Determinants of Child Malnutrition in Senegal: Individual, Household, Community Variables, and their Interaction

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Abstract

The relationship between poverty and nutrition is a two-sided one: on the one hand, economic growth (which is generally associated with an eradication of poverty) leads to reduced malnutrition. On the other hand, nutrition is one of the key ingredients for human capital, which in turn represents one of the fundamental factors of growth.

There are numerous studies that show the correlates of malnutrition using both household and community level variables. However, few of these studies test for the potential endogeneity of community infrastructure or indicate their interplay with characteristics of the mother. The current study looks at the socioeconomic determinants of child malnutrition at the individual and the household level, and investigates how programs compensate for the increased risks facing young mothers and their children or substitute for a low social standing of the mother in the household.

The empirical results show that mothers' education and access to clean drinking water are important determinants of the nutritional status of children. Children of mothers giving birth at a young age are disadvantaged in terms of their anthropometric status. Weak social status of young mothers in the household measured by a large age difference to the household head has a significant impact on child health when taking interactions of this characteristic with community infrastructure into account. The interaction effects of the presence of a NGO or a health post in the village with young age of the mother and her social status stress the important role played by these institutions in helping disadvantaged mothers overcome their difficulties. These findings bear important policy implications and represent a further step towards gaining an improved understanding of the complex determinants of child (mal)nutrition.

Keywords: nutrition, height, weight, anthropometry, Senegal

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1. Introduction

It has long been recognized that the well-being of a population is not solely captured by measures of consumption and income. Social indicators such as life expectancy, health, and education serve an important complementary function, although these dimensions of well-being are often difficult to measure. Malnutrition in children leads to permanent effects and to their having diminished health capital as adults (Strauss and Thomas, 1998; Alderman, Hoddinott, and Kinsey, 2006). Thus, an intergenerational cycle may commence: a worse health capital stock may be passed on from adults to their children. Thomas and Frankenberg (2002) argue that there is ample evidence at the macroeconomic as well as the microeconomic level that health is positively associated with other dimensions of economic prosperity, and that causality goes both directions: people with higher income invest more in their human capital and hence health, while healthier workers tend to be more productive and achieve higher earnings. Such considerations are not new, as the efficiency theory of wages, which presents one aspect of the transmission mechanism, goes back at least to Leibenstein (1957).

Few papers in the literature on the determinants of malnutrition in children have investigated the interactions between determinants at the individual level, such as child and mother's characteristics, and community services such as the presence of an NGO or a health post in a village. Ignoring such effects can be problematic as it may lead to effects being averaged over different population groups. In this case, the total observed effect may be close to zero despite group-specific effects that are statistically significant and sizable. Moreover, if there are interaction effects that are either negative (indicating a substitution effect between the two variables concerned) or positive (pointing towards a complementarity of the two variables involved), programs may be designed to better target services and to offset limitations.

Papers that investigate interaction effects between community variables and variables at the individual or household level go back to Caldwell (1979) who studies the determinants of child mortality in Nigeria and finds a complementary relationship between maternal education and health services. In contrast, Rosenzweig and Schultz (1982) argue for substitutability between education and availability of a health facility in a village as they believe that such services would narrow the educational differences in utilization behavior. A paper that has reached seminal status is Barrera (1990), who finds a substitutive relationship of mother's education with community cleanliness and water connection in the Philippines, but a complementarity of maternal education and toilet connections as well as with health care facilities.[1]

This paper investigates the impact of NGO services and public clinics in Senegal as well as their interaction with characteristics of the mother in the communities where these are available for outcomes in terms of nutritional status. We also look at the social status of the mother within the household as an explanatory variable, as in bargaining models of household decisions a weak social standing may not only lead to reduced health stock of the mother that is then passed on to her child, but may also affect the food allocation to the child directly in a negative way (Smith et al., 2003, p.23; Strauss, 1990).

The remainder of the paper is structured as follows. Section two describes the theoretical model underlying the empirical analysis, in section three the empirical specification is presented and the variables used are discussed. Section four describes the data, followed by the empirical results in section five. Section six concludes.

2. The Model

Health or anthropometric production functions relating child height or child weight to biological correlates have been studied extensively in the economics literature (Grossman 1999). The stock of health capital can be seen as given by

$$(1) \qquad H_{t+1} = H_t(1-d_t) + I_t(M_t, T_t; E_t)$$

where H stands for the health capital stock at time t, d signifies the depreciation rate, and I denotes the gross investment as a function of a vector of input goods M and time inputs T, conditional on the agent's stock of knowledge E concerning health capital.

From an econometric point of view, the estimation of this or similar production functions specifications is problematic as inputs are endogenously chosen. That is, the level of inputs or the utilization of services is likely to be determined at the same time with the anthropometric outcome. In order to avoid simultaneity problems of this kind, one would have to find appropriate instruments for these choice variables. This is not a trivial undertaking.

The approach taken by many studies is to include a form of the above health production function into a framework depicting households as intertemporally utility-maximizing entities in order to arrive at reduced form equations that are functions of exogenous variables only, allowing the investigation of effects of exogenous changes in the socioeconomic environment of the households on nutrition outcomes. The model frequently used in this literature, based on Becker (1981), assumes that parents have identical preferences that are intertemporally separable and exhibit a per-period subutiliy function that is quasi-concave in its arguments, notably consumption, the leisure of the household members, as well as health (including height and weight) and number of children. The optimization problem then consists of the parent's utility function, the health production function presented above, and a budget constraint for each period. The solution to this maximization problem can be expressed as a reduced-form equation of nutrition demand of the parents for their children that is a function of exogenous variables *Z* at the level of the individual *i*, the household *h*¸ the community *c*, and non-wage income *y* only, where these terms can also enter multiplicatively, i.e. as interaction terms:

(2) $H_t = g_t\,(Z_i, Z_h\,, y\,, Z_c\,, \varepsilon_i),$

where the community variables now act through their direct impact as well as through their effects on the inputs *M*. The unobserved child heterogeneity ε_i is assumed to be uncorrelated with the other elements of *g*. In this formulation, health (or nutritional status) is a function of the health stock in the previous period, and correspondingly, all health inputs since the birth of the child.

The estimation of reduced form equations similar to equation (2) has been the object of current studies on the determinants of child nutrition such as the papers in the symposium presented by Behrman and Skoufias (2004). While in principle this type of reduced form model could be estimated with wages and non-wage income on the right hand side, such models are often estimated as conditional on income or expenditures.[2] Alternatively, the reduced form estimates can include the household's asset stock. This approach is followed below[3].

3. Variable definitions and empirical specification

For ease of exposition, we write the empirical specification of the model developed in the previous section in linear form:

$$(3) \qquad H_i = Z\beta + \varepsilon_i \,,$$

where H_i is a vector of anthropometric measures of the child under consideration, Z is a vector of covariates $\{z_i, z_h, z_c\}$ at the individual-, household-, and community level, respectively, and ε_i is an error term with zero mean. We will now turn our attention to the variables entering this equation.

Anthropometric measures

The health status H can be captured by different variables, which are typically either self-reported, subjective measures, or objective measures such as height, weight, or body mass index (Falkner and Tanner, 1986). We focus here on two commonly used measures of long-term nutritional status, height for age as well as weight for age (Trapp and Menken, 2005). The latter largely reflects the same processes as those which determine height for age but also is influenced by recent phenomena. In contrast, a commonly used measure for clinical assessment, weight for height, is more indicative of short term conditions; as most regressors in cross sectional studies are stock rather than flow variables it is generally not practical to study this variable with such data (Alderman, 2000).

Concerning the explanatory variables, we include factors at the level of the individual, the household, as well as the community, as laid out in the theoretical as well as the empirical model above.

Variables at the level of the child

Child characteristics included are child age, expressed in six-month brackets, with the base group being children 0-5 months of age in order to accommodate well known age-specific patterns in nutritional status (Shrimpton et al., 2001). Sex of the child is included as well as the status of being a twin, as twins frequently show lower birth weight (Hatkar and Bhide, 1999).

Variables at the household level

Characteristics of the mother included in the regression are a dummy variable for whether the mother was younger than 21 years of age at time of birth of the child. Adolescent mothers typically have higher risks of poor pregnancy outcomes (for the medical literature on this issue see Conde-Agudelo et al., 2004; Gilbert et al., 2004; Fraser et al., 1995). While age may reflect biological factors it also reflects socioeconomic considerations including standing in the household hierarchy. According to the bargaining literature on household decisions, status could influence those resources that the mother may receive for herself as well as for her child, possibly leading to adverse nutrition consequences (Smith et al., 2003). We address this possibility by including a binary variable indicating a large age difference (set at 20 years or more) of the mother relative to the head of the household.

Education of the mother is included as a categorical variable indicating whether the mother has primary, or secondary or higher education, with mothers with less than primary education representing the control group (the effect of secondary education is measured separately from that of primary education and is not to be interpreted as an additional effect). The same education variables are included to control for the schooling status of the husband. In both cases the education variable will indicate the role of education on income as well as the role of information access. As education of spouses is likely to be highly correlated, exclusion of the education of either parent is likely to bias the coefficient of the included education upwards. We also include a dummy variable indicating missing observations for the husband's education, as this was the case for about 5% of the observations.

Non-labor household income is proxied by a wealth index derived using principal component analysis, following the approach of Filmer and Pritchett (1998)[4]. Other household variables that may exert an influence on child anthropometrics are the presence of a water toilet in the house as well as the availability of running water in the household. We also indicate the effect of household size on children's z-scores. However, the variable may not be truly exogenous as there may be a trade-off between the quality and quantity of children. To the degree that women have access to effective birth control, birth spacing and household size is determined by the mother or the family. Where family planning is not so wide-spread these variables have a more exogenous character[5]. However, as it is difficult to find acceptable instruments to address this possible simultaneity, the results presented below include household size, while we note if the inclusion of this variable has an effect on the estimation of the other coefficients.

Variables at the community level

The model includes a dummy variable to indicate the presence of a non-governmental organization (NGO) in the village, while for a second specification we only look at those NGOs offering services such as sanitation, nutrition, and alphabetization of mothers and children that are likely to improve nutrition outcomes. A second dummy variable stands for the availability of a public health facility in the village. As the data does not indicate actual take-up of these facilities, our analysis is limited to the presence of the facilities rather than their utilization. However, an argument advanced by Strauss (1990) is that availability is preferable to actual take-up of community services as the latter reflects household choice and would then have to be treated as an endogenous variable.

One issue that poses potential endogeneity problems in this study is that NGOs and public hospitals might not be placed randomly in the villages, which would lead to biased estimates of the associated coefficients. Placement of both health facilities and NGOs can either reflect need or unknown (to the researcher) potential for a favorable impact, and the results might be biased by such selective placement. Even the sign of such a bias is unknown (Pitt, Rosenzweig, and Gibbons, 1995). If such health facilities were placed in areas where population health was poorest, the impact of the facilities would exhibit a downward bias. A positive bias is also plausible since facilities might be placed in more accessible and more prosperous areas. In the analysis below, we present in a first step OLS regressions including community variables, while we test for endogeneity of NGO and health facility placement by using variables at the community level that are argued to exert an influence on placement of these facilities but do not exercise a direct effect on child nutritional status after the other variables are controlled for, i.e. serve as valid instruments. We use similar instruments to those in Alderman, Hoogeveen, and Rossi (2006), one of the few studies that addresses the potential endogeneity of community services. Although the instruments of mean village wealth level, quality of the road and the distance to the next village, the presence of a market and a weekly market likely influence placement, they may also have a direct impact on child nutritional status. The results for these instrumented regressions therefore have to be interpreted with caution. However, even if placement is not random, the difference in the response among different groups within the community affords a glimpse at the *relative* impact of these services.

Interaction terms

The variables used in the literature indicating whether services substitute or complement human capital are mainly related to the education status of the mother as well as the household wealth level, as these two variables may influence the degree to which mothers can take advantage of public services available. In the analysis below, we look at two further characteristics of mothers that may have an impact on their ability to use community services. We interact the status of being a mother of less than 20 years of age when giving birth with the presence of a health facility or a NGO in the village in order to test whether community-level facilities can serve the role of alleviating potentially negative effects these women suffer due to their young age. We also interact the presence of these institutions with the social status of the mother as proxied by her showing a large age difference to the head of household, as this variable on the one hand may have an impact on child nutritional status while on the other hand such disadvantaged mothers may benefit relatively more from community services, in particular if they are targeted at them.

4. Data description

The data underlying the analysis represent the baseline survey for a nutrition intervention program conducted in the regions of Fatick, Kaoloack, and Kolda in Senegal in early 2004. The aim of the study was to determine the prevalence of malnutrition of children aged 0-35 months in treatment as well as control villages, the former of which receive nutrition intervention and counseling preceding wave 2 of the study that is currently being implemented. Data from 211 villages were collected and include information on 4319 households and 4966 children. 2851 households have a mother with a child of 35 months of age or less, leading to a sample of 4296 children of 4174 different mothers for analysis.[6]

The indicators of nutritional status are expressed in "z-scores" which are derived by comparing the child's height and weight with that of a "reference" group of well nourished children (WHO, 1995)[7]. More specifically the stunting z-score is the difference (expressed in standard deviations) of a child's height for age from the median height of children of the same age and sex in the reference population. When working with z-scores, it is important to consider the issue of cut-offs points, i.e. which observations to exclude from the analysis that stem from wrong measurements or erroneous data entry, as outliers can influence the estimation results in a non-trivial way. The World Health Organization (WHO) has defined two different types of limits for acceptable data: on the one hand, it suggests a flexible exclusion range, defined as +/- 4 z-score units from the observed mean z-score, but with a maximum height-for-age z-score of +3.0. The other recommended filter is a fixed restriction range for observations with a mean z-score of higher than -1.5, and bounded by a lower value of -5.0 for both weight-for-age and height-for-age, and an upper bound of +3.0 for height-for-age, and 5.0 for weight-for-age. Given that the mean values for the data at hand are -1.35 for weight-for-age and -1.05 for height-for-age, we make use of the second definition established by the WHO in the analysis to follow.

In Appendix 1, the means and standard deviations of the key variables used in the regressions are presented. The children in the sample are relatively evenly distributed over the six month – age groups. Slightly fewer than 3% of them are twins. About 12% of children show a weight-for-age z-score below -3 standard deviations, which according to the WHO is a sign of severe malnutrition, and over 30% of children in the sample show a z-score of lower than -2, compared to a national prevalence of this measure of about 22% (DHS 1992). Slightly less than one fourth of mothers were 20 years or younger at birth, and about two-thirds reside in a household where the household head is more than 20 years their elder. The education status is very low for both sexes with less than 15% of men and women having obtained at least primary education. Secondary or higher education is rare; only 2% of the women and 7% of the men show such an education level. Slightly over one third of the households in the sample have access to tap water, while only 12% of households can use a water toilet. In the sample, about 40 percent of the villages host a NGO offering services likely to improve nutrition outcomes, and slightly more than 30% have a health post in the village.

Figure 1 indicates that current child nutritional status increases with the age of the mother at the time of birth up to approximately 20 year of age. The graph excludes foster children and children of mothers older than fifty years of age. As we do not have the birth weight of the child it is not possible to separate out the effects of the biology of adolescence in utero from subsequent child care since a young mother at birth is also likely to be relatively inexperienced in child rearing. An additional factor that could contribute to the anthropometric status of children born to young mothers is that these mothers may be at a disadvantage regarding their social status in the household, potentially translating into a weak bargaining position over scarce household resources.

5. Results

Table 1 presents the results of regressions for height for age that include the main individual and household determinants of nutritional status along with community variables. Similar regressions can be found for weight for age in Table 2. In these specifications the community variables *healthpost* and *NGO* represent the average effect over the sample.

The dummy variable for gender indicates that males are significantly smaller than females, a result that is not novel in the literature dealing with data from the African continent. Indicator variables for child age-groups indicate a lag in height growth compared to the reference population; malnutrition increases up to an age of two years and then seems to level off, confirming the results of previous studies (Shrimpton et al, 2001)[8]. Both primary and secondary schooling of mothers have a significant and sizeable influence on child height for age. In contrast, only children of fathers with higher education benefit from this schooling. Education can influence nutrition by shifting the production function outward or influence the amount of inputs purchased either by relaxing the budget constraint or by influencing intra-household budgeting allocation. Education may also proxy for the health status of the parents; maternal height – a common determinant of birth weight - is not available. As this is a reduced form equation, the different potential roles of education cannot be fully delineated. However, the education variables are attenuated when wealth is added to the model indicating the correlation of these factors and the missing variable when wealth is not controlled for.[9]

Children of teenage mothers have been found to suffer from lower birth weight and associated increased risk of mortality in rich as well as developing countries (Treffers et al., 2001; Rees, Lederman, and Kiely, 1996). For the sample at hand, children of mothers who were 20 years of age or less when giving birth have lower nutritional status by 0.19 standard deviations for height for age. We also include a variable for those mothers who are twenty or more years younger than their household head, as there may be a detrimental effect for mothers with low social standing in the household. However, in the present sample and in the context of height for age, the negative effect of being a young mother is of several orders of magnitude larger than that of showing a large age difference to the household head, the latter of which is statistically insignificant for the dependent variable of height for age. The education gap as another variable related to the social standing of the woman relative to her husband or the head of the household is insignificant in all specifications, in contrast to the findings of Smith et al. (2003).[12] The wealth index created using principal component analysis has a statistically significant impact on child nutrition in most specifications when controlling for household size, which shows a negative and significant impact. This result on the role of per capita wealth is in line with the findings in Haddad et al. (2003) on the relationship between instrumented expenditures and nutritional status.

The community variables entered are the presence of a health facility and NGOs. In all four specifications presented, healthposts are associated with an improvement in child nutritional status for the uninstrumented regressions of about one tenth of a standard deviation as shown in columns 2 and 3. The availability of a NGO in the village is however not associated with a positive effect on height for age. This is true for the presence of any type of NGO in the village as presented in column 2, as well as for the presence of NGOs offering activities that are closely linked to nutrition interventions (child sanitation, mother sanitation, nutrition, and alphabetization) provided by a NGO as indicated in column 3. A possible reason for this result is that NGOs may not have not been in the villages long enough for the effect of their activities to be reflected in height-for-age, an anthropometric measure that mainly reflects long-term influences on child health status. Unfortunately, we do not have information on the duration of NGO presence in a village to pursue this point further.

For the instrumented regressions presented in column 4, the measured impact of these institutions increases sizeable in magnitude, although the coefficient associated with NGO services is statistically insignificant. A Hausman test for the endogeneity of these regressors indicates that we cannot reject the hypothesis that the ordinary least squares estimator yields consistent estimates. Therefore, for the case at hand no systematic bias in the placement of the health and NGO facilities seems to be present, implying that analysis using OLS is most efficient.

In Table 2, the results for the same empirical specifications are presented for weight for age. The main differences to the results in Table 1 are that the weight of children falls behind the US reference group quicker after birth than their height for age as indicated by the magnitude of the coefficients for the child age group dummies. However, by the age of three years, children on average show a lower height for age than weight for age score. Both primary and secondary schooling of the mother have similar point estimates for their influence on child nutritional status. However, only the former is statistically significant, perhaps reflecting the smaller number of women with secondary education in the sample. In contrast to the previous regressions, the wealth index is not statistically significant, potentially reflecting its value as a tool to increase long-term nutritional status. Healthposts show a similar impact on height for age and weight for age of about one tenth increase of a standard deviation of the z-score for the uninstrumented regressions, and about twice that when using instruments for taking a potentially endogenous placement of healthposts into account. The availability of services offered by all types of NGOs are again found to be non-significant, although the more specific category of nutrition-related NGO services has a positive and statistically significant impact that is of the order of magnitude of the impact of the healthpost in the village, indicating a potentially valuable role of such organizations in a village.

5.1 Regressions including interaction terms

The results presented in Table 3 include the interaction of the community variables of the presence of a NGO or a health post in the village and mother's characteristics relating to young age when giving birth as well as the mother showing an age difference to the household head of at least 20 years.

For height for age, the only significant interaction term is the dummy variable standing for a large age difference of the mother to the household head interacted with the presence of a healthpost in the village, indicating that these mothers benefit proportionally more form such services than the other mothers. The interaction terms of the status of being a young mother with community services are never significant. While the age of the mother at birth potentially represents endogenous choice, the change in the impact (i.e. the interaction term) may be looked on as a second derivative holding this choice constant. When the interaction terms are entered separately, neither the magnitude nor the statistical significance of the coefficient estimates changes substantially. An interesting result concerns the non-interacted variable of being a mother residing in a household where the head is more than 20 years her elder. In the regressions without interaction terms, this variable is statistically non-significant in Table 1. In the current Table, where we include interaction terms of the variable with community services, children of mothers with low social standing as indicated by this variable experience a lower nutritional status than children from mothers residing in households with an age difference to the household head of less than 20 years. The magnitude of the negative coefficient is sizeable and of the same order as the positive impact of having a healthpost in the village. In column 2, where we investigate the role of community services for mothers that are both young and reside in households with a significantly older head of household, the dummy variable for age difference loses its statistical significance when including the double interaction of young mothers showing a large age difference to the household head, while children of young mothers continue to show a significantly lower nutrition status.

For weight for age, the positive and statistically significant coefficient on the status of being a mother with large age difference interacted with the presence of a NGO in the village as shown in column 3 indicates that these mothers seem to benefit relatively more from the services offered by NGOs. In column 4 where we include double interactions of being a young mother with a potentially low social status in the household as proxied by a large age difference to the head of household reports a sizeable negative and statistically negative impact of this status, while these mothers are found to benefit from both the presence of a NGO and a health post in the village. The results indicate that community intervention programs may exert a heterogeneous impact; the analysis of such interaction effects can be a useful tool in the evaluation of intervention policies and their better targeting towards specific groups.

6. Conclusion

This paper investigates the determinants of child nutrition at the individual and household level as well as the impact of NGO services and public clinics in Senegal as well as their interaction with characteristics of the mothers in the communities where these are available for outcomes in terms of nutritional status. We also look at the social status of the mother within the household as an explanatory variable, as in bargaining models of household decisions a weak social standing may affect the food allocation to the child directly in a negative way.

Most findings in this paper confirm those of previous studies, such as that primary education of the mother and the presence of sanitary facilities in the household exert a positive influence on child nutritional status. One of the more novel findings in the paper is that the relative age difference between the mother and the household head is not a significant explanatory variable, in contrast to the absolute age of the mother: whereas children of young mothers experience a significantly diminished anthropometric status, child health is not markedly influenced by the social standing of the mother in our sample. However, these findings need to be modified when we interact the low social status of the mother in the household with community characteristics, indicating the heterogeneity of project effects.

While it has been argued that NGOs and health posts may be placed in areas that are easily accessible, show greatest need, or are purposely chosen on some other criteria, there is no indication that facilities are placed in manner that is endogenous to nutritional status in our sample. We find that the presence of a health facility or NGO in a village can be a useful tool for addressing the adversities faced by young women and mothers in households where the household head is 20 years or more their elder. We also detect a sizeable negative effect of being a young mother with low social status that is ameliorated by the presence of a NGO and a healthpost in the village. These findings then bear important policy implications and represent a further step towards gaining an improved understanding of the complex determinants of child (mal)nutrition.

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Table 1: Height for age with Individual, Household, and Community variables

	(1) OLS Individual and Household variables		(2) OLS with Community Variables		(3) OLS with nutrition-related NGOs		(4) Instrumental Variable Regression	
Aged 6-11 months	-.314	***	-.313	***	-.312	***	-.315	***
	(.087)		(.087)		(.087)		(.087)	
Aged 12-17 months	-.642	***	.646	***	-.645	***	-.647	***
	(.082)		(.082)		(.082)		(.084)	
Aged 18-23 months	-.910	***	-.911	***	-.910	***	-.913	***
	(.086)		(.085)		(.086)		(.087)	
Aged 24-29 months	-1.040	***	-1.038	***	-1.037	***	-1.026	***
	(.084)		(.083)		(.083)		(.085)	
Aged 30-35 months	-1.035	***	-1.036	***	-1.036	***	-1.039	***
	(.096)		(.095)		(.096)		(.097)	
Male child	.015		.015		.015		.016	
	(.045)		(.045)		(.045)		(.046)	
Twin child	-.778	***	-.787	***	-.788	***	-.795	***
	(.177)		(.178)		(.178)		(.177)	
Mother <21yrs when giving birth	-.202	***	-.194	***	-.194	***	-.189	***
	(.052)		(.052)		(.052)		(.053)	
Age difference >20 yrs	-.058		-.063		-.062		-.064	
	(.047)		(.046)		(.047)		(.049)	
Mother primary edu	.178	***	.161	***	.162	***	.144	**
	(.062)		(.061)		(.061)		(.064)	
Mother secondary edu	.321	**	.294	*	.295	*	.240	
	(.163)		(.163)		(.163)		(.166)	
Husband primary edu	-.027		-.038		-.038		-.043	
	(.083)		(.076)		(.076)		(.078)	
Husband secondary edu	.272	***	.251	***	.250	***	.242	***
	(.083)		(.085)		(.085)		(.088)	
Education status of husband missing	.183		.171		.171		.182	
	(.115)		(.114)		(.114)		(.115)	
Wealth index	.032	**	.036	**	.035	**	.043	***
	(.015)		(.016)		(.015)		(.016)	
Household size	-.012	***	-.012	***	-.012	***	-.013	***
	(.003)		(.003)		(.003)		(.003)	
WC	.132	*	.112		.112		.091	
	(.080)		(.081)		(.081)		(.081)	
Tap water	.212	***	.195	***	.194	***	.175	***
	(.058)		(.060)		(.059)		(.062)	
Health Post	-		.122	*	.117	*	.224	*
			(.070)		(.069)		(.122)	
NGO	-		-.026		.002		.034	
			(.067)		(.061)		(.248)	
R^2	.102		.103		.103		.103	
Number of observations	4165		4165		4165		4101	

Notes: Absolute value of standard errors below the coefficient estimates in parentheses. * indicates significance at 10% level; ** at 5% level and *** significant at 1% level of confidence. Five dummy variables for the six health districts in the sample are included but not reported (they pass the F-test of joint significance, as do the age bracket variables). Column 3 uses instrumented variables for the presence of either a NGO or a health post in a village. The set of community level instruments includes: mean wealth level of the village; presence of a market in the village; presence of a weekly market in the village; the presence of impassable roads to the next village; distance to the next village; as well as the other exogenous variables in the second stage regression. The p-value of a Hausman test for endogeneity of the presence of a healthpost or nutrition-related services by a NGO is 0.4933, we can therefore not reject exogeneity of the two variables. The first stage F-values for the instrumental variable regression are 136.59 (healthpost) and 24.39 (NGO). The F-value for testing the overidentifying restriction is 0.47, suggesting that the instruments do not have a direct impact on height for age. The standard errors are corrected for clustering at the village level.

Table 2: Weight for age with Individual, Household, and Community variables

	(1) OLS Individual and Household variables		(2) OLS with Community Variables		(3) OLS with nutrition-related NGOs		(4) Instrumental Variable Regression	
Aged 6-11 months	-.875	***	-.873	***	-.875	***	-.874	***
	(.077)		(.078)		(.077)		(.078)	
Aged 12-17 months	-1.480	***	-1.482	***	-1.482	***	-1.486	***
	(.074)		(.074)		(.074)		(.076)	
Aged 18-23 months	-1.574	***	-1.573	***	-1.575	***	-1.569	***
	(.084)		(.084)		(.084)		(.085)	
Aged 24-29 months	-1.351	***	-1.348	***	-1.346	***	-1.328	***
	(.079)		(.079)		(.079)		(.080)	
Aged 30-35 months	-1.051	***	-1.052	***	-1.058	***	-1.067	***
	(.083)		(.083)		(.082)		(.085)	
Male child	.009		.011		.015		.026	
	(.041)		(.041)		(.041)		(.043)	
Twin child	-.585	***	-.598	***	-.595	***	-.601	***
	(.180)		(.181)		(.181)		(.180)	
Mother <21yrs when giving birth	-.124	**	-.116	**	-.117	**	-.113	**
	(.048)		(.048)		(.048)		(.050)	
Age difference >20 yrs	-.025		-.027		-.024		-.021	
	(.042)		(.042)		(.042)		(.044)	
Mother primary edu	.179	***	.163	***	.164	***	.152	**
	(.058)		(.058)		(.058)		(.063)	
Mother secondary edu	.180		.153		.156		.112	
	(.144)		(.145)		(.144)		(.147)	
Husband primary edu	.059		.047		.051		.052	
	(.070)		(.070)		(.070)		(.071)	
Husband secondary edu	.227	**	.202	**	.208	**	.212	**
	(.091)		(.089)		(.090)		(.091)	
Education status of husband missing	.126		.114		.114		.120	
	(.091)		(.091)		(.090)		(.093)	
Wealth index	.025		.027		.026		.031	*
	(.017)		(.017)		(.017)		(.018)	
Household size	-.008	**	-.008	**	-.008	**	-.008	***
	(.003)		(.003)		(.003)		(.003)	
WC	.077		.055		.053		.028	
	(.073)		(.073)		(.073)		(.073)	
Tap water	.204	***	.183	***	.185	***	.166	***
	(.053)		(.053)		(.053)		(.056)	
Health Post	-		.116	*	.120	*	.210	*
			(.067)		(.066)		(.119)	
NGO	-		.050		.101	*	.245	
			(.066)		(.061)		(.248)	
R^2	.175		.177		.178		.174	
Number of observations	4151		4151		4151		4086	

Notes: Absolute value of standard errors below the coefficient estimates in parentheses. * indicates significance at 10% level; ** at 5% level and *** significant at 1% level of confidence. Five dummy variables for the six health districts in the sample are included but not reported (they pass the F-test of joint significance, as do the age bracket variables). Column 3 uses instrumented variables for the presence of either a NGO or a health post in a village. The set of community level instruments includes: mean wealth level of the village; presence of a market in the village; presence of a weekly market in the village; the presence of impassable roads to the next village; distance to the next village; as well as the other exogenous variables in the second stage regression. The p-value of a Hausman test for endogeneity of the presence of a healthpost or nutrition-related services by a NGO is 0.4242, we can therefore not reject exogeneity of the two variables. The first stage F-values for the instrumental variable regression are 137.29 (healthpost) and 24.55 (NGO). The F-value for testing the overidentifying restriction is 0.50, suggesting that the instruments do not have a direct impact on weight for age. The standard errors are corrected for clustering at the village level.

Table 3: Results including interaction terms

	Height for age				Weight for age			
	(1)		(2)		(3)		(4)	
	OLS with interactions				OLS with interactions			
Male child	.016		.016		.012		.010	
	(.045)		(.045)		(.042)		(.041)	
Twin Child	-.790	***	-.790	***	-.601	***	-.599	***
	(.177)		(.177)		(.181)		(.180)	
Mother <21yrs when giving birth	-.278	***	-.183	*	-.237	***	.070	
	(.077)		(.098)		(.083)		(.093)	
Age difference >20 yrs	-.150	*	-.060		-.119		.018	
	(.086)		(.053)		(.081)		(.046)	
Young mother * age diff. >20 yrs	-		-.168		-		-.494	***
			(.135)				(.127)	
Mother primary education	.160	***	.161	***	.161	***	.164	***
	(.061)		(.062)		(.058)		(.059)	
Mother secondary education	.290	*	.288	*	.148		.145	
	(.164)		(.164)		(.147)		(.146)	
Husband primary education	-.036		-.036		.050		.051	
	(.077)		(.077)		(.070)		(.070)	
Husband secondary education	.248	***	.250	***	.199	**	.199	**
	(.085)		(.085)		(.090)		(.090)	
Education status of father missing	.183		.181		.126		.138	
	(.116)		(.115)		(.091)		(.091)	
Wealth index	.035	**	.035	**	.027		.027	
	(.016)		(.016)		(.017)		(.017)	
Household size	-.012	***	-.012	***	-.008	**	-.008	**
	(.003)		(.003)		(.003)		(.003)	
WC	.108		.112		.052		.056	
	(.080)		(.080)		(.072)		(.072)	
Tap water	.194	***	.194	***	.181	***	.179	***
	(.059)		(.059)		(.053)		(.053)	
Healthpost	.156	*	.097		.144	*	.081	
	(.084)		(.073)		(.078)		(.069)	
Interaction young mother	.112		-		.164		-	
	(.124)				(.105)			
Interaction age difference to head of household	-.113		-		-.123		-	
	(.095)				(.088)			
Young mother * age diff. * healthpost	-		.132		-		.184	*
			(.127)				(.109)	

NGO	-.138		-.057		-.076		-.003	
	(.087)		(.073)		(.078)		(.071)	
Interaction young mother	.073		-		.108		-	
	(.105)				(.105)			
Interaction age difference to head of household	.178	*	-		.189	**	-	
	(.098)				(.094)			
Young mother * age difference * healthpost	-		.167		-		.272	***
			(.110)				(.102)	
R^2	.104		.104		.179		.180	
Number of observations	4165		4165		4151		4151	

Notes: Absolute value of standard errors below the coefficient estimates. * indicates significance at 10% level; ** at 5% level and *** significant at 1% level of confidence. Dummies for the age brackets of children and dummies indicating the six health districts in the sample are suppressed for space reasons. The standard errors are corrected for clustering at the village level.

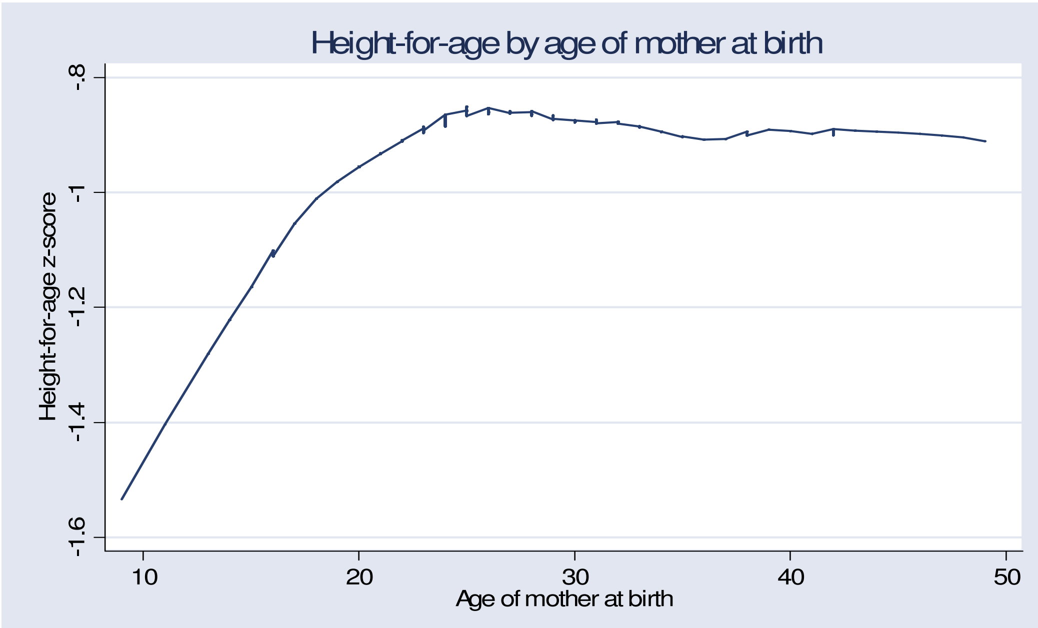
Appendix 1: Descriptive statistics of the variables used

	Mean	Standard Deviation
Continuous variables		
Height for age	-1,047	1,409
Weight for age	-1,354	1,383
Asset Index	0,000	0,164
Categorical variables		
Male Dummy	0,511	0,500
Age 0-5 months	0,181	0,395
Age 6-11 months	0,170	0,376
Age 12-17 months	0,190	0,392
Age 18-23 months	0,145	0,352
Age 24-29 months	0,187	0,390
Age 30-35 months	0,113	0,317
Mother <21years at birth	0,238	0,426
Age diff. to household-head >20yrs	0,657	0,475
Mother primary schooling	0,143	0,351
Mother secondary schooling	0,023	0,149
Husband primary schooling	0,121	0,326
Husband secondary schooling	0,072	0,259
Education status of husband missing	0,050	0,218
Household size	14,889	8,483
Access to tap water	0,372	0,483
Water Closet	0,121	0,326
NGO in village	0,414	0,493
Healthpost in village	0,319	0,466

Appendix 2: Components of the Wealth Index created using Principal Component Analysis

	Mean	Standard Deviation
Number of items per household		
Bicycles	0.224	0.544
Mopeds	0.080	0.303
Carts	0.686	0.760
Ploughs	1.622	1.564
Horses	1.105	1.253
Cows	5.531	16.066
Donkeys	0.627	0.981
Sheep	7.369	13.056
Poultry	13.991	22.271
Hectares of land	7.825	15.441
Fraction of Households with dirt floor	0.696	0.460

Figure 1


Height-for-age by age of mother at birth
Height-for-age z-score
-.8
-1
-1.2
-1.4
-1.6
10
20
30
40
50
Age of mother at birth

[1] Other studies in this vein include Thomas, Strauss, and Henriques (1991); Thomas and Strauss (1992); Raghupathy (1996); and Sastry (1996).

[2] As labor income is jointly determined with child health ideally income should be treated as endogenous.

[3] If we believe in the permanent income hypothesis, consumption expenditure would also be a valid measure of life-time resources, in particular in the absence of credit constraints and other obstacles preventing full consumption smoothing. This measure should also be less volatile than labor-income.

[4] Descriptive statistics for the variables used in the construction of the index can be found in Appendix 2.

[5] According to the DHS (1992), about 4.8% of married women were using any modern method of family planning, indicating that birth planning may not be very common in Senegal.

[6] The sample used for analysis is smaller than the original sample as it included 592 children over the age of 35 months. Additional observations had to be dropped when constructing the anthropometric measures due to missing data or obviously erroneous observations such as a child of three months with a weight of 66.5 pounds.

[7] In 2006, the WHO published a new set of child growth standards that can be accessed at http://www.who.int/childgrowth/en/ . There is, however, no reason to believe that the results of this analysis would be affected by reformulating the z scores.

[8] In Stata, two reference populations are available when calculating z-scores: US CDC Growth Charts from 2000, and 1990 British Growth Charts. As both reference populations are valid comparison groups, we chose one of them (the US), calculations for the UK reference group (that do not differ significantly from the results presented below) can be obtained from the authors upon request.

[9] Similarly, since education is strongly correlated among spouses the parental education variables are biased upwards if only the education of one of the parents is included.

[12] The results for the variable are not reported here but can be obtained from the authors upon request.