Mothers' Skills and Schooling and Child Health in Ghana†

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Abstract:
This paper examines the impact of mothers' literacy and numeracy skills and schooling on the production of children's health in Ghana. The analysis considers child health inputs and outputs, examining the determinants of pre- and post-natal care, vaccinations and mortality. Previous studies of the determinants of child health have mostly been limited to investigating the impact of mother's schooling only and, as a consequence, largely have not considered skills, including literacy and numeracy skills and health knowledge, and also have ignored alternative routes to acquiring skills, such as adult literacy programs. Analyzing a recent household survey for Ghana, this paper addresses both of these issues. To allow for the possible endogeneity of mothers' skills and schooling an IV-based estimation approach is pursued. Exogeneity of skills and schooling is rejected or marginally maintained for most measures and sub-group analyses. The results indicate that literacy and numeracy skills are largely not important once schooling is controlled for but at the same time also indicate a positive association between adult literacy course participation and child health. The latter points towards the potentially important role of adult literacy programs in promoting child health by the acquisition of health knowledge by participants, something which has previously received little to no attention in the economics literature but has important policy implications.

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"The education of parents, notably that of the mother, appears to be an omnibus. It affects the choice of mates in marriage. It may affect the parents' preferences for children. It assuredly affects the earnings of women who enter the labor force. It evidently affects the productivity of mothers in the work they perform in the household, including the rearing of their children. It probably affects the incidence of child mortality, and it undoubtedly affects the ability of parents to control the number of births."

Theodore W. Schultz (Schultz, 1973 p. 8-9)

1. Introduction

One of the strongest and most consistent findings in development and health economics is the positive relationship between mothers' schooling and child health. This empirical relationship has been confirmed in numerous studies across different time periods, countries and measures of child health. These studies generally treat education as a "black box", however. What is measured is not what the mother has learned in terms of skills such as for example literacy, numeracy and health knowledge but rather what level or grade she has completed. Two main issues are involved here. First, the link between schooling and child health really goes from schooling to skills to productivity to child health. As the link between schooling and skills is more tenuous in developing countries due to often poor school quality, it is imperative that this part of the process receive particular attention in empirical analyses in this context. Second, policies focusing on education rather than on skills might be misdirected. With multiple paths to achieving skills (including formal education and adult literacy programs) and with limited public budgets, cost-effectiveness of programs is essential.

In response to these issues, I suggest that literacy, numeracy and other skills, including health knowledge, be viewed as intermediate outputs in a production process where the main inputs are formal (child) schooling and non-formal (adult) literacy course attendance. Subsequently, literacy, numeracy and other skills enter as inputs in a production process to generate the final outputs of child health.

Building on the above sketched two-pronged production process, this paper examines the relationship between mothers' literacy and numeracy skills, formal education and adult literacy course participation and child health in Ghana. The health measures examined include child health inputs and final child health outcomes, namely vaccinations, pre- and postnatal care and mortality. The possible endogeneity of mothers' skills and schooling is addressed by pursuing an instrumental variables estimation strategy.

Ghana is an ideal candidate for investigating these issues. First, the Ghanaian education system is one of the most developed in Sub-Saharan Africa, so there is ample opportunity to study more closely the individual components of the schooling-skills-productivity-child health. Second, it has been a priority for the Ghanaian government to provide basic literacy and numeracy skills for adults who never (or only briefly) attended child schooling by means of adult literacy programs so that the multiple paths to literacy and numeracy skills may be studied.

Similarly, the fourth round of the Ghana Living Standards Measurement Survey (GLSS), collected in 1998/99, is well-suited to study this link more closely. First, the survey includes information on the main inputs of child schooling as well as adult literacy course participation. Second, it includes information on the intermediate outputs of literacy and numeracy skills. Third, the survey contains information on child health including vaccinations, pre- and postnatal care and mortality.

The rest of this paper is structured as follows. The next section presents the conceptual framework of this paper, while section three discusses previous evidence on the maternal schooling/skills child health link in the context of the conceptual framework presented in section three. Section four discusses estimation strategies and related issues. Section five presents the data, discusses sample restrictions and also provides preliminary, descriptive analyses of the interlinkages of mother's literacy and numeracy skills, formal schooling and adult literacy course participation in Ghana. The multivariate econometric analyses follow in section six, while section seven concludes and discusses policy implications.

2. Conceptual Framework

The inter-linkages between skills and child health are examined in the context of Grossman's (1972) health production model. In the original model, an individual maximizes utility with respect to his/her own health and consumption. I extend the model by letting the mother also obtain utility from child health and by allowing the human capital effects to come from a set of individual skills, rather than from education per se. Further, the skills effects run from the mother's skills to the child's health. While this model might be posed entirely in terms of a verbal description, a mathematical representation helps highlight some important issues and the latter will therefore be pursued in the following.

Specifically, I consider a two-person household consisting of a mother and a child in which the mother has preferences over the child's health (Z_1) and other commodities (Z_2). Alternatively, the set-up may be viewed as regarding a multi-person household, where the focus is on the interlinkages of mothers' skills, schooling, labor supply and child health investments and the resources of other household members enters the model through their added resources in terms of earned and unearned income (see below).[1] The utility of final goods is affected by three

[1] Again, so as to focus on the main subject of this paper, namely the interlinkages of mothers' skills, schooling and child health investments, issues related to intrahousehold bargaining over resources are not explicitly incorporated here. A large literature, starting with Manser and Brown (1980) and McElroy and Horney (1981), examine issues related to marriage and household decision-making. One of the main results from this literature is that the bargaining power over resources within the marriage (or household) related to for example child health depends on the opportunities outside of marriage (or the household). To the extent that bargaining power is correlated with mother's skills and schooling, however, the analyses here will at least capture some elements of the bargaining

types of preference shifters: human capital skills, S,[2] observed family background including needs or fertility, ethnicity/tribal association, B, and unobserved characteristics including tastes, δ, giving rise to the following utility function:

$$U = u(Z_1, Z_2; S, B, \delta) \tag{2.1}$$

The utility function is assumed to exhibit the required desirable properties, most importantly it is assumed to be quasi-concave.

The household's utility maximization is subject to three types of constraints: technological, budget and time constraints. First, the technological constrains are given by the two production functions f_1 and f_2, which give output of child health and all other goods as functions of their respective inputs of a market good (X) and mothers' time (T), conditional on the mother's skills,[3] S, (both production functions) and the (unobserved) initial child health endowment, η, (only child health production) and community specific health related variable, C, which includes health infrastructure, treatment practices, and the disease environment (also only included in the child health production function):

$$Z_1 = f_1(X_1, T_1; S, \eta, C), \tag{2.2}$$

$$Z_2 = f_2(X_2, T_2; S), \tag{2.3}$$

The household's budget constraint defines the consumption frontier of the household as a function of its potential income sources. Specifically, the household may obtain income from engaging in labor activities, supplying H amounts of labor at the rate W, which is affected by the

structure within the household. For a review of family economics, including cooperative household models, see also Bergstrom (1996).

[2] S may be viewed either as a generic skill or alternatively as a vector of skills including, for example, literacy and numeracy skills and health lnowledge.

[3] To simplify the discussion, skills are not modeled explicitly here. Following Blunch (2004), one might imagine skills being produced from time in child schooling, T_1, time attending adult literacy classes, T_2, the quality of these two types of education, Q_1 and Q_2, conditioned by a taste shifter, φ, capturing different tastes for education due to for example religion, ethnicity and/or cultural norms and traditions in the community: $S = s(T_1, T_2, Q_1, Q_2, \varphi)$.

vector of human capital skills, S, and from other sources, N, including unearned income and transfers, which also depends on human capital skills:

$$W(S)H + N(S) \geq P_1X_1 + P_2X_2. \tag{2.4}$$

Lastly, the maximization of (2.1) is also subject to a time-constraint:

$$T_1 + T_2 + H = K, \tag{2.5}$$

where K is the maximum time available for home-production and market work after accounting for time to eat and sleep, say, 16 hours a day (alternatively, it could be normalized to one).

The problem of the mother, therefore, is to maximize (2.1) with respect to T_1, T_2, X_1, X_2 and H subject to the constraints (2.2)-(2.5), that is to decide the amount of time and goods inputs in the production child health and other commodities and the amount of time devoted to market work so as to maximize utility subject to the set of constraints.[4] Solving the model yields a series of market goods demands and production time supply functions. The child health input demand function has our main interest:

$$X_1^* = x_1(W(S), N(S), P_1, P_2, S, B, \delta, \eta, C). \tag{2.6}$$

Substituting X_1^* from (2.6) into (2.2) yields the reduced form child health production function:

$$Z_1^* = z_1(W(S), N(S), T_1, P_1, P_2, S, B, \delta, \eta, C). \tag{2.7}$$

The child health input demand function (2.6) and the child health production function (2.7) are what will be estimated in the empirical analyses.

From this discussion several issues with implications for the empirical analyses come out. First, the reduced form child health input demand and child health production functions (2.6) and (2.7) suggest the variables that are potentially important determinants conceptually and therefore should be included in the empirical analyses. These variables include the mother's skills level,

[4] The amount of time devoted to market work and one of the market good inputs are redundant due to the linear dependence between these variables.

her wage rates as well as prices of health care and time use of health care services/child health production, needs and tastes. Second, several interesting research questions come out of the model (I will return to this after extending the conceptual framework a bit). Third, the reduced form (input) demand for child health market goods (2.6) and the reduced form child health production function (2.7) make clear that human capital skills have both direct and indirect effects on child health input demands and child health production. May it be possible to disentangle the direct and indirect effects empirically? (2.6) and (2.7) hint that it is: inclusion of skills will capture the direct effects, while inclusion of wages will control for indirect effects.

Lastly, the conceptual model outlined above also highlights the importance of unobserved heterogeneity and endogeneity for the subsequent analyses. From the presence of δ (unobserved family characteristics, including tastes) and η (unobserved child health endowment) in both (2.6) and (2.7), unobserved heterogeneity is seen to affect both child health input demand and the production of child health. Further, the issue of endogeneity or simultaneity involved in an examination of determinants of child health input demands and child health outcomes are also apparent from (2.6) and (2.7): child health input demand and child health outcomes, which are chosen by the mother, both depend on skills and wages, which are themselves chosen by the mother, also. In turn, these twin issues of unobserved heterogeneity and endogeneity/simultaneity highlighted by this model needs to be dealt with in the subsequent empirical analyses.

Treating skills as one generic skill or vector of skills, S, simplified the presentation for the mathematical model above. At the same time, however, this simplified model helped bring out several important issues related to both the theoretical interlinkages of child health inputs and outcomes, mothers' skills and other variables and the subsequent empirical analyses.

Conceptually, however, several extensions to the above model are warranted. First, where do skills come from? Rather than skills (implicitly) being obtainable via only one route, it is more realistic to consider several routes for achieving skills. In particular, I suggest that skills may be obtained either from formal schooling during childhood or from participation in adult literacy programs during youth or adulthood. Second, while it seems intutitve that *S* contains several skills (each of which are obtainable through one or both of the two alternative routes of achieving skills) which skills is it more precisely that *S* actually contains? In discussing in more detail the exact nature of the different skills and the channels through which the different components of *S* affect child health inputs and outcomes I will distinguish between direct effects on the mother's home productivity in child health production (working through her child health production function (2.2)) and other indirect skills effects.

Starting with the direct skills effects, there are several reasons why skills might affect the mother's home productivity of child health. First, the production of child health depends crucially on literacy and numeracy skills—being able to read and accurately follow prescriptions, for example. These are skills which are potentially obtainable from either formal education or adult literacy course participation, although the former appears to be much more efficient in generating literacy and numeracy skills in Ghana (Blunch, 2004). Second, health knowledge would seem to increase the efficiency in the production of child health so that for a given demand of child health related goods or services, an increase in health knowledge would increase the output in terms of child health. Health knowledge plays a major role in education, although arguably more so in adult literacy programs than in the formal schooling system. In the formal education system, children learn about health related issues from science classes,[5] while in the

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[5] Starting at the higher primary level, children have Integrated Science (Science and Agricultural Science), which at the junior secondary level subsequently is divided into Science and Agricultural Science.

national[6] adult literacy programs 10 out of the total 28 topics taught in addition to literacy and numeracy skills include health related issues, for example “Family Planning”, “Immunization”, “Safe Motherhood and Child Care” and “Safe Drinking Water”. Both the fact that such a large fraction of the curriculum taught at adult By their very natureWhereas literacy and numeracy skills may be viewed as more generally applicable skills, health knowledge may be considered a more specialized skill, which mainly affects the demand and home productivity of child health. So how might increased efficiency in the (home) production of child health work its way through this modified Grossman health production model? Initially, (home) production will shift towards the production of child health, assuming that this is a normal good and that it is not relatively “much” more time-intensive than other commodities. At the same time, however, there will be more time available for market work, which will enable the individual to purchase more of the market-good input for production of child health and other commodities. While this effect therefore depends on the relative time and goods intensities of the various commodities, intuitively, the net effect on the production of child health is most likely positive.

The indirect effects work mainly through the household’s consumption possibilities and preferences. Most importantly, an individual’s wages may increase from participation in schooling activities. This could be due to a direct productivity effect from literacy and numeracy skills or from socialization or discipline skills obtained from childhood schooling. Alternatively, earnings capacity may increase either from credentialism or signaling (Spence, 1973) obtained from childhood schooling or from participation in adult literacy programs, where participants learn about income generating activities and frequently engage in them directly under the

[6] There are several adult literacy providers in Ghana, including various NGOs, both faith-based and others. The largest program, however, is the NFLP (National Functional Literacy Programme), and the specific program information concerns, strictly speaking, only this program. However, most programs include a core of health related issues, so that this program may be taken to be roughly representative of all the programs.

direction of the teacher. The increased income potential of the household reduces the need to depend on children as a source of income, thus decreasing child labor. In turn, this will positively affect child health. Again, both substitution and income effects may be operating here—the net effect from these indirect effects, however, is likely to be positive. In addition to affecting the household's consumption possibilities, participation in schooling activities may also affect needs or tastes for child health. Indeed, if an individual is not aware of health practices and/or their usefulness, why would s/he demand them in the first place? First, parents may become aware of the harmful effects of child labor on child health (and child schooling). Second, the composition of the consumption basket may shift from predominance of food to include more non-food items, including child health related items. Both of these effects come through the increased health knowledge from schooling activities. Again, the acquisition of health knowledge would seem to be more responsive to adult literacy course participation than from participation in formal schooling.

A few potentially important determinants are not included in the conceptual framework. For example, savings and assets are not included. Spill-over effects from having other literates and/or literacy course participants in the household (and/or in the community) are also not included. While both of these factors might be considered, I choose to exclude these possibilities from the current analyses, hence focusing at the impact of the mother's skills and schooling.

Based on this expanded conceptual framework I will examine the following research questions. First, do literacy and numeracy skills increase demand for child health inputs and improve final child health outcomes once schooling has been controlled for? Second, has education any impact on intermediate and final child health outcomes once the impact from literacy and numeracy skills have been controlled for? Third, if so, what is the relative impact of non-formal education, that is, adult literacy programs, vis-à-vis formal education?

3. Previous Evidence on Linkages Between Mothers' Schooling, Skills and Child Health

As is also clear from the quote from T.W Schultz (1973) opening this paper, maternal education has been considered an "omnibus" for quite some time now. Indeed, the positive (negative) correlation between mothers' educational attainment and child vaccinations, pre-and postnatal care (child mortality) could rightly be viewed as a stylized fact, owing to the wealth of studies examining this link.[7] Schultz (1973) is in many ways itself an omnibus in the sense of summarizing many of the issues involved and thus "setting the stage" for subsequent studies in this literature. For the purposes of the analyses here, the emphasis on the household production function and human capital as it relates to the bearing and rearing of children (which presumably also includes health investment considerations) is notable: "It is obvious that bearing a child and caring for the infant child are normally highly labor-intensive activities on the part of the mother. What has not been clear is the difference in the value of time of mothers in bearing and rearing children associated with the difference in the human capital of mothers" (p. 6). This observation implicitly points toward the dual role of mothers' human capital—or, in terms of the conceptual framework of the previous section, skills and schooling—in the production of child health. On one hand, educated mothers may be more aware of healthy practices as it relates to child bearing and rearing, including pre- and postnatal care, immunizations, breastfeeding practices, nutrition and so on but on the other hand the value of her time in terms of foregone earnings is higher, which may decrease the time she spends on or with her child. As this foregone child time results in increased earnings, however, she will have more resources for purchasing market goods,

[7] For comprehensive reviews see Behrman and Deolikar (1988), Behrman (1990) and Strauss and Thomas (1995).

including market goods for child health production (X_1 in the model in the previous section). In turn, this will positively affect the production of child health.

Subsequent studies have mostly found the impact of mothers' (formal) education on child health to be positive. In a series of studies considered to be among the most comprehensive in the literature (Strauss and Thomas, 1995), The Cebu Study Team (1991, 1992), found that in the Philippines, mothers' education lead to more hygienic waste disposal and higher non-breastmilk calorie intake. These factors both affect child health positively, by, for example, decreasing the incidence of diarrhea. On the other hand, mother's education is found to negatively affect the age of weaning, which affects child health negatively, again, by increasing the incidence of diarrhea. In terms of the conceptual framework outlined in the previous section, this points both towards the positive impact of mother's education in terms of increasing her health knowledge and thus her efficiency in the production of health but at the same time also increasing the opportunity cost of her time (earlier weaning allows for earlier return to the labor market). Again, however, in line with the conceptual framework of the previous section, the increased earnings opportunities from the earlier return to the labor market may well increase the consumption of child health related market goods. As also pointed out by Strauss and Thomas (1995), the comprehensiveness of these studies at the same time may be their weakness. Their attention to detail necessitates instrumenting of many potentially endogenous variables, in turn possibly imposing improbable exclusion restrictions among these. For other studies on the positive association between mothers' schooling and child health, see Behrman and Deolikar (1988), Behrman (1990) and Strauss and Thomas (1995).

As argued in the conceptual framework of the previous section, however, mother's education per se need not be the end of the story: it may be that literacy and numeracy skills and health knowledge exert an effect on child health independent of that of education. Moving to the smaller literature, which have considered literacy and/or numeracy skills in the maternal education-child health relationship, there does seem to be some evidence that these skills have a positive impact on child health. Khandke, Pollit and Gorman (1999), analyzing Guatemalan data, examine the links between mother's formal education and literacy skills on child health, where child health was measured as respiratory illness through the fourth year of age and the assessment of literacy was established in a test. They found, first, that formal schooling was a significant negative predictor of child respiratory illness, controlling for socioeconomic variables. Second, however, when including mother's literacy score that, too, had a significant negative effect on child respiratory illness. Glewwe (1999) analyzes child health in Morocco, where child health is measured in terms of height-for-age. While Glewwe finds no evidence of a direct effect from literacy and numeracy skills on child health, he argues for the presence of an indirect, coming through health knowledge. Health knowledge is not directly learned in school, it is argued, rather it is learned using the literacy and numeracy skills obtained in school. In line with Glewwe (1999), Kovsted, Pörtner and Tarp (2003) find that ………… A more recent study examining the possibility of literacy mediating the relationship between maternal schooling and health behavior is LeVine, LeVine, Rowe and Schnell-Anzola (2003???), which examine Nepalese data. It is found that, first, maternal schooling statistically significantly affects health behavior in terms of predicting comprehension of radio and printed health messages, the ability to follow instructions on oral rehydration salts and the ability to tell a coherent story about an illness—her own or her child's—to an interviewer. Second, when introducing literacy skills, these are statistically significant, while the maternal schooling variable becomes statistically insignificant. Sandiford, Cassel, Montenegro and Sanchez (1995) is a rare study, examining the impact of maternal literacy on child health and in so doing additionally distinguishing whether the literacy skills were obtained through the formal education system during childhood or through participation in non-formal education during adulthood. The data analyzed are for Nicaragua and allow for creating three distinct groups of mothers: one consists of illiterate mothers, one of mothers who became literate through attending primary schooling as children and the third is made up of mothers who acquired literacy through attending adult schooling. Women who attended both primary school and adult literacy classes were excluded from the analyses. The child health measures examined include weight-for-age, height-for-age, mid-upper arm circumference for age and mortality. It is found that children of mothers who became literate through formal education fare better than children of illiterate mothers in terms of these measures but not as well as children of mothers who became literate from primary school. The only exception is height-for-age, where there is no statistically significant difference between the three groups.

A problem with the studies that examine the possible impact from literacy and/or numeracy skills is that the sample sizes are frequently quite low, due to the extensive resources required for formal testing of literacy and/or numeracy skills. The sample underlying the analyses in LeVine et al (2003????????), for example, contains 167 mothers, while the sample underlying the analyses in Khandke et al (1999) contains 266 children and their mothers. This illustrates quite clearly the trade-off between sample size and validity of measure: if one insists on a more rigorous test score measure rather than a self-assessed literacy/numeracy measure, this typically come at a cost of obtaining a much smaller sample size.

Moving to the available evidence for Ghana, Benefo and Schultz (1996) examine the determinants of and the interlinkages between fertility and child mortality and so doing, include variables for mothers' years of schooling by level of education (i.e. primary, middle and secondary or higher). In the analyses of child mortality rates, none of the education variables are individually statistically significant. Additionally including interaction effects between years of schooling and other variables, however, revealed differential effects between educated and uneducated mothers. The interaction between years of schooling and rural location was negative and statistically significant, indicating that female schooling has a greater impact on child mortality in rural than in urban areas. Similarly, the interaction between years of schooling and protected water source was negatively statistically significant, indicating a relatively higher impact of protected water source from more educated mothers. Lastly, the interaction between years of schooling and distance to nearest health clinic was positive, indicating that the proximity to a health clinic complement mothers' education. A potential methodological issue with this study, however, is that it does not allow for mothers education to be endogenous. Asenso-Okyere, Asante and Nubé (1997) examine the determinants of child health as measured by nutrition, weight-for-height and height-for-age. Neither mothers' literacy skills nor mothers education as measured by years of schooling are found to impact any of these measures statistically significantly when controlling for other factors. An issue here is that literacy skills and schooling are never included in the models simultaneously, it is always one or the other. It is also not clear exactly what the literacy measure applied here is.[8] Additionally, the estimations are done using OLS, that is disregarding the possible endogeneity of mothers' schooling and literacy skills. Analyzing the determinants of child survival, weight-for-age and height-for-age, Lavy, Strauss, Thomas and de Vreyer (1996) find mixed evidence for the maternal education-child health link. In the analyses of child survival mothers' education as measured by years of education is not statistically significant, agreeing with the results in the two earlier mentioned studies for Ghana. When turning to the weight-for-height and height-for-age

[8] In the GLSS 1, analyzed in Asenso-Okyere, Asante and Nubé (1997), the questions pertaining to literacy and numeracy are "Can [NAME] read a newspaper?", "Can [NAME] write a letter?" and "Can [NAME] do written calculations?" but which of these questions the measure is based on is not clear.

analyses mothers' education is found to have positive and statistically significant at higher levels of education but negative effects at lower levels and may be, it is argued, reflect a threshold effect of education. As was the case with the other studies for Ghana, education is treated as predetermined. In line with the previously reviewed studies for Ghana, Glewwe and Desai (1999) also find no impact from mothers' schooling, English reading or math skills when examining determinants of height-for-age.[9] This is true no matter whether schooling, literacy or numeracy measures are entered separately or together. However, when examining the determinants of weight-for-height, there is a positive and statistically significant effect from numeracy skills, while the impact of mother's schooling is negative and statistically significant (at 10 a percent level of significance). This is argued to be due to multicollinearity (which is supported by the fact that when mother's schooling is entered by itself it is negative but very small and not statistically significant at conventional levels, having an associated t-value of about 0.5). Similar to the previously reviewed studies for Ghana, Glewwe and Desai (1999) also treat mothers' skills and schooling as predetermined.

While the evidence on the possible impact of adult literacy programs, or, more generally, health knowledge, on child health is scarce for the literature as a whole, for Ghana it appears to be non-existent: a search in Econlit using either "adult education", "non-formal education" or "adult literacy program(me)" and "Ghana" in either title, keywords, or abstract does not yield any results (as of September 27, 2004). In turn, this is evidence for the pressing need of examining this link, especially since such programs may be a cost-effective alternative to formal education in terms of promoting child health in Ghana and elsewhere.

[9] English reading and math skills are here measured by the results from the tests on English reading and mathematics that were given to a sub-sample of the households covered by the GLSS 2.

4. Estimation Strategies and Issues

From the previous section skills directly affected child health outcomes by increasing the efficiency of household productivity and indirectly affected these outcomes by increasing consumption possibilities and changing tastes. The empirical analysis will rely on linear specifications of the optimal intermediate and final child health outcome equations. These equations are written:

$$X_i = \alpha + \beta_1 S_i + \beta_2 E_{1i} + \beta_3 E_{2i} + \beta_4 W_i + \beta_5 F_i + \beta_6 A_i + \beta_7 P_i + \beta_8 C_i + \varepsilon_i, \qquad (4.1)$$

$$Z_i = \alpha + \beta_1 S_i + \beta_2 E_{1i} + \beta_3 E_{2i} + \beta_4 W_i + \beta_5 F_i + \beta_6 A_i + \beta_7 P_i + \beta_8 C_i + \nu_i, \qquad (4.2)$$

where X_i is child health input (vaccinations, or pre- or postnatal care); Z_i is child health output (mortality); S_i is literacy and numeracy skills; E_{1i} is childhood schooling; E_{2i} is adult literacy course participation; W_i is the wage rate; F_i is fertility; A_i is access to health facilities (for example health center, midwife, doctor) in the community; P_i is prices on health related goods and services; C_i is a vector of other controls, including age of the mother (to capture experience and time having been of child-bearing age) and the child (to capture child needs and age specific productivity effects in health production), geographical location, and ethnicity and ε_i is an error-term capturing unobservables. (4.1), therefore, is a factor or intermediate output demand function, while (4.2) is a commodity production function.

One potentially important estimation issue is that mothers' skills and schooling may be endogenous. If this is the case, the resulting estimates will be biased and therefore misleading as far as establishing links between mothers skills and schooling and child health is concerned. One widely applied approach to deal with endogeneity involves instrumental variables. How to choose the instruments, however, is crucial: the instrumental variables estimates are only as good as the instruments. Arguably, human capital accumulation and literacy and numeracy skills acquisition depend on the availability of schools as well as their quality. This has led researchers to include variables for current availability and quality of schools in the local area. However, especially when analyzing issues related to the human capital accumulation of adults, these measures differ from the relevant school supply and school quality variables in at least two dimensions, namely time and space. First, the relevant school supply and school quality variables are those at the time of attending school, rather than current school supply and school quality. Second, the relevant school supply and school quality variables are those of the geographical area, where the individual grew up, rather than school supply and school quality of the current area of residence. Additionally, current measures of school supply and school quality may not be truly exogenous due to purposive migration to areas with better access to or better quality of schools, whereby in practice one runs the risk of substituting one set of endogenous variables with another. The instruments proposed here, birth cohort multiplied by region of birth, which are similar in spirit to those applied in Angrist and Krueger (1991) and Blau and Hagy (1998), attempt to address all three of these issues. First, birth cohort and region of birth both are closer in time to the relevant time period for school attendance and skills acquisition than are school supply and school quality variables of the current time period. The time of birth is likely to explain school supply and school quality through differential effects for different cohorts following changes in economic and political conditions in Ghana at the time relevant for school attendance and skills acquisition. Similarly, the region of birth is likely to explain school supply and school quality through differential effects for the different geographical regions at the time relevant for school attendance and skills acquisition. Second, birth cohort and region of birth are also spatially closer to the relevant school supply and school quality variables than are school quality and school quality variables of the geographical location of residence in adulthood. The school supply and school quality of the region of birth is more likely to explain the school attainment and skills level of an individual than are the school supply and school quality of the current residence.

The are several reasons for cutting the sample, thus examining child health determinants of specific sub-samples in addition to the full sample. First, from a methodological viewpoint adult literacy programs seem to be particularly relevant for rural areas due to the generally lower human capital stock in rural areas. Additionally, rural areas are generally poorer than urban areas, which is typically associated with lower access and utilization of health care, as well. From a policy perspective, it would therefore be interesting to do a sub-analysis specifically for the rural areas, as well. Similar reasoning applies to focusing on mothers who received no formal education. Methodologically, the correct counterfactual for mothers who have attended adult literacy programs is not merely mothers who did not attend adult literacy programs but rather mothers who did not attend adult literacy programs *and* have not received any formal (childhood) education, either. This motivates a separate analysis for mothers, who did not receive any formal education. Additionally, from a policy perspective, these mothers would also seem to be more at a disadvantage in terms of providing health care for their children and therefore the experiences of this group should be of special interest to policy makers.

Lastly, the underlying survey design is incorporated by applying sampling weights and adjusting for the clustering of observations in the estimations. Failing to do so, that is, assuming identically distributed random sampling, could potentially lead to biased results for the population by either obtaining “wrong” point estimates (if not applying weights) and/or “wrong” standard errors (if not incorporating clustering, although standard errors also may be affected by failing to incorporate the sampling weights). In particular, one would likely obtain standard errors that are far too low compared to what they “should” be (for the population), thus failing to reject the null hypothesis of no association too often.

5. Data and Descriptive Analyses

The Ghana Living Standards Survey (GLSS) is a nationally representative multi-purpose household survey, carried out in 1987/88, 1988/89, 1991/92 and 1998/99 as four independent cross-section surveys. The most recent round of these (GLSS 4) is used for the analyses in this paper. The household survey contains information on educational attainment, participation in adult literacy courses, literacy and numeracy, as well as information on background variables such as age, gender, tribal association/ethnicity and region, which are also important factors in analyses of human capital processes. In addition to the household survey, each round also includes a community and a price questionnaire. The community questionnaire contains information on access to facilities, including schools, hospitals, markets, roads, public transportation and adult literacy programs. Due to the difficulties involved in defining communities in urban areas the community questionnaire was only administered to rural areas. The most important variables will now be described in turn, starting with the dependent variables.

Child health outcomes

Four different child health outcomes from the GLSS 4 are examined in this paper. They may be classified into child health inputs (vaccinations, pre-and post-natal care) and final child health outcomes (child mortality). The information is provided by the mother. Since these variables are crucial to subsequent analyses, I will got through them in some detail, starting with the child health input measures.

The child health input measures are all based on information on whether the service in question was ever received by the child (vaccinations and postanatal care) or mother (prenatal care). The samples subjected to the questions on vaccinations and postnatal care are children 7 years and below and 5 years and below, respectively, while the question on prenatal care was only given to females, who either were pregnant currently or had been pregnant within the past 12 months (and were between 15 and 49 years old).

One problem with these measures is that it is not known when the service was provided. For vaccinations, for example, it is not known when a vaccination was provided, which type(s) and whether the full series of vaccinations for a given type was given (for example, polio and dpt vaccinations, to be fully effective, each require three consecutive vaccinations). Further, it may be that the child will or will not receive a (the) vaccination(s) in the future. One way to address the latter, though, would be to chose a lower cut-off high enough that it would seem that children not vaccinated at this age would likely never be vaccinated, say 3 years of age. Since this causes a large drop in observations this strategy is not pursued here, however. Similar issues exist for postnatal care, except that the timing problem is reversed: postnatal care seems to be most relevant for younger children, so that here the issue is to chose an appropriate upper cut-off, say, two or three years. While timing problems do not appear substantial for the prenatal care measure, the exclusion of mothers who are not currently pregnant or have not been pregnant within the past 12 months naturally limits the sample size considerably. Additionally, the prenatal and postnatal care measures are potentially riddled with unobserved heterogeneity (or self-selection): mothers who have experienced complications either with their current pregnancy or past pregnancies would seem to be more likely to seek prenatal care for themselves and postnatal care for their children. Vaccinations do not appear to be prone to these issues to the same degree.

Moving to final child health outcomes, the child mortality measure is constructed from the fertility module, which includes information on the number of children ever born and ever died to a woman (15 to 49 years old) but not when, which is unfortunate: it would have been useful to be able to combine the information on child mortality with birth-spacing, since the latter may be an important determinant of child mortality. Additionally, since it is possible that the child(ren) died far back in the past, the explanatory variables, which are current, may be poor predictors as a result. If a mother has recently participated in an adult literacy program, for example, this of course has no impact on the past deaths. Similarly, high child mortality might have induced the mother to participate in the programs in order to be able to prevent future deaths. I construct a binary measure of mortality based on this information, which is one if any children have died to a woman and zero otherwise.

Literacy and numeracy

The information on literacy skills from the GLSS 4 include Ghanaian reading and writing proficiency and English reading and writing proficiency, while numeracy measures the ability to do written calculations. The question on English reading (writing) skills is: "Can (NAME) read (write) a letter in English?", while the question on Ghanaian reading (writing) skills is: "In what Ghanaian language can (NAME) write a letter?" (stating the one in which (NAME) is most proficient). The question on written calculations is: "Can (NAME) do written calculations?" The respondent to these as to most of the other questions in the survey is "preferably the head of household, if not available, any adult member of the household who is able to give information on the other household members". While this may be an issue for concern, it is hard to correct. Another concern, which may be examined a bit further, is the subjective nature of the literacy and numeracy measures. In order to gain additional insights into this issue and the extent to which it poses any problems in practice educational attainment and literacy and numeracy skills proficiency for adults is tabulated in Table 5.1.

Table 5.1 Distribution of Self-reported Skills Across Highest Educational Level Completed

	Ghanaian reading	Ghanaian writing	English reading	English writing	Written Calculations
Full sample	0.435	0.400	0.498	0.519	0.609
None	0.060	0.046	0.038	0.033	0.132
Primary school	0.435	0.381	0.462	0.422	0.758
Middle school	0.741	0.689	0.875	0.846	0.960
Junior Secondary school	0.700	0.656	0.882	0.861	0.968
Secondary and above	0.874	0.841	0.999	0.998	0.996
Vocational	0.735	0.651	0.997	0.991	1.000
Other	0.937	0.885	1.000	1.000	1.000

Notes: Sample is individuals 15-65 years of age who have answered whether they have attended an adult literacy course, yielding a total of 13,403 observations.

Three findings from Table 5.1 indicate that such concerns may be unwarranted. First, the literacy and numeracy skill incidence does not appear heavily inflated—if it was close to one, it would definitely be a cause of concern. Second, literacy and numeracy rates increase with the level of education completed. Third, few literates have not attended school (some of these may be genuine, though, resulting from home-schooling or participation in adult literacy programs).

A related but somewhat different issue is the potentially high correlation among the four literacy measures and the numeracy measure empirically. The main issue here is that while conceptually the four literacy measures and the numeracy measures span five distinctly different dimensions in the "skills space", as it were, empirically, the high correlation among the five measures may cause "funny" results in terms of inference: statistically insignificant results of one or more of the measures and/or results of opposite directions of effects between sets of these variables, say between English reading and writing skills.[10] The reason such correlation may come about is that when an individual can write, she or he will also be able to read and also tend to be able to do written calculations, although the association between writing and reading skills would seem to be somewhat stronger than that between writing (and reading) skills and numeracy skills. To examine this issue in a bit more detail, consider the following correlation matrix for the estimation sample for the vaccination analyses (chosen since this is the largest of the four sub-analyses estimation samples and therefore likely to shed relatively most light on this issue):

Table 5.2 Correlation Matrix for Full Set of Literacy and Numeracy Skills Variables

	Ghanaian reading	Ghanaian writing	English reading	English writing	Written calculations
Ghanaian reading	1.000	--	--	--	--
Ghanaian writing	0.894***	1.000	--	--	--
English reading	0.664***	0.657***	1.000***	--	--
English writing	0.656***	0.657***	0.944***	1.000	--
Written calculation	0.636***	0.606***	0.696***	0.674***	1.000

Notes: Sample consists of the 4802 mothers from the vaccination analysis sub-sample. ***: statistically significant from zero at 1 percent.

The results from Table 4.2 confirm that there is a high degree of correlation among the five skills measures, highest between Ghanaian reading and writing skills on the one hand and English reading and writing skills on the other. The correlation between either of the four literacy measures and numeracy is somewhat smaller.

As a result of the high correlation empirically among the four literacy measures and the numeracy measure, I will include only one, composite "functional literacy" measure in the

[10] Such results were indeed obtained for preliminary analyses where all five skills measures were included simultaneously.

multivariate analyses. This measure is one if the individual can either read a Ghanaian language *or* English *and* do written calculations and zero otherwise. The motivation for this measure is that reading skills may be interpreted as the lower but more relevant standard relative to writing skills. What matters is being able to collect health related information, including reading prescriptions, instructions, newspapers and health information signs. Further, it may be suggested that it is the reading skills per se, i.e. the ability to collect any health information at all rather than the specific language that is most important in the information collection process. Calculations, on the other hand, are important in terms of processing information, including correctly following prescriptions. An added advantage of collapsing the skills space (from five to one) is that the proposed IV estimation strategy described previously will likely be more successful, the less endogenous variables need to be instrumented for.

Education variables

Educational attainment is measured as the highest level completed, ranging from "none" through "university" and also includes vocational and technical training. Similarly to what was the case for the skills measures, the dimensionality of this measure may be an issue concerning the proposed IV estimation strategy, which is likely to be more successful the smaller is the number of potentially endogenous variables. I therefore propose two sets of educational attainment variables are used: a continuous measure, where school attainment has been converted into years of schooling and a binary measure, which is one if the mother has continued porimary or higher and zero otherwise. Adult literacy course participation is a binary measure, stating whether an individual has ever attended an adult literacy course program. A problem with this, of course, is that the time of participation is unknown. An individual may just have started attending a class, for example, in which case the impact from the program will not have fully kicked in yet. Any impact from adult literacy course participation, therefore, is likely to be downward biased. Also, the quality and content of adult literacy programs may vary across time or across areas, since these programs are—and for a long time have been—offered by many different providers, including several different NGOs and the government. There is only information on whether or not an individual participated, however, and not on who the provider was.

Economic variables

The information on wages and earnings in the GLSS 4 is riddled with many zeros. For example, of the 4,802 mothers in the sub-sample for the vaccination analyses (the largest of the four sub-samples) almost 30 percent report zero earnings. Examining this a bit further by cross-validating with these mothers' responses to the labor module of the survey, these zeros are genuine in the sense that the overwhelming majority of these mothers, 99.7 percent, report not having done work in the past 12 months for which a wage or any other payment was received. Even though the zero earnings responses are genuine it still seems problematic to include them in the estimations, since the earnings distribution is so heavily skewed towards zero. I therefore run a Heckman selection model for (the log of) mother's (daily) earnings, using as identifying instruments marital status and the number of children born. For mothers where the observed wage rate is zero, the predicted wage rate is then imputed. The motivation for including this (somewhat imprecisely measured) variable is to obtain a measure of the opportunity cost of the mother's time. Also, if a mother faces a higher (potential) wage rate, she would seem to have relatively more bargaining power within the household, controlling for other factors, which in turn should affect the demand for child health related items in the household's consumption basket.

Additionally, geographical variables (rural-urban location and region of residence) capture economic conditions specific to the area (as well as everything else related to rural-urban residence or the region in question). While these variables may confound different factors, which exert possibly opposing influences on child health demand, I am not after pinning down the impact of these variables per se but rather want to make sure to control for as many factors as possible in order to render the impact estimates of the primary variables of interest, mothers' skills and schooling, valid.

Access to facilities and cost of health services

While these variables are mainly included so as to ensure valid inference on impacts from the variables of primary interest, namely mothers' skills, schooling and adult literacy course participation, their construction is a bit tricky and therefore require somewhat detailed explanations as compared to what one might first think is warranted.

The natural first point when discussing the construction of community level health variables would seem to be the community questionnaire. However, although the community questionnaire contains fairly detailed information on availability of health personnel and facilities in the community,[11] there are several reasons to turn to the household survey for community level health information. First, in the community questionnaire there is no information on prices of services (and in the price questionnaire there is only limited information on health related items, such as aspirin, paracetamol and penicillin), so that the household part of

[11] This includes information on which types of facilities and health personnel are available in the community as well as the distance both in terms of physical distance and travel time. Facilities include hospitals, drugstore/chemical store, pharmacy, maternity home, clinic or health post and family planning clinic, while health personnel include doctor, nurse, pharmacist, trained midwife, family planning worker, community health worker, traditional birth attendant, traditional healer and medical assistant.

the GLSS 4 would have to be consulted for that information, anyway. Second, due to the difficulty of defining communities in urban areas, the community questionnaire was only administered in rural areas. Using the information from the community questionnaire, therefore, automatically decreases the effective estimation samples substantially. I therefore construct community health information on facility availability and prices of services using the information on actual usage of health services from the household survey.

Specifically, questions asked include whether an individual consulted a health practitioner or dentist or visited a health center or consulted a traditional healer during the past two weeks, type of health practitioner (traditional healer, doctor, dentist, nurse, and so on) and type of facility (hospital, dispensary, pharmacy, clinic, and so on). On the cost side, there is information on the fee paid for the last vaccination given to a child. For children, who has been taken for postnatal care during the past 12 months there is information on whether or not there was a fee and, if so, how much is usually paid for one consultation. Additionally, for women who were pregnant during the past 12 months and received any pre-natal care during this pregnancy, there is information on how much was paid for the first consultation.

This information may be used to create variables for access to and prices of health care services in the community in a way such that these variables, by construction, are exogenous to the individual even though they are based on information of actual usage. Specifically, based on the responses from individuals who has consulted a health practitioner within the past two weeks, I create a binary access variable defined as one if at least one individual in the community (child or adult) has attended a health practitioner at a hospital and zero otherwise. Similarly, consultation cost may be constructed as the average cost for the given type of service. Missing observations quickly become an issue here, however, so I focus only at a few prices: cost of pre-and postnatal care consultations and vaccinations. To ensure exogeneity of the access and price variables I calculate these variables for each household separately, leaving out the contribution of the individual household from the calculations.

An important issue in these calculations is the level of aggregation. The sample contains 300 enumeration areas (clusters), covering 101 of the 110 districts in Ghana, both of which may be further divided into either one of the three ecological zones (Coastal, Forest and Savannah) or rural-urban location. In principle, community averages could be calculated at a level of aggregation according to either of these variables (or combinations of these variables). However, the calculations face an obvious trade-off between including more observations in the analysis and losing variation in the calculated community access or price variable. Since these variables are only of secondary importance and so as to include as many observations as possible, thereby possibly increasing the precision in the estimates of the parameters of particular interest, namely mother's skills, schooling and adult literacy participation, I chose the district level as the level of aggregation in the construction of these variables. In sum, the community level information constructed includes availability of hospital and cost of vaccinations, pre- and postnatal care. The resulting variables are based on an average number of observations per district of 10.4 (access to hospital), 13.5 (vaccination cost), 15.1 (cost of postnatal consultation) and 9.3 (cost of prenatal consultation) but with a somewhat wide range. For example, the minimum number of observations on postnatal consultation cost per district is 1, while the maximum number of observations is 100. While the range of the number of observations for the other measures is not quite as extreme, they all have at least one district with only one observation. The typical number of observations per district across the measures is about 8 or 9. While these measures are clearly prone to criticism in terms of their precision (or lack thereof), they are not essential to the subsequent analysis but mainly included as additional controls so as to increase the validity of the inference from the skills and schooling variables.

Other variables related to child health inputs and outcomes

Other variables related to child health inputs and outcomes not already captured by the previous groupings include the age of the mother and the child, the number of other adults and children in the household, water source and type of sanitation of the household.

The birth cohort of the mother proxies the potential general experience of the mother, while the age of the child proxies the needs of the child (the latter is only available for the vaccinations and postnatal care samples, however, since the mortality and prenatal care samples are at the level of the mother). For example, vaccinations are more needed at the earlier ages (and also mostly administered to young children, say, below age three). Both of these are entered with a linear and a quadratic term to allow for non-linearities. The number of other adults (than the mother) and other children (than the child in question) indicates availability of time resources for child care, while the latter at the same time also indicates needs in terms of other children in the household.

In addition to these other variables related to the health inputs and outcomes the household survey includes information on the source of drinking water (indoor plumbing, public standpipe, rainwater, and so on) and type of toilet (flush toilet, pit latrine, and so on). This information is particularly relevant when examining mortality determinants. For example, diarrhea, which has been estimated by the World Health Organization to kill about 2.2. million people each year, mainly children in developing countries,[12] is thought to be caused mainly by contaminated water. The contamination may be caused by human faeces from municipal sewage, septic tanks and

[12] http://www.who.int/water_sanitation_health/diseases/diarrhoea/en/

latrines, for example. It is more common when there is a shortage of clean water for drinking, cooking and cleaning. To capture these factors, I create a binary variable for whether the household has access to piped water and whether the household has a flush toilet.

Lastly, ethnicity/tribal association, rural-urban location and region of residence may capture the taste for child health within the tribal culture and/or the culture of the local community. At the same time, however, these variables confound cultural factors with the economic conditions and experiences of different ethnicities and between different geographical locations. Again, since I am mainly interested in ensuring that valid estimates may be obtained for the skills and schooling variables and not in distinguishing between the relative impacts of cultural and economic factors per se, the issue of confoundedness as it relates to these variables is not critical to the analyses in this paper.

Sample restrictions

As was also apparent from the previous discussion on child health outcome variables, the way the questions pertaining to child health outcomes were administered in the survey implicitly gives some of the sample restrictions, while others are to be chosen. When analyzing the determinants of ever being vaccinated and ever received post-natal care, the samples are therefore restricted to children in the relevant age ranges (vaccinations: 7 years of age or younger; post-natal care: 5 years of age or younger). When analyzing the determinants of pre-natal care, the sample is restricted to women between the ages of 15 and 49 who were pregnant within the past 12 months, while the determinants of child mortality is examined for all women between the ages of 15 and 49 years of age. To ensure consistency between the different sub-analyses, the estimations involving vaccinations and post-natal care are restricted to children for whom the mother is between the ages of 15 and 49.

Moving to the explanatory variables, mothers should have had a chance to complete primary schooling, while at the same time being eligible for participation in adult literacy programs (the lower limit). Also, individuals should not be "too old", since then measurement issues start to kick in more (upper limit). Restricting the sample to women between the ages of 15 and 49 therefore remains a reasonable strategy. Lastly, some explanatory variables are missing for some observations, which causes a further drop in the sample sizes. The drop in sample size when moving to the effective sample size is never more than 0.61 percent, however. Table 5.3 summarizes the sample restrictions and the impact on the estimation sample sizes for the various analyses.

Table 5.3 Sample Restrictions and Impact on Estimation Sample Sizes

Sub-analysis	Sample	Initial sample	Estimation sample	Decrease (%)
(1) Vaccinations	Children 0-7 years	4827	4802	0.52
(2) Mortality	Females, 15-49 years	1155	1148	0.61
(3) Prenatal care	Females, 15-49 years, who were pregnant in past 12 months	3615	3601	0.39
(4) Postnatal care	Children 0-5 years	4208	4193	0.36

Notes: Initial sample is sample, for which information on the dependent variable is available and the mother is between 15 and 49 years old. Estimation sample is sample where all explanatory variables are available.

6. Results

As discussed previously I adopt an IV (2SLS) estimation strategy to take the potential endogeneity of skills, schooling and adult literacy participation into account. Additionally, OLS results are offered as the consistent alternative to IV, should the assumptions underlying this method not be satisfied. For each health measure, models are estimated in two flavors, one with a continuous measure of schooling and one with a binary measure for completion of primary education or higher (except, of course, for the sub-sample of mothers with no formal education).

Additionally, the underlying survey design is incorporated by applying sampling weights and adjusting for the clustering of observations in the estimations. Failing to do so, that is, assuming identically distributed random sampling, could potentially lead to biased results for the population by either obtaining "wrong" point estimates (if not applying weights) and/or "wrong" standard errors (if not incorporating clustering, although standard errors also may be affected by failing to incorporate the sampling weights). In particular, one would likely obtain standard errors that are far too low compared to what they "should" be (for the population), thus failing to to reject the null hypothesis of no association too often.

The first step when applying IV methods is to assess the explanatory power of the instruments from the first stage regressions (in the 2SLS framework). This is done in terms of F-tests of the joint significance of the identifying instruments, the results of which are shown in Table 6.1. On the grounds of these results, the instruments appear to be highly correlated with the potentially endogenous variables for all sub-samples. The relatively weakest results are obtained for literacy course participation for the mortality analyses (full sample and rural samples), where the F-test statistics are considerably lower than the other F-test statistics (except for the one from the prenatal care analyses). However, the test still passes at a 1 percent level of significance and so indicates that the explanatory power is high enough so as to justify their inclusion in these analyses, also. Moving to the results from the second stage for the full sample, the results indicate no separate impact from literacy and numeracy skills once formal schooling and adult literacy course participation are controlled for (see Table 6.2). Formal education affects vaccinations positively significantly for the binary schooling measure, while years of schooling has a negative and statistically significant impact on mortality. Adult literacy course participation only affects the demand for postnatal care but it does so for both flavors of the model and is also of a sizeable magnitude, the impact estimate being almost 55 percent. In turn this indicates an impact of health knowledge—which is an integral part of the adult literacy course curriculum in Ghana (Blunch and Pörtner, 2004)—on individual health seeking behavior in terms of demand for postnatal care. Again, had only formal educational attainment been included in the analyses, this important channel of health knowledge diffusion would have been overlooked. Turning to the OLS results, both the impact of formal schooling and of adult literacy course participation comes out stronger in terms of the number of statistically significant coefficients, although the estimated impacts are smaller than the corresponding IV estimates (except for the specification using years of schooling for vaccination, where the estimate for adult literacy course participation is smaller by 0.001 percentage-point). For postnatal care, for example, the impact estimate for adult literacy course participation drops from about 54 percent to being about 9 percent. This is still a substantial impact, however.

[Continue analyses write-up]

Table 6.1 F-tests for Exclusion of Identifying Instruments from First-Stage Regressions, 2SLS.

	Vaccinations	*Prenatal care*	*Postnatal care*	*Mortality*
Full sample:	F(77, 298) =	F(66, 281) =	F(75, 297) =	F(79, 299) =
Skills	11.04***	6.71***	10.60***	14.96***
Literacy course	27.37***	39.26***	31.09***	2.51***
Schooling, cont.	6.07***	9.59***	6.68***	5.58***
Schooling, binary	11.13***	15.37***	6.91***	7.80***
Number of observations	4802	1148	3601	4193
Rural sub-sample:	F(75, 189) =	F(61, 181) =	F(73, 189) =	F(78, 189) =
Skills	27.41***	10.83***	26.25***	73.60***
Literacy course	53.32***	46.68***	39.49***	3.69***
Schooling, cont.	18.23***	12.24***	25.75***	19.78***
Schooling, binary	25.14***	21.46***	26.44***	27.58***
Number of observations	3480	807	2647	2782
Mothers with no formal education:	F(75, 268) =	F(63, 210) =	F(74, 265) =	F(78, 286) =
Skills	1131.79***	0.83	1261.78***	1501.81***
Literacy course	14.44***	29.89***	14.13***	32.93***
Number of observations	2647	575	2018	2064

Notes: ***: statistically significant at 1 percent

Table 6.2 Results for Skills and Schooling Variables, Full Sample

	Vaccinations		*Prenatal care*		*Postnatal care*		*Mortality*	
	Spec 1	Spec 2	Spec 1	Spec 2	Spec 1	Spec 2	Spec 1	Spec 2
IV (2SLS):								
Literacy and numeracy	0.051	0.022	-0.046	0.040	0.087	0.113	-0.090	-0.188
	[0.096]	[0.088]	[0.131]	[0.120]	[0.192]	[0.165]	[0.164]	[0.132]
Literacy course	0.048	0.050	-0.037	-0.064	0.539***	0.549***	-0.285	-0.274
	[0.065]	[0.065]	[0.185]	[0.182]	[0.175]	[0.174]	[0.210]	[0.202]
Years of schooling	0.009		0.019		0.013		-0.030*	
	[0.008]		[0.012]		[0.021]		[0.017]	
Primary and above		0.144*		0.056		0.101		-0.195
		[0.076]		[0.098]		[0.162]		[0.139]
OLS:								
Literacy and numeracy	0.009	0.016	0.015	0.0001	-0.003	0.010	-0.044	-0.064**
	[0.013]	[0.013]	[0.035]	[0.035]	[0.034]	[0.033]	[0.030]	[0.027]
Literacy course	0.049***	0.047***	0.032	0.035	0.093***	0.092***	0.035	0.038
	[0.015]	[0.015]	[0.050]	[0.049]	[0.035]	[0.035]	[0.037]	[0.037]
Years of schooling	0.004***		0.004		0.001		-0.009***	
	[0.001]		[0.003]		[0.004]		[0.003]	
Primary and above		0.029**		0.064*		-0.009		-0.067**
		[0.013]		[0.033]		[0.031]		[0.027]
Specification tests:								
Hansen (1982) J-test for overidentification:	$\chi^2(74)$ =		$\chi^2(63)$ =		$\chi^2(72)$ =		$\chi^2(76)$ =	
Years of schooling	69.01 [0.642]		65.66 [0.385]		74.13 [0.409]		81.91 [0.301]	
Primary and above	70.15 [0.605]		3831.34 [0.000]		73.94 [0.415]		83.61 [0.257]	
Wu (1973)-Hausman (1978) endogeneity test:	F(3, 298) =		F(3, 281) =		F (3, 297) =		F(3, 299) =	
Years of schooling	1.01 [0.389]		0.69 [0.562]		3.78** [0.011]		3.53** [0.015]	
Primary and above	1.70 [0.166]		0.13 [0.942]		3.88*** [0.010]		3.16** [0.025]	
Number of observations	4802		1148		3601		4193	

Notes: Robust Huber-White Sandwich (Huber, 1967; White, 1980) standard errors in brackets under parameter estimates. Terms in brackets for specification tests are the p-values of the corresponding test-statistic. Test hypotheses are as follows. Hansen's (1982) J-test for overidentification; H_0: The instruments are uncorrelated with the error term *and* are correctly excluded from the main (i.e. stage two) regression, H_1: The instruments are correlated with the error term *or* are incorrectly excluded from the main (i.e. stage two) regression. Wu (1973)-Hausman (1978) endogeneity test; H_0: Accept exogeneity, i.e. OLS should be employed, H_1: Reject exogeneity, i.e. IV should be employed. *: statistically significant at 10 percent; **: statistically significant at 5 percent; ***: statistically significant at 1 percent.

Table 6.3 Results for Skills and Schooling Variables, Sub-sample for Rural Areas

	Vaccinations		*Prenatal care*		*Postnatal care*		*Mortality*	
	Spec 1	Spec 2	Spec 1	Spec 2	Spec 1	Spec 2	Spec 1	Spec 2
IV (2SLS):								
Literacy and numeracy	0.024	0.093	-0.071	-0.032	-0.071	0.020	-0.350***	-0.280***
	[0.113]	[0.099]	[0.109]	[0.102]	[0.213]	[0.191]	[0.123]	[0.098]
Literacy course	0.146*	0.122	-0.107	-0.120	0.364**	0.342**	-0.387**	-0.414**
	[0.083]	[0.077]	[0.219]	[0.213]	[0.170]	[0.167]	[0.194]	[0.193]
Years of schooling	0.028*		0.018		0.033		0.006	
	[0.015]		[0.013]		[0.024]		[0.019]	
Primary and above		0.183*		0.121		0.196		-0.064
		[0.099]		[0.102]		[0.162]		[0.137]
OLS:								
Literacy and numeracy	0.013	0.026	0.005	0.003	0.014	0.004	-0.069	-0.088**
	[0.018]	[0.018]	[0.043]	[0.045]	[0.047]	[0.042]	[0.044]	[0.035]
Literacy course	0.060***	0.058***	0.014	0.014	0.068*	0.069**	0.003	0.006
	[0.018]	[0.017]	[0.061]	[0.061]	[0.035]	[0.035]	[0.038]	[0.037]
Years of schooling	0.006***		0.007		-0.002		-0.007*	
	[0.002]		[0.005]		[0.005]		[0.004]	
Primary and above		0.038**		0.069		-0.006		-0.047
		[0.016]		[0.043]		[0.039]		[0.035]
Specification tests:								
Hansen (1982) J-test for overidentification:	$\chi^2(72)$ =		$\chi^2(58)$ =		$\chi^2(70)$ =		$\chi^2(75)$ =	
Years of schooling	66.16 [0.672]		64.09 [0.271]		60.37 [0.787]		76.92 [0.417]	
Primary and above	66.73 [0.653]		64.74 [0.253]		61.88 [0.745]		77.48 [0.400]	
Wu (1973)-Hausman (1978) endogeneity test:	F(3, 189) =		F(3, 181) =		F(3, 189) =		F(3, 189) =	
Years of schooling	1.98 [0.119]		0.45 [0.718]		2.22* [0.087]		4.28*** [0.006]	
Primary and above	1.96 [0.122]		0.25 [0.863]		2.06 [0.107]		3.71** [0.013]	
Number of observations	3480		807		2647		2782	

Notes: Robust Huber-White Sandwich (Huber, 1967; White, 1980) standard errors in brackets under parameter estimates. Terms in brackets for specification tests are the p-values of the corresponding test-statistic. Test hypotheses are as follows. Hansen's (1982) J-test for overidentification; H_0: The instruments are uncorrelated with the error term *and* are correctly excluded from the main (i.e. stage two) regression, H_1: The instruments are correlated with the error term *or* are incorrectly excluded from the main (i.e. stage two) regression. Wu (1973)-Hausman (1978) endogeneity test; H_0: Accept exogeneity, i.e. OLS should be employed, H_1: Reject exogeneity, i.e. IV should be employed. *: statistically significant at 10 percent; **: statistically significant at 5 percent; ***: statistically significant at 1 percent.

Table 6.4 Results for Skills and Schooling Variables, Sub-sample for Mothers with No Formal Education

	Vaccinations	*Prenatal care*	*Postnatal care*	*Mortality*
IV (2SLS):				
Literacy and numeracy	-0.141	-0.012	0.598*	-0.513
	[0.212]	[0.326]	[0.318]	[0.402]
Literacy course	0.173**	-0.047	0.390**	-0.111
	[0.072]	[0.204]	[0.158]	[0.179]
OLS:				
Literacy and numeracy	0.002	0.040	-0.092	0.025
	[0.043]	[0.120]	[0.088]	[0.084]
Literacy course	0.073***	0.003	0.109***	0.002
	[0.016]	[0.071]	[0.038]	[0.046]
Specification tests:				
Hansen (1982) J-test for overidentification:	$\chi^2(73)$ =	$\chi^2(61)$ =	$\chi^2(72)$ =	$\chi^2(76)$ =
Years of schooling	71.20 [0.538]	68.45 [0.239]	62.52 [0.780]	70.93 [0.643]
Wu (1973)-Hausman (1978) endogeneity test:	F(2, 268) =	F(2, 210) =	F(2, 265) =	F(2, 286) =
	1.46 [0.235]	0.04 [0.959]	5.18*** [0.006]	1.41 [0.247]
Number of observations	2647	575	2018	2064

Notes: Robust Huber-White Sandwich (Huber, 1967; White, 1980) standard errors in brackets under parameter estimates. Terms in brackets for specification tests are the p-values of the corresponding test-statistic. Test hypotheses are as follows. Hansen's (1982) J-test for overidentification; H_0: The instruments are uncorrelated with the error term *and* are correctly excluded from the main (i.e. stage two) regression, H_1: The instruments are correlated with the error term *or* are incorrectly excluded from the main (i.e. stage two) regression. Wu (1973)-Hausman (1978) endogeneity test; H_0: Accept exogeneity, i.e. OLS should be employed, H_1: Reject exogeneity, i.e. IV should be employed. *: statistically significant at 10 percent; **: statistically significant at 5 percent; ***: statistically significant at 1 percent.

7. Conclusion

This paper examines the relationship between mothers' literacy and numeracy skills, formal education and adult literacy course participation and child health in Ghana. It does so attempting to look into the "black box" of education, viewing the accumulation of human capital as a two-pronged production process, where schooling produces skills, which subsequently enters as inputs (or intermediate outputs) to create demand for child health inputs and final child health outcomes. The health measures examined include child vaccinations, pre- and postnatal care and child mortality. The contribution of this paper includes (1) analyzing the impact on child health from skills, including reading and writing skills and that for both English and indigenous languages, as well as numeracy skills and health knowledge and (2) including adult literacy course participation as a pathway of achieving skills, two issues which have not been addressed in the previous literature. It considers how these skills affect the production of health, including mothers' pre-natal care and children's vaccinations and post-natal care, and how they affect that most crucial of child health outputs, child mortality. The estimation strategy includes both exogenous (OLS) specifications and IV-based (2SLS) specifications, where the latter allows for mothers skills, schooling and adult literacy course participation to be endogenous.

The results indicate that literacy and numeracy skills are largely not important once schooling is controlled for but at the same time also reveal a positive association between adult literacy course participation and child health. The latter points towards the potentially important role of adult literacy programs in promoting child health by the acquisition of health knowledge by participants, something which has previously received little to no attention in the economics literature but has important policy implications. If mothers achieve significant health knowledge through participation in adult literacy programs—which typically are of a duration of about 21 months with maybe two or three weekly meetings, each of a few hours duration—this points towards further strengthening and promotion of these programs as a potentially important priority for future education policy in Ghana.

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