250***	0.248***	0.249***	0.249***	0.247***	0.245***	0.252***
	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.026)	(0.094)
Mother's _BMI	0.048***	0.047***	0.049***	0.050***	0.044***	0.044***	0.047
	(0.008)	(0.009)	(0.009)	(0.009)	(0.008)	(0.009)	(0.085)
Rural residence	-0.162***	-0.137**	-0.158***	-0.160***	-0.072	-0.063	-0.062
	(0.057)	(0.056)	(0.055)	(0.057)	(0.062)	(0.058)	(0.804)
Constant	-0.843***	-0.774***	-1.057***	-1.056***	-0.760***	-0.914***	-0.426
	(0.286)	(0.287)	(0.264)	(0.271)	(0.279)	(0.264)	(2.051)
Observations	5,964	5,886	5,846	5,846	5,964	5,771	5,760
R-squared	0.190	0.192	0.193	0.192	0.192	0.196	0.146
Number of provinces	45	45	45	45	45	45	45

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Turning to the WHZ results, no direct effect of maternal education on child HAZ was found (Column 1 of Table 8). When pathway variables are included in Columns 3-6 of Table 6, the results indicate that these variables have no impact on child WHZ. This lack of significance of maternal education and the pathway variables could be explained by the lower variability in WHZ compared to HAZ (see table A_2 in Appendix).

Table 8: OLS/FE and IV Regressions for WHZ

VARIABLES	(1) OLS/FE WHZ	(2) OLS/FE WHZ	(3) OLS/FE WHZ	(4) OLS/FE WHZ	(5) OLS/FE WHZ	(6) OLS/FE WHZ	(7) IV WHZ
Mother's years of education	0.003	0.000	0.005	0.004	0.000	0.001	0.101
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.916)
Mother's health knowledge		0.011				0.009	0.040
		(0.022)				(0.022)	(1.046)
Mother's bargaining power index 1			-0.020			-0.019	0.272
			(0.019)			(0.020)	(2.486)
Mother's bargaining power index 2				0.029		0.022	-1.938
				(0.019)		(0.019)	(5.497)
Wealth index					0.000	0.000	-0.016
					(0.000)	(0.000)	(0.024)
Child age (months)	0.020***	0.020***	0.022***	0.022***	0.020***	0.021***	0.021**
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.008)
Squared child age	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Gender (male=1)	-0.062*	-0.061*	-0.066*	-0.067*	-0.063*	-0.068*	0.028
	(0.034)	(0.035)	(0.035)	(0.035)	(0.034)	(0.035)	(0.222)
Children under 5	-0.011	-0.009	-0.009	-0.008	-0.012	-0.007	-0.026
	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.111)
Mother's _age	0.012***	0.011***	0.012***	0.012***	0.012***	0.011***	0.021**
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.009)
Mother's marital status (married=1)	-0.130	-0.147*	-0.160	-0.159	-0.133	-0.157	-0.315
	(0.083)	(0.084)	(0.107)	(0.107)	(0.083)	(0.107)	(1.469)
Father's years of education	0.009	0.010	0.008	0.007	0.006	0.006	0.149
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.460)
Mother's _HAZ	0.321***	0.315***	0.327***	0.324***	0.322***	0.321***	0.378***
	(0.061)	(0.061)	(0.061)	(0.061)	(0.061)	(0.061)	(0.131)
Mother's _BMI	-0.030*	-0.028	-0.032*	-0.032*	-0.032*	-0.031*	0.028
	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.146)
Rural residence	0.117**	0.121**	0.098*	0.097*	0.142***	0.119**	-0.855
	(0.050)	(0.052)	(0.051)	(0.051)	(0.055)	(0.057)	(1.402)
Constant	-0.270	-0.281	-0.188	-0.184	-0.241	-0.194	0.538
	(0.444)	(0.446)	(0.452)	(0.452)	(0.445)	(0.455)	(3.855)

Table 8: Con't

VARIABLES	(1) OLS/FE WHZ	(2) OLS/FE WHZ	(3) OLS/FE WHZ	(4) OLS/FE WHZ	(5) OLS/FE WHZ	(6) OLS/FE WHZ	(7) IV WHZ
Observations	5,961	5,883	5,843	5,843	5,961	5,768	5,757
R-squared	0.075	0.075	0.075	0.075	0.075	0.075	-1.997
Number of provinces	45	45	45	45	45	45	45

Robust standard errors in parentheses

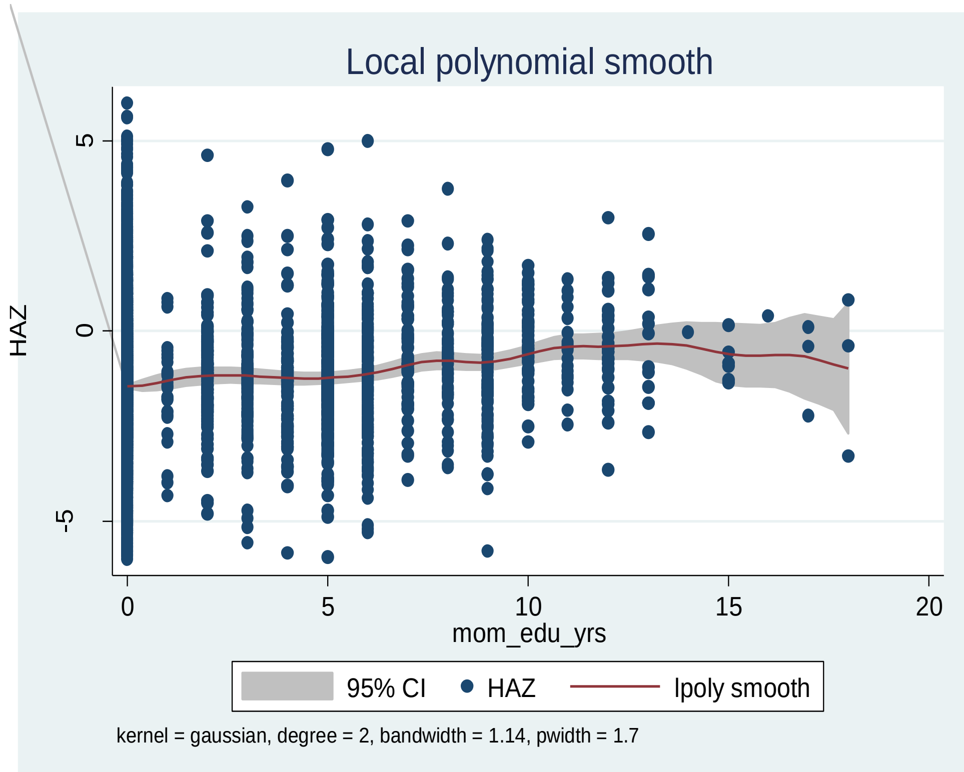
Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

5.2 Semi-Parametric Regressions

To check for threshold effects, I first look at the bivariate relationship between maternal education and child health. A local polynomial smooth of the semi-parametric relationship between HAZ and mother's education, along with 95% confidence interval curves, are presented in Figure 4. A second-order polynomial degree is used. The graph seems to indicate that the relationship is non-linear. Given that overall educational attainment in Burkina Faso is very low, the confidence intervals become very wide after 12 years of education; too few people have reached 12 years of education, hence the estimates at those levels of education are less precise.

Figure 4: Semi-parametric Regression of HAZ on Mother's Years of Education



5.3 Threshold Effects

In the previous section, the bivariate relationship between mothers' education and children's HAZ was found to be non-linear. Therefore, separate binary variables for different levels of maternal schooling are added to the regression to check for threshold effects. The regression in Table 9 includes all variables in Column 6 of Table 7. The largest statistically significant and positive impact of mothers' education is estimated at 12 years for HAZ. For instance, 12 years of maternal schooling will increase child HAZ by 0.410 standard deviations, compared to 0.369 standard deviations for 10 years of education. The negative coefficients may reflect very bad students among the pool of students at those levels of education. In particular, the negative and significant coefficient for nine years of education suggests a non-trivial number of poor quality students who achieved nine years of education.

Table 9: Threshold Effects Estimation Results

VARIABLES	OLS/FE HAZ
Mother's education 1 year	-0.362
	(0.281)
Mother's education 2 years	0.125
	(0.108)
Mother's education 3 years	0.177
	(0.181)
Mother's education 4 years	-0.257
	(0.159)
Mother's education 5 years	0.062
	(0.094)
Mother's education 6 years	0.003
	(0.101)
Mother's education 7 years	0.230
	(0.210)
Mother's education 8 years	0.229
	(0.208)
Mother's education 9 years	-0.334*
	(0.174)
Mother's education 10 years	0.369***
	(0.134)
Mother's education 11 years	0.274
	(0.310)
Mother's education 12 years	0.409**
	(0.167)
Mother's education 13 years	0.065
	(0.319)
Mother's education 14-18 years	-0.065
	(0.180)
Constant	-0.861***
	(0.262)
Observations	5,771
Number of provinces	45
R-squared	0.198

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

6. Conclusion

This paper examines the impact of maternal education on child health in Burkina Faso for children ages five years and under. A change in the country's primary school educational policy (consisting of 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 the estimates of maternal education from endogeneity bias; however, the identification assumption was not met. In addition, tests of endogeneity of mothers' education, health knowledge, bargaining power, and household wealth concluded that these variables were not endogenous. Therefore, OLS regressions with province-fixed effects were run .The results show that a mother's education significantly and positively affects her children's height-for-age (long term malnutrition). The effect of maternal education on children's weight-for-height (short-term malnutrition) is positive but statistically insignificant, suggesting no direct effect.

These results suggest that efforts to educate girls should be increased and sustained, as the healthiness of their future children depends on it. Given that nutrition in the first two years of life is crucial for both physical and mental development and that nutrient deficiency can have long-lasting impacts, investing in girls' education today can provide benefits in the future in terms of increased worker productivity.

Household wealth, mothers' health knowledge, and mothers' bargaining power seem to be pathways through which mothers' education affects children's HAZ. For WHZ, none of the pathway variable was significant. The pathways results imply that nutrition and health knowledge education programs targeted at girls and women can help reduce the prevalence of stunting in the country. The wealth index impact implies that women should be encouraged to participate in income-generating activities so as to contribute to household expenses and invest in their children's nutrition and health. Women with higher bargaining power in household decision-making and in their interactions with their husbands have healthier children. Therefore, radio and TV shows denouncing wife beating and spousal abuse can help improve children's nutrition outcomes in Burkina Faso.

The threshold effects estimation indicates that the largest impact of maternal years of education on children's HAZ occurs at 12 years of education. Thus, education policies targeted to girls should focus on trying to keep them in school for 12 years or more. This will come at a high financial cost, but windfall revenues from the gold boom and from other promising mining projects, such as the Tambao manganese project scheduled to begin extraction in 2016, can be a source of financing for girls' education in the country.

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Appendix

Table A1: First-stage results for WHZ IV regression

VARIABLES	(1) Education	(2) Health knowledge	(3) Bargaining power 1	(4) Bargaining power 2	(5) Wealth index
Child age in months	0.005	0.002	-0.000	0.000	-0.137
	(0.006)	(0.002)	(0.003)	(0.003)	(0.129)
Squared child age	-0.000	-0.000	0.000	0.000	0.002
	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)
Gender (male=1)	0.027	0.032	-0.021	0.027	2.234**
	(0.050)	(0.021)	(0.024)	(0.024)	(1.101)
Children under five	-0.076***	-0.019*	-0.026**	-0.002	-1.454***
	(0.024)	(0.010)	(0.012)	(0.012)	(0.533)
Mother's age	-0.011**	0.005***	0.004*	0.004*	-0.111
	(0.005)	(0.002)	(0.002)	(0.002)	(0.111)
Mother's marital status	-0.964***	0.087	-0.072	0.006	-0.593
	(0.152)	(0.063)	(0.073)	(0.074)	(3.368)
Father's education (years)	0.328***	0.054***	0.037***	0.015***	7.134***
	(0.011)	(0.004)	(0.005)	(0.005)	(0.235)
Mother's HAZ	0.116	0.088**	0.073*	0.050	-0.032
	(0.087)	(0.036)	(0.042)	(0.043)	(1.935)
Mother's BMI	0.031	-0.006	-0.009	-0.008	2.896***
	(0.026)	(0.011)	(0.013)	(0.013)	(0.587)
Rural	-0.339***	-0.325***	0.032	0.080*	-13.393***
	(0.092)	(0.039)	(0.044)	(0.045)	(2.049)
Young cohort	0.093	-0.163**	0.002	-0.090	-5.774
	(0.167)	(0.069)	(0.080)	(0.082)	(3.692)
High intensity province	0.011	0.004	-0.099***	-0.116***	-1.390
	(0.076)	(0.031)	(0.036)	(0.037)	(1.674)
Young cohort*high intensity	-0.412**	0.206**	-0.065	0.149	2.250
	(0.197)	(0.082)	(0.094)	(0.096)	(4.368)
Mother listens to radio	0.259***	0.389***	-0.069***	0.032	6.889***
	(0.052)	(0.022)	(0.025)	(0.025)	(1.145)
Mother has a living sister	0.002	0.069*	-0.046	-0.042	0.109
	(0.086)	(0.036)	(0.041)	(0.042)	(1.906)
Number of co-wives	-0.009	-0.013	-0.057***	-0.060***	7.726***
	(0.040)	(0.017)	(0.019)	(0.020)	(0.892)
Mother's worked in the last 12 months	-0.227***	0.323***	0.155***	0.058	-3.715**

Table A1: Con't

VARIABLES	(1) Education	(2) Health knowledge	(3) Bargaining power 1	(4) Bargaining power 2	(5) Wealth index
	(0.073)	(0.031)	(0.035)	(0.036)	(1.626)
Community wealth index	0.006***	0.003***	0.001***	0.001*	0.679***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.014)
Constant	2.029***	-0.178	0.340	0.331	-58.185***
	(0.664)	(0.277)	(0.318)	(0.325)	(14.716)
Observations	6,128	6,128	6,128	6,128	6,128
R-squared	0.370	0.346	0.145	0.105	0.699
F test of joint significance of IVs	19.26	76.02	6.95	3.55	319.29
p-value	0.000	0.000	0.000	0.000	0.000
Sargan statistic			5.855		
p-value			0.119		
DWH test	0.213	2.227	0.044	0.112	0.540
p-value	0.645	0.136	0.833	0.738	0.462

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A2: Compared Variability of HAZ and WHZ

Child's age	Std dev HAZ	Std dev WHZ
0	1.65	1.57
1	1.53	1.38
2	1.43	1.33
3	1.44	1.24
4	1.34	1.19

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