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Abstract

We analyzed the role that health programs played in improving the nutritional status of children aged five years and younger in East Africa during a period when health policies aiming to reduce malnutrition were implemented. We used several waves of Demographic and Health Surveys over the 1992–2006 period for Kenya, Rwanda, Tanzania, and Uganda. Our results show that malnutrition rates fell substantially over the sample period but that some countries then registered reversals. This finding suggests that the implementation of nutrition policies was not consistent. However, the country-level results show that different factors matter in different countries. For example, maternal health is most important in Uganda and Rwanda. Furthermore, different levels of education matter for different countries. For example, in Kenya, only the mother's post-secondary education is significant, but in other countries, it is important to address generally low education levels to improve child nutritional health. Overall, due to resource constraints, addressing the nutritional health of young children in East Africa will continue to rely on low cost approaches, such as nationwide vaccinations and maternal education, and not on programs like conditional cash transfer schemes, which have proved successful in addressing under-nutrition in wealthy and middle-income countries.

Keywords: East Africa, Child Malnutrition.

JEL classification: I12, I18, J13, O15, 057.

I. Introduction

The goal of reducing child malnutrition is far from being fulfilled in most developing countries. Over the past 20 years, some developing countries have registered only minimal changes for this critical aspect of child health. According to the 2009 United Nations Children's Fund (UNICEF) report on tracking child and maternal nutrition, the proportion of stunting among children aged five years and below in the developing world decreased from 40% to 29% between 1990 and 2008 (UNICEF, 2009).[1] SSA is one of the regions that made the least progress, having reduced its proportion of stunted children only from 38% to 34% during the same period.[2] As a result, policymakers and researchers are increasingly concerned about such poor indicators of child health in an era of increased social spending. This concern is based on the understanding that a poor level of child nutrition can have detrimental effects on long-term human development. At the individual level, nutritional inadequacy has long-lasting effects, especially on children's cognitive development (Alderman *et al.* 2009) and adulthood labor productivity; this effect is particularly significant for children from poor households (Strauss, 1986; Behrman, 1993).

It is not surprising, then, that attempts to address child malnutrition have taken on an important role in policy, particularly through the implementation of the Poverty Reduction Strategy Papers (PRSPs). However, the types of policies that are implemented have varied greatly, especially in SSA. For example, some countries

[1] Stunted is defined as more than two standard deviations below the population standard for height for age.
[2] The large decline in under nutrition in Asia was attributed to progress made in China where stunting rates reduced from 33% in 1990 to 11% by 2005 (UNICEF, 2009). In terms of policies, China increased the proportion of household consuming adequate amounts of iodized salts from 51% in 1990 to 95% by 2005. Related, china increased coverage of piped water and improved sanitation to 72% and 65% of the population respectively.

(e.g., Uganda and Ethiopia) have provided nutritional supplements for children at risk of malnutrition, and others have relied on nutritional information campaigns and broader access to maternal and child health care. Furthermore, countries that implemented similar policies registered different impacts on child nutrition; although some countries reduced malnutrition, the other countries failed. For example, countries such as Eritrea, Ethiopia, Uganda, and Tanzania have significantly reduced the levels of stunting in young children since the 1990s while Kenya and Niger registered an increase in stunting rates during the same period (UNICEF, 2009). Thus, it is important to understand the ways that different African nations have addressed this crucial aspect of child health and the impact, if any, of the various policies and programs that aimed to reduce the high rates of under-nutrition in Africa.

In this paper, we examine the programs and interventions that were implemented to improve the nutritional status of children aged five years and below in East Africa. There are important reasons for focusing on this age group. First, there is evidence that under-nutrition in young children contributes more to a country's overall disease burden than under-nutrition in adolescents, for example. According to Glewwe and Miguel (2008), in SSA, nutritional problems in children aged 0-4 years contribute twice as much to the overall burden of disease than they do in children aged 5-14 years. Second, various nutritional studies based on cross-sectional data have showed that, on average, young children in developing countries start to fall behind the developed country standard at approximately three months old; they continue to fall further behind until the age of around 24 months, when they stabilize but never fully catch up (World Heath Organization, 1995; Martorell and Habicht, 1986).

Consequently, almost all of the damage of nutritional deficiency happens at a young age.

Third, as earlier noted, nutritional status in young children is significantly related to their subsequent cognitive development and labor productivity. For example, Alderman *et al.*, (2009) show that in Northwest Tanzania, malnourished children are more likely to delay entry into school and perform worse at school than their counterparts of normal nutrition status. Finally, most of the large-scale surveys that are comparable across countries, such as the Demographic and Health Surveys (DHS), only collect nutritional information for children below five years old. Given that we use similar datasets in this study, we restrict our analysis to the nutritional status of young children aged 0-59 months and do not include all children (i.e., under 18 years of age).

For this study, we focused on four East African countries: Kenya, Rwanda, Tanzania, and Uganda. We chose these specific countries not because of their geographical proximity, but because they include a disproportionate share of SSA's population of malnourished children. According to UNICEF, 24 countries account for 80% the 195 million children, aged five years and below, who are globally classified as stunted (UNICEF, 2009). Of these 24 countries, 10 are in SSA. Worse still, in 2008, the combined population of undernourished children in the three East African countries of Kenya, Tanzania, and Uganda was eight million, which represents 21% of the SSA total. Although Rwanda is among the 24 countries globally with the largest population of young children stunted, the country nevertheless has the highest stunting rate in East Africa of 51% in 2008. Therefore, East Arica's high prevalence of stunting in combination with a large population of young children with inadequate nutrition is a unique case to study the determinants of child nutritional status.

The overall objective of the study is to assess the progress that East African countries made in improving children's nutritional health during the 1990s and 2000s. Specifically, the study examined the impact that access to health care services (e.g., vaccinations and maternal use of health facilities for childbirth) has on child nutritional status and whether such health policies became more significant over time. For the four countries, we used anthropometric indicators to classify young children aged five years and below into three possible states of nutritional health: normal nutritional status, malnourished or severely stunted and therefore at risk of abnormality. We employed the order probit regression approach for 11 sets of DHS surveys in East Africa from 1992 to 2006. This time span includes the periods before and after the aforementioned health-related PRSPs policies were implemented. DHS datasets are arguably particularly suited to our task because they collect information on a child's health status and his household and community characteristics. More precisely, we have detailed information on children and mothers' use of and access to health care services.

In the following section, we describe some of the national programs that were implemented in developed and developing countries to improve the nutritional health of children. This section is followed by a review of the literature on the key determinants of young children's nutritional health in developing countries. Section 4 outlines the East African context and some of the policies in the PRSPs that target child nutritional health. Section 5 describes the data and methods employed in the analysis. We present the results obtained of the analysis in Section 6, and in Section 7 we provide the conclusions and implications of the study.

II. Background on policies targeting the nutritional health of young children.

Developed and developing countries have used both cash and in-kind transfer programs to target child nutritional health. For example, the US pioneered cash transfers that target the nutritional status of young children with the Aid to Families with Dependent Children (AFDC) cash transfer program, which was operational from 1935 to 1990. This program provided grants to pregnant mothers from low-income families as an indirect means of reducing low birth weights (Currie and Cole, 1993). Nonetheless, most public programs that target nutritional health in the USA have been in-kind rather than cash transfers. The most cited in-kind program is the Special Supplementary Nutritional Program for Women, Infants, and Children (WIC), which is a federally-funded and state-run program that provides food and nutritional advice to pregnant women and to infants and children who are nutritionally-at-risk or from low-income families. The program started in 1972, and, by 2007, it had enrolled 8 million households and cost US$4 billion per month (Currie, 2008). A number of authors have shown that the WIC program has had a beneficial impact on child health. For example, Devaney *et al*. (1992) showed that the program resulted in substantial savings on child health expenses. Additionally, Bitler and Currie (2004) showed that WIC infants are less likely to require treatment in an intensive care unit and that a pregnant mother's enrolment in the program reduces the probability of a low birth weight by as much as 29%.

Other in-kind transfer programs in the USA include the Food Stamp Program, the National School Lunch Program (NSLP) and National School Breakfast Program (NSBP). The last two programs provide free or subsidized meals in public schools, and, in the 2007 financial year, 27 million children were enrolled in the NSLP program at an annual cost of US$6 billion (Currie, 2008). Given that under-nutrition is not a serious problem in the USA, as in most advanced countries (i.e., compared to obesity), most evaluations of the above nutritional programs focus on their impact on quality of diet and obesity. For example, Bhattacharya *et al*. (2006) used the National Health and Nutritional Examination Survey (NHANES) III data to show that children participating in the NSBP significantly have a higher quality of diet, exhibit a higher intake of specific food groups, especially minerals, and have a lower share of fats and saturated fats in their total caloric intake.

Developing countries have also used a combination of cash and in-kind transfers to target child nutritional health. Perhaps the most studied program in developing countries is the Programa de Educacion, Salud y Alimentacion (PROGRESA-Oportunidades), which was implemented in rural Mexico to target the nutritional status of pre-school children and the school enrolment of children aged 6-17 years. The program started in 1997 with 140,000 households, and, by 2006, at least 25% of the Mexican population was enrolled in the program. The key components of this large-scale program are cash transfers to households that are conditional on infants attending health clinics and older children attending school; participation in the *platican* (regular meetings at public health facilities to distribute information on child health); nutritional supplements for pregnant women, children aged 4-24 months, and older children (aged 2-5 years) who are at risk of malnutrition; and, finally, a continuous monitoring of children's growth. Most of PROGRESA- Oportunidades's impact has been registered in improved school enrolment, and only a few studies have found improvements in child health. Behrman and Hoddinot (2005) are among the few studies to show that PROGRESA's nutritional supplements significantly reduced the probability of stunting for children aged 12-36 months. Other studies showed that children from families in the PROGRESA program had a lower experience of illness and were also 25% less likely to be anemic (Gertler, 2004).

Most of the other large-scale, conditional cash transfer programs in developing countries are concentrated in Latin America (e.g., the Red de Protecci ó n Social Program in Nicaragua and Families in Action in Columbia). Some countries in SSA operate much smaller, Social Action Fund (SAF) and Conditional Cash Transfer (CCT) programs that generally target poverty reduction and school enrolment without specifically addressing child or nutritional health (Kakwani *et al.*, 2005; Schubert and Slater, 2006). Cost is a key factor that determines the implementation and extent of cash and in-kind transfer programs in advanced and developing countries. For example, the NSBP in the US costs about US$49 per month for each of the seven million children who receive this grant. On the other hand, the PROGESA program costs US$1.8 billion annually. Given that many developing countries suffer from generally higher levels of deprivation coupled with low tax revenues, most such countries have to rely on external assistance to finance such large-scale programs to target child nutritional health.

III. Literature Review

A number of studies have examined the determinants of child nutritional status in SSA (e.g., Gewa, 2009; Zivin *et al*., 2009; Alderman 2007; Alderman et al., 2006; Madise et al., 1999). For instance, Madise *et al*. (1999) used DHS surveys between 1990 and 1994 to examine the correlates of child nutrition status for Ghana, Malawi, Nigeria, Tanzania, Zambia, and Zimbabwe. They found that, based on weight for age z-scores (WAZ) in children under three years old, different factors have different impacts across the six countries. For example, mothers' attainment of secondary education significantly boosts children's nutritional health in Ghana, Nigeria, and Tanzania. On the other hand, the presence of a flushing toilet in the house significantly influences the WAZ for Ghana, Malawi, Nigeria, and Zambia. However, for all six countries, the children who suffered from diarrhea two weeks before the DHS surveys were significantly below the appropriate weights for their age groups.

There have also been attempts to examine the nature, extent, and determinants of child nutritional status in East Africa. Examples of recent empirical studies include Kabubo-Mariara *et al.*, (2009), Lawson and Appleton (2007), Alderman (2007), Ssewanyana (2003), and MacKinnon (1995). Most of the above studies found that access to health facilities is a significant determinant of child nutrition. For example, Kabubo-Mariara *et al*. (2009), using the 1998 and 2003 Demographic and Health Survey data, showed that maternal education and the use of public health services are key factors in child nutritional status in Kenya. For Uganda, Lawson and Appleton (2007) show that incomes are key to the nutritional status of infants—especially young boys. On the other hand, Alderman (2007) showed that community development programs in Uganda (i.e., programs that provide vaccines, vitamin supplements, and de-worming medicines to households) improved the nutritional status of children under a year old. However, previous research in the sub-region has been based mainly on national assessments and focused predominantly on selected countries, notably Kenya and Uganda. Given the heterogeneity of East African countries, especially in terms of child health policies (described in section four), it is important to know whether the numerous programs articulated in the PRSPs have been successful in reducing child under-nutrition.

Apart from the studies that used DHS surveys, there have been smaller surveys that examined the impact of specific interventions on child nutritional status. Some of these studies used randomized experiments. For example, Zivin *et al*. (2009) used the Academic Model for Prevention and Treatment of HIV/AIDS (AMPATH) data to examine the impact that providing adults with anti-retroviral (ARVs) therapy has on child nutritional status. The researchers set up a rural HIV/AIDS clinic in Western Kenya in 2001 and, in 2004/5, evaluated 775 households of the population that had access to the clinic. The sample included households without an AMPATH patient, households with AMPATH patients and receiving ARVs, and households with an AMPATH patient receiving no ARVs. Zivin *et al*. (2009) found that the weight of children aged 0-5 years significantly improved during the period that immediately followed the initiation of ARVs. However, after more than two years of ARVs, the nutritional status of children in HIV/AIDS-affected households did not significantly differ from those in households that were not receiving ARVs.

Studies on Kenya have pointed to the importance of maternal education as a key determinant of nutritional status among young children. For example, Deolalikar (1996) showed that young children whose mothers have a secondary education are significantly taller than comparable children whose mothers have no schooling. Other studies on Kenya showed that a higher maternal education level may be linked to childhood obesity. For example, Gewa (2009) showed that higher maternal education is significantly associated with over-nutrition/obesity in children aged three to five years. According to the authors, higher maternal education is associated with a higher income and a corresponding access to “high status foods”, which are rich in sugars and saturated fats.

Alderman et al. (2006) also used a small survey of about 900 households from North-western Tanzania to examine the importance of income for child nutritional status. Using four waves of the Kagera Health and Development Survey (KHDS), conducted between 1991 and 1994, the authors found that household income growth is an important determinant of weight for age for children five years and below. In addition, they find that specific community factors, such as proximity to a motorable road, maintenance of the community road, and the proportion of children who are vaccinated, improve children’s nutritional status. However, Alderman *et al*. (2006) found, based on simulations of these significant factors, that sustained income growth alone cannot help Tanzania to meet its nutrition MDG target. Tanzania aims to halve the proportion of malnourished children by 2015, and this result can only be achieved by a sustained per capita income growth of about 3.0 per annum, universal community access to motorable roads, 95% child vaccination rates and the education of the heads of households.

IV. The East African context

The four countries in this study are part of the East African Community (EAC), a regional grouping with a population of 127 million persons that had a Gross Domestic Product (GDP) of US$70 billion in 2008 (IMF, 2009).[3] In comparison to all of Africa, the four countries account for 13% of the continent's population, but only 5.5% of the GDP. Among the four countries, Kenya is the most economically advanced, and it accounts for 44% of the regional GDP even though its population share is only 29%. Despite Kenya's relative economic advantage, the country's human development is fairly similar to that of its regional neighbors. In the 2009 Human Development Index, Kenya was ranked 147th out of 182 countries; Tanzania was ranked 151st, Uganda 157th, and Rwanda 167th (UNDP, 2009). Kenya's relatively low human development status may be partly explained by its high rate of income poverty and inequality compared to that of its neighbors. Between 2000 and 2006, Rwanda had the highest proportion of poverty in its population (60.3%), followed by Kenya (52%), and Uganda and Tanzania had similar rates of head-count poverty of approximately 37% of the population (UNDP, 2009).

Similarly, key health indicators vary widely in East Africa. Table one shows the indicators for child nutritional status, child mortality, and HIV/AIDS prevalence rates for the four countries compared to the rest of SSA. For children aged five years and below, Rwanda has the highest rates of child malnutrition or stunting (45%), followed by Uganda and Tanzania (at about 38%); Kenya exhibited the lowest levels of child stunting, 30%, in 2003. Additionally, with the exception of Rwanda for stunting rates,

[3] Burundi is the fifth country is this regional grouping but it is not considered in this study due to data limitations, which implies that its most recent level of under nutrition and population of children suffering from under nutrition are unknown.

other East African countries have stunting and wasting rates that are comparable to the rest of SSA. These four countries only have rates that are much lower than the SSA average for underweight status among children. On the other hand, for nutrition health indicators for infants aged one year or less, Uganda exhibits some of the worst indicators. For example, Uganda's wasting rate of 9% is more than three times that of Tanzania (2.2%). Similarly, the rate of underweight infants in Uganda exceeds that of any other East African country. The table also shows that the stunting rates of infants (aged 0-12 months) are much lower than the overall stunting rates for all young children (aged 0-59 months) in the four countries.

There are also wide variations in other child health indicators across the four countries. For instance, Uganda's infant mortality rate (IMR) is similar to Kenya's but much higher than Tanzania's. Indeed, Tanzania reduced IMR by 34% between 1999 and 2007/08 (TDHS, 2008), which puts it among the few African countries likely to meet the MDG target of reducing child mortality rates by two-thirds. Table one also shows that the HIV/AIDS prevalence rates in East Africa are about 6%, except in Rwanda, which has a commendably low rate of HIV/AIDS prevalence compared to its neighbors. Tanzania has made some recent progress by reducing the prevalence rate from 7.0% in 2003/04 to 5.7% in 2007/08 (TACAIDS *et al*., 2008). Overall, the HIV/AIDS prevalence rates in Eastern and Southern Africa are about three times the corresponding rates for West and Central Africa.

Table 1: Selected health indicators in East Africa, 2003-2008

	East Africa				Sub Saharan Africa (2007) [2,3]		
Health indicator	Uganda	Kenya	Rwanda	Tanzania	All	Eastern and Southern Africa	West and Central Africa
DHS Round	*2006*	*2003*	*2005*	*2004/05*			
Child nutrition status (0-59 months of age)							
Height for-age (stunting)	38.1	30.6	45.5	37.7	38.0	40.0	36.0
Weight-for-height (wasting)	6.1	4.8	3.9	3.0	9.0	7.0	10.0
Weight-for-age (underweight)	15.9	19.1	22.5	21.8	28	28	28
Infants nutrition status (0-12 months of age) [4]							
Height for-age (stunting)	15.7	13.1	19.3	17.7			
Weight-for-height (wasting)	9.1	5.7	5.1	2.2			
Weight-for-age (underweight)	17.8	10.6	14.5	13.1			
Child mortality							
Infant mortality rate	76	77	86	58	89	80	97
Under five mortality rate	137	115	152	91	148	123	169
	HIV/AIDS Prevalence						
	2004/05	**2003**	**2005**	**2007/08**			
HIV/AIDS Prevalence (15-49 years)	6.4	6.7	3	5.7	5	7.8	2.6
Female	7.5	8.7	3.6	6.6			
Male	5	4.6	2.3	4.6			

Sources: The country indicators are from the published DHS reports, specifically, Uganda Demographic and Health Survey 2006; Uganda HIV/AIDS Survey 2004/05; Tanzania Demographic and Health Survey 2004/05; Tanzania HIV/AIDS and Malaria Sero-Behavioural Indicator Survey 2007/08; Kenya Demographic and Health Survey 2003; and the Rwanda Demographic and Health Survey 2005.

[2] The SSA regional indicators are from: the 2009 State of World Report by UNICEF (UNICEF, 2008).

[3] No regional indicators for child nutrition are reported for infants aged 1 year or less. Also no gender disaggregated HIV/AIDS prevalence rates are reported at the SSA and other regional levels.

[4] The nutrition status indicators for infants are based on the author's calculations from the respective DHS surveys.

The large variance in key health indicators may be partly attributed to the differences in healthcare financing across the four countries. In Rwanda, citizens pay for public health services, and the country has a thriving community-based social health insurance scheme ("*mutuelle de santé*") that covered at least 27% of the employed and self-employed population in 2007 (IMF, 2008). Similarly, Tanzania operates a cost-sharing system in government health facilities, although the country has an exemption and waiver system for poor and vulnerable groups. Kenya also charges user fees at public health facilities, although the country has a long-established National Health Insurance Fund for employees. On the other hand, in 2001, Uganda abolished user fees at all public health facilities and a number of studies show that this particular change more than doubled health care utilization in the country (Deininger and Mpuga, 2005; Ssewanyana *et al*., 2004). We cannot directly relate a country's health status to overall national spending on health or to citizens' out-of-pocket expenditures for health. However, the Kenyan government attributes its poorer citizens' limited use of public health services to user fees (Government of Kenya, 2008).

Most of the policies in the sub-region that aim to improve child health in general and nutritional status in particular have focused mainly on expanding vaccination coverage, improving maternal health, and providing of safe drinking water. However, some countries have implemented slightly different programs. For example, Rwanda targeted neo-natal child health by focusing on improving maternal healthcare services and recruiting more midwives for rural health facilities (IMF, 2008). Tanzania has emphasized that expanding access to safe water is one of the key programs for improving child health (United Republic of Tanzania, 2000). At the same time, despite their geographical proximity, the four countries have wide socioeconomic and geo-political differences. For example, Rwanda and Uganda have experienced prolonged periods of civil conflict that could ultimately harm child nutritional health.

Uganda was one of the first developing countries to produce a PRSP in 1997. With regard to child nutrition, the 1997 Uganda Poverty Eradication Action Plan (PEAP) focused on providing mothers with food supplements and nutritional education (Government of Uganda, 1997). Starting in 1998, Uganda implemented a World Bank-funded community growth promotion project (the Nutrition and Early Child Development Project) that covered 39 of the country's 55 districts. This project provided grants to the community that could be used to purchase dietary supplements for malnourished children and to finance nutrition awareness campaigns to encourage breast-feeding. The initial evaluations of the program pointed to improvements in children's nutritional status, but only during the first year of life as earlier noted. In addition, since 2002, Uganda has implemented the *child days* initiative (Government of Uganda, 2005). These are bi-annual nationwide immunization and de-worming campaigns, which are held at non-medical facilities (e.g., primary schools).[4] Despite these relative successes, the overall national indicators of child nutritional status in Uganda remained unchanged from 1995 to 2006 (UBoS and Macro International Inc., 2007).

The East African countries have set different goals and strategies for improving maternal health. The 2000 Kenyan PRSP set the target of increasing the proportion of mothers who give birth in a health facility from 56% in 2000 to 70% by 2008 (IMF, 2005). Uganda also aimed to increase the proportion of childbirths supervised by qualified health professionals from 38% to 50% between 1997 and 2004 by expanding lower-level health facilities to include maternity units (Government of Uganda, 1999). The state also provided birthing kits, called "mama bags", to expecting mothers in the poorest districts to encourage them to use health facilities during childbirth (Government of Uganda, 2005).[5] On the other hand, Rwanda increased the share of midwives assigned to rural health facilities as part of the country's strategy to draw mothers to health facilities (IMF, 2008).

Other maternal health programs have focused on increasing women's access to family planning services. This initiative is based on the understanding that a smaller family size improves the overall quality of childcare and, consequently, nutritional health.

[4] During *child days*, children who have missed any vaccinations are provided with a catch up service while de-worming is undertaken for children from 1 to 14 years.

[5] Mama bags are birthing kits with basic supplies to ensure safe and hygienic child delivery. They contain examination gloves, disposable scalpels, chux pads, disposable tower, gauze pads, bulb syringe, water proof sheet and lubricant gels. The 2007/08 Annual Uganda health performance reports an increase in the number of women giving birth in health facilities due to the free provision of these kits (Government of Uganda, 2008).

Indeed, most governments in East Africa provide free contraception to women who request it, and recent trends point to an increasing use of family planning services. For example, the use of modern family planning in Rwanda increased from 4% in 2000 to 10% by 2005; however, this rate remained below the pre-genocide level of 13%, which was registered in 1992 (IMF, 2008). The East African governments have also addressed child health through programs outside the health sector. For example, the 2000 PSRPs for Tanzania and Rwanda sought to increase the proportion of the rural population that has access to safe drinking water from 48% in 2000 to 55% by 2005. At the same time, Rwanda sought to reduce the proportion of the population without latrines from 5% to 0% by 2012. On the other hand, Uganda was one of the first developing countries to offer free primary education as a strategy to boost overall educational attainment among women.

In summary, although these East African countries have implemented a number of programs to address poor child nutritional health, the problem persists. In the next section, we describe the methods that we used to analyze the determinants of child nutritional health in East Africa.

V. Methods

A The Data

This paper used DHS data for Kenya, Rwanda, Tanzania, and Uganda. The DHS surveys are part of a global program supported by the United States Agency for International Development (USAID) and are conducted by Macro International Inc. in conjunction with national statistical agencies.[6] The surveys monitor population, health, and nutrition programs in developing countries. The surveys are nationally representative and use standardized questionnaires across the different countries. Indeed, although the coverage of DHS surveys has changed over time, the surveys have nonetheless remained similar across countries.[7] They are conducted every five years in most low-income countries. In this study, we considered the DHS surveys for Kenya, Rwanda, Tanzania, and Uganda that were conducted between 1992 and 2006.[8] All four countries had at least two rounds of regular DHS surveys during this period.[9] The sample size is relatively large and covers about 10,000 households in each survey round. Table 2 shows the particular surveys for each country that were used in our analysis.

Table 2: Country DHS surveys used in the analysis

Country			
Kenya	Rwanda	Tanzania	Uganda
2003	2005	2004/05	2006
1993	2000	1996	2000/01
	1992	1991/92	1995

Source: DHS datasets, www.measuredhs.com, MEASURE DHS, Macro International Inc.

The DHS surveys are based on a two-stage cluster sampling design. In the first stage, clusters are the principal sampling unit, and, in the second stage, 25-30 households are

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[6] Further details about the conduct and content of DHS surveys can be obtained at http://www.measuredhs.com/

[7] For examples, all regular DHS surveys have collected children's anthropometric information while information on women's nutritional status was only introduced in the 1990s. Furthermore, questions concerning female experience of domestic violence and testing of respondents for HIV/AIDS were only introduced after 2002.

[8] Burundi is the only other member of the East African community not include in the study because it has only one DHS survey undertaken in 1987,

[9] Tanzania is the only country with four surveys during the period: the 1991/92, 1996, 1999, and 2004/05. However, in the analysis, we exclude the 1999 DHS due to comparability issues with other TDHS survey. Furthermore, we exclude the 1998 Kenya Demographic and Health Survey as it did not collect complementary information on children aged over 3 years.

randomly selected from each cluster. Each DHS survey is composed of at least two questionnaires: the household and individual questionnaires. The household questionnaire covers the characteristics of the household (e.g., demographic composition, assets held and access to public services). The individual questionnaire, which mainly targets individuals in the reproductive age category (15-49 years), collects information on birth histories and anthropometric indicators for women and their children under the age of five. The individual questionnaire also covers women's background characteristics and contraceptive use and their husbands' background characteristics. In our estimations, we used household weights to account for the survey design, especially clustering and stratification, when we calculated the means of the samples used. As indicated by ORC Macro International—the agency that supervises the collection of DHS surveys, the use of sampling weights is inappropriate during regression estimations. [10] Therefore, we did not apply any weights to our ordered probit estimations.

B Ordered probit estimation

In our estimations, we aimed to identify the key determinants of malnutrition over time across the four East African countries. Furthermore, we investigated how these various determinants have changed for malnourished and severely stunted children. We distinguished between these two categories of nutritional status because, in all of the countries considered, about 30% of children suffer from some form of malnutrition. Consequently, the failure to distinguish between the different categories of malnutrition would hide very useful information, especially regarding the progress

[10] For details, see the following website
http://www.measuredhs.com/help/Datasets/sampling_weights.htm

made to reduce extreme stunting. We employed the ordered-probit model to account for differences in the severity of malnutrition because the measure of stunting is ordinal. Furthermore, this approach does not assume that various states of stunting are equally spaced, but ranks them from the best nutritional status to the worst. Previous studies have employed a similar framework to examine malnutrition in an environment with high levels of under-nourishment (e.g., Pal, 1999, in India). Consequently, we categorize children as normal (i.e., having a height for age z-score of greater than minus two), malnourished (i.e., having a z-score of greater than minus three but less than minus two), or severely stunted (i.e., having a z-score of less than minus three). The distributions for all of the children in the sample, based on the above categorization, are presented in Table 3.

Table 3: Extent of child under nutrition in East Africa, for children aged 5 years or less (%)

	Child Nutrition Status			
	HAZ>-2	Malnourished -3<HAZ<-2	At risk of abnormality HAZ<-3	Row Total
Kenya (All)	68.2	20.1	11.6	*100*
1993	66.8	20.6	12.5	*100*
2003	69.6	19.7	10.8	*100*
Rwanda (All)	55.1	25.4	19.5	*100*
1992	51.6	27.2	21.2	*100*
2000	57.8	23.6	18.7	*100*
2005	54.9	26.2	18.8	*100*
Tanzania (All)	59.3	25.3	15.4	*100*
1991/92	57.0	26.0	17.0	*100*
1996	56.7	25.4	17.8	*100*
2005	63.2	24.5	12.3	*100*
Uganda (All)	63.1	22.8	14.2	*100*
1995	61.8	23.2	15.0	*100*
2000/01	61.7	23.5	14.8	*100*
2006	68.7	20.2	11.1	*100*

Source: Author's calculations from the DHSs for Kenya, Rwanda, Tanzania, and Uganda

Formally, the order probit model is based on a latent regression variable (S_i^*), which is a linear function of observable characteristics (X) and boundary parameters (μ). This variable can be represented as follows:

(1) $$S_i^* = X^{'}\beta + \varepsilon_i$$

where β represents regression coefficients, and ε_i is the error term. The latent variable is related to child nutritional status, defined by the various categories of stunting ($j = 0,...,J$), as follows:

(2) $S_i = 0$ if $S_i^* \leq 0$ (if a child has a normal nutritional status)

=1 if $0 \leq S_i^* \leq \mu 1$ (if a child is malnourished)

=2 if $\mu 1 \leq S_i^*$ (if a child is at risk for abnormality),

where $\mu^{'}$ are the threshold parameters to be estimated with the regression coefficients (β). Following Pal (1999), we obtained the following marginal effects:

(3) $$\frac{\delta \Pr ob[cell_j]}{\delta X_k} = [\phi(\mu_{j-1} - \beta^{'} X_k) - \phi(\mu_j - \beta X_k)] * \beta ,$$

where ϕ is the standard normal function.

C. Dependent Variable

It is conventional for studies that examine the effects of child nutritional health to consider nutritional status (as measured by anthropometric indicators) up to a child's fifth birthday, even though further anthropometric information may be available on the child at an older age. For example, Currie and Thomas (1995) examined the impact of Head Start, which is a US federally-funded matching grant that targets the education and health of poor children. They used a panel sample of 6,283 young women from the National Longitudinal Survey of Youth (1979-1990) to examine the impact of Head Start on young children's immunization and nutritional status. Despite the authors' access to the newest anthropometric information on the school-going children, they nevertheless used the height for age z-scores that were closest to the children's fifth birthdays. This approach is used because, as mentioned in the introduction, nutritional deficiencies are not easily reversed once a child is over five years old. Nonetheless, studies in rich and middle-income countries have examined the effects of programs on the nutritional health of older children. For example, Daponte (2000) compared the impact of food pantries and food stamps in the US on the anthropometric measures of children below the age of 12, and the Cebu longitudinal health survey in the Philippines tracked the nutritional health of infants into adulthood (Cebu Study Team, 1991).

Researchers studying developing countries also use anthropometric z-scores to examine child nutritional health, rather than other indicators (e.g., based medical examinations) for reasons of cost. In surveys like DHS, researchers measure the height and weight of women and children aged 0-59 months. Due to resource constraints, the collection of these anthropometric measures and other background household information for a national survey can only be conducted once every five years, and it is more than likely to be externally financed by a donor agency. In more developed countries, physicians carry out the process of collecting health and nutritional data. For example, during the National Health and Nutrition Examination Survey (NHANES) in the US, physicians conducted medical examinations and collected urine and blood samples for laboratory tests. For consistency, the same teams of physician conducted the medical exam across different sampled areas. Each round of this survey took 8-10 years to complete (Currie, 2008). For most developing countries, it is not feasible to finance survey teams for more than a year.

Therefore, we adopted the standardized height for age (HAZ) z-scores for children aged five years or less as the measure of nutritional status in this study. There is extensive evidence to show that, for young children, the HAZ measure reflects any sustained experience of inadequate nutrient intake and untreated illness, which can result in stunted growth (Keller, 1983; Mosley and Chen 1984). The HAZ z-score is defined as follows:

(3) $$\frac{h - h_r}{\delta_r},$$

where h is the observed height of a child in a specific age and gender group, h_r is the median height of the reference population of children in the same gender and age group, and δ_r is the standard deviation of height for the reference population. Extensive nutritional research has shown that children's height is only remotely related to genetic or racial differences (Martorell and Habicht, 1986; WHO, 1985). Therefore, this study used the population of US children in 2000, as compiled by the US National Center for Health Statistics, as its reference population (Kuczmarski, *et al.*, 2002**)**. Following the WHO (1983) recommendations, a child was classified as stunted if the z-scores were less than two standard deviations from the reference population.

D Other variables

We defined a young child as a child aged 0-59 months. The DHS surveys only collected nutritional information for this age group, and there are important reasons for focusing on young children, which are highlighted in the introduction of this study. We included a number of the children's characteristics in our calculations. For instance, our models take into account children's demographic information, including information on gender and age. We included the age of the child, which was squared to capture any nonlinearity arising from age. Gender was included because previous research showed that boys are more likely to be malnourished than girls (Ssewanyana, 2003). The other child-level indicators that we included are the child's birth order and whether the child is a twin. These two variables show the extent of competition between children for household resources.

We considered a number of household variables. First, given that DHS surveys did not solicit information on income, we used an asset index to stand in for household wealth. Like previous studies that used DHS surveys (e.g., Filmer and Pritchett, 2000; Sahn and Stifel, 2003; Ssewanyana and Younger, 2008), our study used factor analysis to construct the asset index.[11] DHS surveys also recorded household sources of water, which allowed us to identify four variables that indicate whether a

[11] The following household assets are included in the index: having transport means (either a motor cycle or car); having a radio, TV, and refrigerator; havening access to piped water; having a non latrine toilet; the floor material used for constructing the household; and the household's head education in years.

household used piped water, a public standpipe, a borehole, and/or a protected well or spring. Water sources are important given evidence in the sub region which showed that more technologically advanced water systems e.g. bore holes do not always lead to better household health due to congestion (Ssewanyana *et al,* 2006). The use of open water sources was the reference category. Regarding toilet facilities, we considered whether a household has access to a flush toilet (the most technologically advanced toilet facility) or a traditional latrine. We also included a number of variables related to the child's mother, given the mother's primary role as caregiver. We considered the mother's age at the time her child was born and her marital status. Most importantly, we included the mother's level of educational attainment.

A number of variables related to healthcare use in the DHS surveys are choice variables, and therefore any attempt to include them in regression models would raise endogeneity concerns. Thus, we created district averages based on the year a child was born for all of the choice variables, which included whether a mother had at least one tetanus vaccination during pregnancy, whether the mother had at least one pre-natal visit during pregnancy, whether the mother had birthing assistance during childbirth, and whether the child received any or all vaccinations.

Likewise, we avoided endogenous variables in our estimations by creating cluster/community averages for the variables related to a mother's use of modern contraception and her knowledge of re-hydration therapies; these averages were conditional on the mother in question having given birth in the past five years. Previous studies using DHS data, such as Kabubo-Mariara *et al*. (2009), employed a similar mechanism to deal with potential endogeneity issues. In total, we studied data on over 52,000 children below the age of five from the four countries. Table 4 presents the means of the variables used for the combined sample and for the individual countries.

As Table 4 shows, female children made up at least 50% of our sample. Similarly, most of the children in our sample had a number of siblings; the average birth order in our sample was 3.9, and the highest in Uganda was 4.1. We found a limited use of flush toilets. This figure was highest in Kenya, where about 6% of the children resided in households with flush toilets. A substantial proportion of the mothers in our sample never had any education (28% for the entire sample), and Rwanda had the largest proportion of illiterate mothers (35%). With regard to the household asset index, we found that Kenyan children enjoy a higher welfare status compared to children in the other three East African countries. In terms of access to health services, most of the children resided in districts with relatively high coverage for any vaccinations; however, the coverage rates for all recommended vaccinations were much lower, especially in Uganda. Similarly, most mothers used prenatal care (combined average 77%), but only a small proportion gave birth under the guidance of qualified health personnel (35%). There is minimal variation in the means for access to health services across the four countries, with the exception of the use of modern contraception. About one-third of women in Kenya, compared to only 9% of Rwandan women, have ever used modern contraception.

Table 4: Means of the variables used in the analysis, by country

	All countries	Country			
	combined	Kenya	Rwanda	Tanzania	Uganda
Height for Age z-score (HAZ)	-1.06	-1.34	-1.07	-1.70	-1.56
Rural	0.86	0.86	0.88	0.81	0.90
Log of Household Assets Index	0.32	0.41	0.26	0.33	0.33
Source of household water					
Piped water in the dwelling	0.14	0.20	0.10	0.21	0.03
Piped water through a public stand pipe	0.09	0.05	0.20	0.06	0.04
Protected Well/Spring	0.54	0.45	0.33	0.58	0.79
Surface water	0.19	0.18	0.38	0.13	0.12
Other Water sources	0.01	0.03	0.00	0.02	0.01
Type of toilet facility					
Flush toilet	0.02	0.06	0.01	0.01	0.01
Latrine	0.75	0.74	0.67	0.83	0.76
Other toilet facility	0.16	0.21	0.13	0.16	0.23
Child's own characteristics					
Gender of the child is female	0.50	0.50	0.50	0.50	0.50
Birth Order	3.93	3.79	4.02	3.80	4.14
Child is a twin	0.02	0.02	0.02	0.03	0.02
Age of the child in months	27	29	28	27	25
Age of the child squared	1,030	1,110	1,096	1,030	896
Education attainment of the mother					
Mother's education, no schooling	0.28	0.16	0.35	0.29	0.27
Mother's education, some primary	0.27	0.18	0.35	0.15	0.41
Mother's education, primary school graduate	0.36	0.44	0.21	0.52	0.21
Mother's education, primary school graduate	0.05	0.09	0.06	0.01	0.08
Mother's education, completed secondary school and above	0.05	0.13	0.03	0.02	0.04
Mother's age at child's birth	27	27	29	27	26
Marital status of the mother					
Mother never married at time of birth	0.04	0.06	0.03	0.05	0.03
Mother formerly married	0.08	0.07	0.11	0.08	0.08
Mother in polygamous household	0.17	0.14	0.09	0.20	0.25
District averages for access to health services					
Year/district average, any vaccination	0.92	0.93	0.96	0.93	0.86
Year/district average, all vaccinations	0.49	0.54	0.63	0.47	0.33
Year/district average, tetanus toxoid	0.81	0.88	0.72	0.86	0.77
Year/district average, any prenatal care	0.77	0.89	0.93	0.52	0.87
Year/district average, any birth attendant	0.35	0.43	0.24	0.38	0.38
Community/Cluster averages					
Cluster average, use of modern contraception	0.15	0.28	0.09	0.14	0.15
Cluster average, rehydration knowledge (birth past 5 yrs)	0.87	0.76	0.87	0.94	0.84
Number of observations	*52,486*	*9,324*	*13,608*	*17,905*	*11,648*

VI. Ordered probit results

Table 5 shows the ordered probit estimates for the four countries combined. In Model 1, we only included the country dummy variables and used Rwanda as the excluded option, but in Model two we included both the country and survey year dummy variables. We used STATA's svyoprobit command to make our estimations; we used the cluster as the principal sampling unit (PSU) and applied household weights. Only the statistically significant variables in our estimations are discussed below. In Model 1, the statistically significant variables include household asset holding, access to a public standpipe, the child's gender, the mother's educational attainment, vaccination coverage, and the mother's access to health facilities for child birth. A positive coefficient implies that the particular variable increases a child's risk for severe stunting (Category 2), and a negative coefficient suggests that the variable can improve a child's nutritional status. For instance, we found that the variables of household wealth status, access to a public standpipe, mother's education attainment, and mother access to health facilities have a negative effect on a child's risk for abnormalities that result from malnutrition before the age of five. On the other hand, we found that the number of a child's siblings, increased age, and vaccination coverage increase a child's risk for abnormalities resulting from under-nutrition.

Table 5 shows that most of the indicators related to the children themselves are significantly related to the severity of malnutrition. For instance, female children are less likely to be either malnourished or severely malnourished than male children. Additionally, the severity of malnutrition increases with age but at a decreasing rate; this finding is indicated by the significance of the squared variable for a child's age. A child's birth order is also significant; older siblings face a higher risk of malnutrition than new born children. Finally, we found that children with multiple siblings significantly suffer from malnutrition, which suggests that children in larger families, in all four countries, face increased competition for scarce nutritional resources. Furthermore, the mothers' characteristics, especially educational attainment, are important for reducing malnutrition. Column 1 of Table 5 shows that when a mother has some primary-level education, the severity of the child's malnutrition is significantly reduced. It should also be noted that the size of the education variables increases with higher maternal educational attainment. A mother's attainment of a secondary or higher level education significantly reduces the severity of her child's malnutrition compared to the severity of malnutrition for a child whose mother either attained some secondary-level education or graduated from primary school.

Table 5: Ordered probit estimates for nutritional status of children (0-5 years) in East Africa, 1992-2006

Variable	**Country only dummy variable** Model [1]		**Country and Year dummy variables** Model [2]	
	Coefficient	T-statistic	Coefficient	T-statistic
Rural	0.049	[1.57]	0.033	[1.09]
Log of Household Assets	-0.479	[15.83]**	-0.539	[16.47]**
Household water sources (cf: unprotected well/spring)				
Piped water in the dwelling	-0.036	[1.31]	-0.074	[2.32]*
Piped water from public stand pipe	-0.057	[2.11]*	-0.042	[1.55]
Protected Well/Spring	-0.009	[0.40]	-0.051	[1.99]*
Other water sources	-0.069	[0.95]	-0.106	[1.48]
Toilet facility used by the household (cf: no toilet)				
Flush toilet	-0.068	[0.92]	-0.016	[0.22]
Latrine	-0.036	[1.88]	-0.005	[0.25]
Child is female	-0.104	[8.66]**	-0.104	[8.66]**
Child's birth order	0.031	[6.01]**	0.029	[5.72]**
Multiple birth	0.588	[12.24]**	0.588	[12.21]**
Child's age in months	0.055	[27.94]**	0.055	[27.37]**
Child's age squared	-0.001	[25.75]**	-0.001	[25.23]**
Household size, including visitors	-0.013	[4.48]**	-0.013	[4.45]**
Education attainment of the mother (cf: No education)				
Mother's education, some primary	-0.034	[1.88]	-0.028	[1.57]
Mother's education, primary school graduate	-0.088	[5.04]**	-0.085	[4.90]**
Mother's education, some secondary	-0.215	[6.38]**	-0.2	[5.93]**
Mother's education, completed secondary school and above	-0.326	[8.02]**	-0.314	[7.72]**
Mother's age at child's birth	-0.015	[8.12]**	-0.015	[7.79]**
Marital status of the mother (cf: Married monogamously)				
Mother never married at time of birth	0.11	[3.45]**	0.105	[3.31]**
Mother formerly married	0.052	[2.38]*	0.055	[2.52]*
Mother in polygamous household	0.051	[2.76]**	0.052	[2.79]**
District averages for access to health services				
Year/district average, any vaccination	0.418	[4.56]**	0.549	[5.51]**
Year/district average, all vaccinations	0.377	[10.00]**	0.362	[8.72]**
Year/district average, tetanus toxoid	-0.025	[0.46]	-0.154	[2.62]**
Year/district average, any prenatal care	-0.087	[1.65]	-0.075	[1.36]
Year/district average, any birth attendant	-0.23	[4.53]**	-0.249	[4.96]**
Cluster/Community average for access to health services				
Cluster average, use of modern contraception	-0.178	[3.43]**	-0.217	[3.97]**
Cluster average, re-hydration knowledge (birth past 5 yrs)	-0.062	[1.20]	-0.01	[0.20]
Country Dummies (cf: Rwanda)				
Kenya	-0.14	[4.78]**		
Tanzania	-0.014	[0.39]		
Uganda	-0.041	[1.36]		
Country and Year Dummies (cf: Rwanda 1992)				
Kenya_1993			-0.267	[7.93]**
Kenya_2003			-0.206	[5.30]**
Rwanda_2000			-0.213	[5.02]**
Rwanda_2005			-0.183	[4.22]**
Tanzania_1992			-0.048	[1.06]
Tanzania_1996			-0.138	[2.77]**
Tanzania_2005			-0.103	[2.41]*
Uganda_1995			-0.065	[1.79]
Uganda_2001			-0.118	[2.93]**
Uganda_2006			-0.251	[5.76]**
m1μ			0.94	[6.38]**
m2μ			1.77	[12.02]**
Number of observations	*52,474*		*52,476*	

T-statistics in brackets * significant at 5%; ** significant at 1%

As is the case for traditional probit models, our parameter coefficients for the ordered probit did not provide any information on the magnitude of a given change. This information is provided by marginal effects estimations, and Table 6 presents the marginal effects for the cross-country models for selected policy variables. For continuous variables (e.g., household wealth status), the marginal probit suggested that, given a unit change in the explanatory variable with the other variables evaluated at the mean, there would be either an increase or decrease in the probability that a child would be placed in a particular category of malnutrition (i.e., normal, under-nourished, or severely stunted). For binary variables, the marginal probits indicated a decrease (or increase) in the probability that a given binary variable would take on a value of one. The tables show the marginal values for the different categories of malnutrition, and a child aged five years and below of normal nutritional status is used as the base. In an earlier draft of this paper, we studied children aged 0-36 months; for this restricted sample, neither the marginal values nor the levels of significance differed much from the results reported here, for children aged 0-59 months.

Table 6: Marginal probabilities for selected policy variables

	Country only dummies [Model 1]		Country and year dummies [Model 2]	
	Nutrition category (Normal is the base)		Nutrition category (Normal is the base)	
	Stunted	Severely stunted	Stunted	Severely stunted
Household water sources				
Piped water in the dwelling	-0.027	-0.048	-0.044	**-0.077**
Piped water from public stand pipe	**-0.033**	**-0.057**	-0.024	-0.043
Protected Well/Spring	-0.010	-0.018	-0.028	**-0.049**
Other water sources	-0.038	-0.067	-0.059	-0.101
Toilet facility used by the household				
Flush toilet	-0.037	-0.066	-0.009	-0.016
Latrine	-0.019	-0.035	-0.003	-0.005
Education attainment of the mother				
Mother's education, some primary	**-0.017**	**-0.031**	-0.013	-0.024
Mother's education, primary school graduate	**-0.049**	**0.085**	**-0.043**	**-0.076**
Mother's education, some secondary	**-0.109**	**-0.180**	**-0.096**	**-0.159**
Mother's education, completed secondary school and above	**-0.172**	**-0.268**	**-0.152**	**-0.241**
District averages for access to health services				
Year/district average, any vaccination	**0.194**	**0.422**	**0.299**	**0.720**
Year/district average, all vaccinations	**0.223**	**0.498**	0.196	**0.427**
Year/district average, tetanus toxoid	-0.014	-0.025	-0.088	**-0.147**
Year/district average, any prenatal care	-0.045	-0.079	-0.052	-0.090
Year/district average, any birth attendant	**-0.129**	**-0.209**	**-0.127**	**-0.206**
Cluster/Community average for access to health services				
Cluster average, use of modern contraception	**-0.099**	**-0.164**	**-0.118**	**-0.192**
Cluster average, re-hydration knowledge (birth past 5 yrs)	-0.029	-0.052	-0.005	-0.010
Kenya	-0.090	**-0.151**		
Tanzania		-0.050		
Uganda		-0.089		
Country and Year Dummies (cf: Rwanda 1992)				
Kenya_1993			**-0.195**	**-0.298**
Kenya_2003			**-0.163**	**-0.256**
Rwanda_2000			**-0.163**	**-0.255**
Rwanda_2005			**-0.146**	**-0.233**
Tanzania_1992			-0.026	-0.047
Tanzania_1996			**-0.126**	**-0.204**
Tanzania_2005			**-0.103**	**-0.171**
Uganda_1995			-0.036	-0.063
Uganda_2001			**-0.112**	**-0.184**
Uganda_2006			**-0.183**	**-0.282**

Notes: The marginal effects are estimated for only key policy variables and are obtained using equation 3. The coefficients in bold indicate that the estimated effect is statistically significant at the 5% level as detailed in Table 5

We found that, among the variables for access to public goods, shown in Model 1, only household access to piped water from a public stand pipe significantly affects the risk of under-nutrition. In particular, the marginal value of -0.033 suggests that if a child is resident in a household with access to a public stand pipe, his probability of being malnourished is reduced by 3.3 percentage points. The availability of public stand pipe also reduces the probability of a child being severely stunted by 5.7 percentage points. For maternal educational attainment, Model 1 shows that a higher educational attainment reduces stunting by 1.7 to 17.2 percentage points, depending on the education level.

Regarding other key policy variables, Model 1 shows that children from districts where a higher proportion of mothers give birth under the supervision of health professionals are significantly less likely to be malnourished. Specifically, a more widespread use of maternal health services in a district reduces the risk of stunting by 12.9 percentage points and reduces the risk of severe stunting by 20.9 percentage points. This variable stands in for the availability and use of maternal health services for childbirth. Therefore, the results suggest that children from areas where mothers are more likely to use health facilities have significantly better nutritional status.

On the other hand, the results of the variable “any vaccination” coverage were contrary to our expectations. In particular, we found that the children from areas with higher rates of “any vaccination” coverage are significantly more stunted. As Table 4 indicates, most children have received some form of vaccination, but only a few have completed all of the required vaccinations. For all of the countries combined, a child’s completion all of the required vaccinations also significantly increases his risk of malnutrition. We believe that this combined model may capture some country-specific and year effects and that the completion of all vaccinations does not, in itself, increase the severity of child malnutrition. Other community-level factors that significantly reduce the severity of malnutrition include the proportion of women in a community who use modern contraception. In terms of actual country indicators, Model 1 shows that the probability of child being stunted drops by 9 percentage points if the child is in Kenya, and the corresponding probability for severe stunting is 15.1 percentage points.

In Model 2, we included both country and year dummy variables to examine the trajectory of children's nutritional status in the four countries since 1992. We selected Rwandese children in 1992 as the base category. We found that, on average, the probability of a child being stunted drops by 19.5 percentage points if the child was resident in Kenya in 1993. On the other hand, the same residence compared to Rwandese children in 1992 reduced the probability of a child being severely stunted by 29.8 percentage points. The marginal values for Kenya also reveal that young children in the country had better nutritional health in 1993 than they did in 2003. In Rwanda, although the probability of children being severely stunted was lower in 2005 than in 1992, the probability of any severe category of under-nutrition was higher in 2005 than in 2000. Since 2001, Uganda appears to have made consistent progress in reducing malnutrition compared to the base category of. Given the overwhelming significance of these year and cohort variables, we concluded that, relative to Rwandese children in 1992, most children in East Africa have achieved better nutritional health over time.

Although it is informative, the cross-country model can mask important trends and their significance. For example, it is possible that maternal education matters in some countries and not others depending on the national level of illiteracy. Consequently, we estimated country-specific ordered probit models. Tables 7, 8, 9, and 10 show the ordered probit estimates for Kenya, Rwanda, Tanzania, and Uganda, respectively. In each country, we estimated a combined model and a separate survey year model. In the discussion below, we focus on the policy variables of safe water and sanitation, maternal education, vaccination, and maternal access to health services.

The tables show that the significant variables differ widely between the countries and over time. First, some sanitation sources do significantly reduce the risk of various forms of under-nutrition. In particular, the presence of an improved sanitation source (latrine) reduces the probability of child stunting in Rwanda and, to limited extent, in Kenya in 1993. On a related point, we found that water sources, with the exception of Tanzania's, do not consistently contribute to reducing the risk of under-nutrition. In Tanzania (Table 9), the variables of piped water in a dwelling and access to a protected well or spring significantly reduced the severity of malnutrition in 1992 and 2005, but not in 1996.

Second, whereas Table 5 shows that maternal education was important in the combined model, a different picture emerges at the country level. For Kenya, only some secondary education significantly reduced the probability of stunting and the risk of severe stunting. Similarly, for Rwanda, maternal attainment of some secondary education had an impact on stunting risk, but only in 1992 and 2000. For Tanzania, maternal attainment of some primary education reduced the probability of a child being either stunted or severely stunted up to 1996, but, from then on, only secondary school attainment had an impact. No consistent picture emerged for Uganda because maternal attainment of some secondary education was significant only in 1995, and post-secondary schooling was significant in 2000. Other maternal characteristics that differ across the countries include a mother's age when she gives birth. This variable is most consistent in Uganda, where, for the 1995-2006 period, children with older mothers had a lower probability of being stunted or severely stunted. We obtained similar results for maternal age for Kenya, Rwanda, and, to a limited extent, Tanzania. The above results suggest that early childbirth significantly increases the risk of under-nutrition among children; this variable is also closely associated with school dropouts and, consequently, lower maternal educational attainment.

As noted above, the indicator for "any vaccination" coverage significantly increased the severity of malnutrition in Tanzania and Uganda, but not in Rwanda. On the other hand, in all four countries, districts with higher coverage rates for "all recommended vaccinations" reported significantly reduced malnutrition. Indeed, it appears that Tanzania and Uganda drove the significance of these variables, as recorded in Table 5. Overall, the results suggest that receiving some vaccinations does not reduce the risk of malnutrition; consequently, receiving only some vaccinations may be just as bad as receiving none. This result suggests that vaccination programs aimed at reducing malnutrition will be more effective if they target children who have not received the recommended number of inoculations. The results regarding access to other health services also vary across countries. For example, maternal receipt of tetanus toxoid inoculations appears to have been important in the early 1990s. Furthermore, maternal use of health facilities, for both prenatal care and childbirth, improved children's nutritional status in Uganda and Rwanda.

Finally, contrary to the picture that the cross-country estimations provided, most of the country models do not show any significant year effects. For Kenya, the estimates in Table 7 show that children were not significantly better off in 2003 compared to 1993. Similarly, although Rwanda's results show a general improvement in nutritional status in 2000 and 2005 compared to 1992, the particular results are nevertheless not significant. The results suggest that Uganda only made improvements to child nutritional status in 2005; however, these results have a weak significance at the level of 10%. Indeed, it is only Tanzania that appears to have recorded a significant reduction in malnutrition between 1992 and 2005. Consequently, the above within-country trends suggest that these countries have only made minimal progress in reducing the severity of national under-nutrition.

VII. Conclusions and implications

This study examined the determinants of child nutritional status in East Africa, a region that accounts for a disproportionate share of the global and SSA population of undernourished children aged five years and under. Using 11 nationally representative surveys of 52,000 young children, we found that, compared to the worst-affected children in 1992, children in most countries made some modest progress toward better nutritional health. However, a number of countries have stalled or even reversed the tide of reducing malnutrition, as happened in Kenya between 1993 and 2003. Additionally, vaccinations reduce children's susceptibility to illness and, consequently, are important for nutritional health. This result suggests that efforts to reduce malnutrition should place more emphasis on ensuring that all children receive the recommended inoculations for their age groups. Most countries in East Africa have implemented nation-wide vaccination days, called *child days*.

The large impact of mothers' educational attainment on child nutritional health suggests that post-primary education has an increasingly large payoff. Previously, in keeping with the millennium development goals, education policy in East Africa focused on universal primary education, and countries such as Uganda and Kenya have managed to sustain primary school enrollments of over 90%. However, the above results indicate that this initiative will have only a small impact on child nutritional status and that universal secondary education would have a much larger impact. However, guaranteeing post-secondary education does not seem feasible, at least in the medium-term, given the costs and efforts these countries have undertaken in the struggle to reduce primary school dropouts.

The results also highlight the importance of maternal access to and use of health facilities for childbirth. As highlighted by previous authors, the nutrition status of young children is heavily influenced by the health status of mothers during pregnancy and while breast feeding (Horton *et al*., 2008; Behrman *et al*., 2004). However, it remains puzzling that women in SSA actively use pre-natal clinics but fail to use health facilities in childbirth. Nonetheless, the implementation of incentive programs like those that Uganda has piloted (i.e., providing birthing kits to pregnant women) appears to be increasing women's confidence to use health facilities. However, most of these initiatives are still driven by donor projects and are yet to be integrated fully into national health ministries.

It is also important to consider whether low-income countries can implement national programs that target nutritional health like those in the US and middle-income countries in Latin America. Limited resources and capabilities make it inconceivable for any of the four East African countries to implement large-scale programs for nutritional health similar to the WIC program in the US or the PROGRESA-Oportunidades program in rural Mexico. Apart from the recurrent costs of running such interventions (e.g., the WIC program costs US$49 per participant per month[12]),

[12] Bitler and Currie (2004).

most low-income countries lack the personnel and infrastructure required to initiate such programs on a national scale. For example, in Uganda, about 35% of the approved health posts in public health facilities remain vacant (Government of Uganda, 2008) and public health services are in some cases of low quality (Kappel *et al*., 2005). Thus, any attempt to initiate an intervention like the WIC program in a country like Uganda would face the problem of inadequate numbers of qualified health personnel.

Also, previous cross country studies examining malnutrition point to the importance of incomes if the MDG of halving under nutrition is to be attained (e.g. Alderman *et al*., 2003). Without sustained growth in real household incomes—as has been the case in most of East Africa, the alternative is to provide some form of cash transfer. However, the large population of potential beneficiaries in low-income countries makes nationwide cash transfer programs impracticable. For example, the WIC program in the US required participating households to be below 180% of the US federal poverty line. Bitler *et al*. (2003) reported that there were 8 million individuals, or about 3% of the US population, enrolled in the WIC program in 2000. In East Africa, children under 15 years old make up 50% of the total population; thus, a much larger population would be eligible for a US-style program. Likewise, any intervention that based participant eligibility on poverty status would also encounter a large population of potential program recipients. As such, the few cash transfer programs that have been implemented in some African countries remain limited to a small scale due to the consideration of substantial costs.

Table 7: Ordered probit estimates for nutritional status in Kenya (children 0-5 years), 1993 & 2003

Variable	Combined	Survey year	
		1993	2003
Rural	-0.051	0.141	-0.164
	[0.85]	[1.65]	[2.13]*
Log of Household Assets	-0.543	-0.504	-0.571
	[6.66]**	[3.94]**	[5.09]**
Household water sources (cf: unprotected well/spring)			
Piped water in the dwelling	-0.091	0.025	-0.136
	[1.29]	[0.12]	[1.45]
Piped water from public stand pipe	-0.146		-0.184
	[1.75]*		[2.07]*
Protected Well/Spring	-0.079	-0.002	-0.118
	[1.38]	[0.01]	[1.76]
Other water sources	-0.149	-0.05	-0.189
	[1.37]	[0.22]	[1.39]
Toilet facility used by the household (cf: no toilet)			
Flush toilet	-0.116	-0.364	0.097
	[0.99]	[1.63]	[0.69]
Latrine	-0.05	-0.171	0.087
	[1.21]	[3.03]**	[1.36]
Child is female	-0.154	-0.143	-0.176
	[5.02]**	[3.03]**	[4.73]**
Child's birth order	0.04	0.041	0.047
	[2.94]**	[2.25]*	[2.40]*
Multiple birth	0.486	0.119	0.749
	[3.60]**	[0.63]	[4.49]**
Child's age in months	0.061	0.057	0.066
	[13.44]**	[7.45]**	[11.16]**
Child's age squared	-0.001	-0.001	-0.001
	[13.57]**	[7.65]**	[11.09]**
Household size, including visitors	0.011	0.007	0.013
	[1.81]	[0.88]	[1.46]
Education attainment of the mother (cf: No education)			
Mother's education, some primary	0.093	0.132	0.006
	[1.52]	[1.83]*	[0.06]
Mother's education, primary school graduate	-0.041	-0.022	-0.097
	[0.78]	[0.30]	[1.27]
Mother's education, some secondary	-0.218	-0.24	-0.24
	[2.91]**	[2.42]*	[2.05]*
Mother's education, completed secondary school and above	-0.267	-0.187	-0.367
	[3.23]**	[1.64]	[3.17]**
Mother's age at child's birth	-0.02	-0.021	-0.02
	[3.97]**	[2.98]**	[2.82]**
Marital status of the mother (cf: Married monogamously)			
Mother never married at time of birth	0.049	0.09	0.018
	[0.72]	[0.96]	[0.18]
Mother formerly married	0.01	-0.056	0.074
	[0.16]	[0.67]	[0.87]
Mother in a polygamous Household	0.021	0.038	0.01
	[0.42]	[0.57]	[0.14]
District averages for access to health services			
Year/district average, any vaccination	0.817	0.085	1.106
	[3.91]**	[0.22]	[4.84]**
Year/district average, all vaccinations	0.211	0.372	0.146
	[1.91]	[1.90]*	[1.08]
Year/district average, tetanus toxoid	-0.171	-0.61	-0.148
	[1.05]	[1.87]	[0.75]
Year/district average, any prenatal care	0.077	0.005	0.064
	[0.42]	[0.01]	[0.29]
Year/district average, any birth attendant	-0.056	0.136	-0.261
	[0.52]	[0.85]	[1.94]
Cluster/Community average for access to health services			
Cluster average, use of modern contraception	-0.299	-0.375	-0.189
	[3.13]**	[2.85]**	[1.43]
Cluster average, rehydration knowledge (birth past 5 yrs)	0.141	0.216	0.104
	[1.43]	[1.50]	[0.77]
Year dummies	0.077		
Year2003	[1.32]		
m1μ	1.303	0.155	1.36
	[5.39]	[0.99]	[4.67]
m2μ	2.08	1.28	2.14
	[8.64]	[2.47]	[7.36]
Number of Observations	*9,416*	*4,876*	*4,540*

T-statistics in brackets * significant at 5%; ** significant at 1%

Table 8: Ordered probit estimates for nutritional status in Rwanda (children 0-5 years), 1992-2005

	Combined	Survey year		
		1992	2000	2005
Rural	0.043	-0.266	0.022	0.077
	[0.83]	[1.87]*	[0.25]	[1.04]
Log of Household Assets	-0.511	-0.366	-0.555	-0.853
	[9.60]**	[5.48]**	[5.27]**	[5.66]**
Household water sources (cf: unprotected well/spring)				
Piped water in the dwelling	-0.05	-0.235	-0.159	-0.149
	[0.76]	[1.38]	[1.26]	[0.74]
Piped water from public stand pipe	-0.021	-0.45	-0.003	-0.043
	[0.58]	[1.71]*	[0.06]	[0.72]
Protected Well/Spring	0.046	-0.177	0.084	0.051
	[1.13]	[1.03]	[1.52]	[0.80]
Other water sources	-0.186	0.175	-0.351	-0.113
	[0.60]	[1.00]	[0.76]	[0.28]
Toilet facility used by the household (cf: no toilet)				
Flush toilet	-0.377		-0.369	0.056
	[1.78]		[1.34]	[0.19]
Latrine	-0.166		-0.158	-0.174
	[2.13]*		[1.72]*	[1.34]
Child is female	-0.083	-0.092	-0.109	-0.035
	[3.52]**	[2.21]*	[3.22]**	[0.78]
Child's birth order	0.039	0.021	0.056	0.042
	[4.02]**	[1.29]	[3.55]**	[2.34]*
Multiple birth	0.641	0.915	0.702	0.386
	[7.04]**	[4.23]**	[4.84]**	[2.42]*
Child's age in months	0.029	0.03	0.029	0.038
	[7.13]**	[3.80]**	[4.97]**	[4.16]**
Child's age squared	0	0	0	-0.001
	[5.64]**	[2.76]**	[3.78]**	[4.02]**
Household size, including visitors	-0.025	-0.019	-0.044	-0.008
	[3.39]**	[1.49]	[3.90]**	[0.47]
Education attainment of the mother (cf: No education)				
Mother's education, some primary	-0.032	0.001	-0.025	-0.073
	[1.23]	[0.02]	[0.56]	[1.30]
Mother's education, primary school graduate	-0.06	-0.096	-0.035	-0.071
	[1.85]	[1.42]	[0.66]	[1.06]
Mother's education, some secondary	-0.192	-0.352	-0.216	0.028
	[3.28]**	[3.37]**	[2.36]*	[0.23]
Mother's education, completed secondary school and above	-0.057	-0.404	0.048	0.189
	[0.63]	[1.79]*	[0.37]	[1.11]
Mother's age at child's birth	-0.014	-0.007	-0.016	-0.02
	[4.11]**	[1.08]	[3.07]**	[3.46]**
Marital status of the mother (cf: Married monogamously)				
Mother never married at time of birth	0.004	0.179	-0.002	-0.204
	[0.05]	[1.52]	[0.02]	[1.81]
Mother formerly married	-0.016	0.097	-0.08	-0.005
	[0.43]	[1.19]	[1.55]	[0.07]
Mother in polygamous household	0.124	-0.023	0.166	0.245
	[2.96]**	[0.37]	[2.45]*	[2.91]**
District averages for access to health services				
Year/district average, any vaccination	0.471	-0.633	0.827	2.024
	[0.80]	[0.67]	[0.60]	[2.27]*
Year/district average, all vaccinations	0.911	1.042	0.899	0.758
	[8.14]**	[5.02]**	[5.18]**	[2.94]**
Year/district average, tetanus toxoid	-0.01	-2.128	0.277	-0.108
	[0.06]	[2.43]*	[1.07]	[0.39]
Year/district average, any prenatal care	-0.318	0.252	-0.115	-0.759
	[1.00]	[0.22]	[0.28]	[1.12]
Year/district average, any birth attendant	-0.189	-0.653	-0.344	0.169
	[1.36]	[2.20]*	[1.30]	[0.54]
Cluster/Community average for access to health services				
Cluster average, use of modern contraception	-0.212	-0.31	0.066	-0.38
	[1.48]	[1.55]	[0.20]	[1.60]
Cluster average, rehydration knowledge (birth past 5 yrs)	-0.188	-0.237	-0.159	-0.195
	[2.04]*	[1.46]	[1.14]	[1.04]
Year dummies				
Year2000	0.017			
	[0.17]			
Year2005	0.053			
	[0.50]			
m1μ	0.484	-2.259	1.107	1.37
	[0.85]	[2.03]*	[0.83]	[1.36]
m2μ	1.291	-1.419	1.849	2149
	[2.27]*	[1.45]	[1.44]	[2.18]
Number of Observations	*13,608*	*4,137*	*5,889*	*3,582*

T-statistics in brackets * significant at 5%; ** significant at 1%

Table 9: Ordered probit estimates for nutritional status Tanzania (children 0-5 years), 1992-2005

	Combined	Survey year		
		1992	1996	2005
Rural	0.071	0.032	0.17	0.036
	[1.15]	[0.29]	[2.36]*	[0.45]
Log of Household Assets	-0.646	-0.597	-0.559	-0.715
	[10.29]**	[6.11]**	[3.92]**	[7.41]**
Household water sources (cf: unprotected well/spring)				
Piped water in the dwelling	-0.055	-0.504	0.826	-0.248
	[1.08]	[5.48]**	[5.00]**	[2.20]*
Piped water from public stand pipe				-0.063
				[1.11]
Protected Well/Spring	-0.023	-0.412	0.796	-0.026
	[0.52]	[3.59]**	[4.76]**	[0.49]
Other water sources	-0.055	-0.433	0.23	-0.027
	[0.46]	[2.23]*	[0.74]	[0.16]
Toilet facility used by the household (cf: no toilet)				
Flush toilet	-0.121	-0.053	-0.1	-0.173
	[0.69]	[0.14]	[0.31]	[0.66]
Latrine	0.061	0.093	0.018	0.047
	[1.60]	[1.48]	[0.28]	[0.88]
Child is female	-0.082	-0.114	-0.078	-0.057
	[3.76]**	[3.08]**	[2.11]*	[1.63]
Child's birth order	0.012	0.02	0.006	0.009
	[1.26]	[1.31]	[0.41]	[0.62]
Multiple birth	0.653	0.662	0.741	0.604
	[9.36]**	[5.93]**	[4.66]**	[5.22]**
Child's age in months	0.06	0.051	0.06	0.06
	[17.31]**	[6.98]**	[9.91]**	[11.55]**
Child's age squared	-0.001	-0.001	-0.001	-0.001
	[15.72]**	[6.53]**	[9.27]**	[9.82]**
Household size, including visitors	-0.018	-0.01	-0.014	-0.027
	[4.75]**	[1.72]*	[2.03]*	[5.18]**
Education attainment of the mother (cf: No education)				
Mother's education, some primary	-0.034	0.006	-0.145	-0.001
	[0.90]	[0.10]	[2.36]*	[0.02]
Mother's education, primary school graduate	-0.083	-0.155	-0.105	-0.021
	[2.84]**	[2.75]**	[2.09]*	[0.39]
Mother's education, some secondary	-0.153	-0.264	-0.089	-0.118
	[2.02]*	[1.46]	[0.69]	[0.92]
Mother's education, completed secondary school and above	-0.335	-0.363	-0.542	-0.2
	[3.37]**	[1.88]	[2.50]*	[1.26]
Mother's age at child's birth	-0.009	-0.016	-0.006	-0.006
	[2.58]*	[2.66]**	[1.16]	[1.27]
Marital status of the mother (cf: Married monogamously)				
Mother never married at time of birth	0.181	0.027	0.257	0.273
	[3.11]**	[0.28]	[2.79]**	[2.52]*
Mother formerly married	0.103	0.015	0.143	0.16
	[2.49]*	[0.20]	[2.10]*	[2.50]*
Mother in polygamous household	0.038	-0.025	0.049	0.053
	[1.26]	[0.47]	[0.95]	[1.01]
District averages for access to health services				
Year/district average, any vaccination	0.66	0.62	0.668	0.766
	[3.82]**	[1.89]*	[2.08]*	[2.48]*
Year/district average, all vaccinations	0.183	0.384	0.421	-0.135
	[2.85]**	[2.32]*	[4.05]**	[1.27]
Year/district average, tetanus toxoid	-0.157	-0.12	-0.852	-0.02
	[1.63]	[0.35]	[3.49]**	[0.19]
Year/district average, any prenatal care	-0.092	-0.455	-0.017	0.001
	[1.40]	[1.75]*	[0.14]	[0.01]
Year/district average, any birth attendant	-0.221	-0.068	-0.206	-0.246
	[2.67]**	[0.36]	[1.61]	[2.19]*
Cluster/Community average for access to health services				
Cluster average, use of modern contraception	-0.148	-0.096	-0.048	-0.259
	[1.37]	[0.28]	[0.27]	[1.65]
Cluster average, rehydration knowledge (birth past 5 yrs)	0.125	0.792	0.037	0.054
	[1.08]	[2.36]*	[0.16]	[0.40]
Year1996	-0.102			
	[2.67]**			
Year2005	-0.098			
	[1.92]*			
m1μ	1.103	0.991	1.545	1.192
	[4.11]**	[2.12]*	[4.06]**	[3.11]**
m2μ	1.896	1.848	2.369	2.106
	[7.58]**	[4.01]**	[6.14]**	[5.46]**
Number of observations	*17,905*	*6,043*	*5,098*	*6,764*

T-statistics in brackets * significant at 5%; ** significant at 1%

Table 10: Ordered probit estimates for nutritional status in Uganda (children 0-5 years), 1995-2006

	Combined	Survey year		
		1995	2000	2006
Rural	0.06	0.163	0.067	-0.072
	[1.05]	[1.92]*	[0.80]	[0.50]
Log of Household Assets	-0.482	-0.541	-0.419	-0.621
	[6.63]**	[4.79]**	[3.94]**	[4.04]**
Household water sources (cf: unprotected well/spring)				
Piped water in the dwelling	-0.049	-0.199	-0.06	0.393
	[0.50]	[1.07]	[0.22]	[1.67]
Piped water from public stand pipe	-0.012		-0.02	-0.045
	[0.15]		[0.18]	[0.29]
Protected Well/Spring	-0.114	-0.253	-0.123	-0.036
	[2.06]*	[1.47]	[1.88]*	[0.38]
Other water sources	0.061	0.212	-0.149	0.423
	[0.40]	[0.82]	[0.84]	[1.33]
Toilet facility used by the household (cf: no toilet)				
Flush toilet	0.141	0.081	0.143	-0.249
	[0.75]	[0.37]	[0.49]	[0.71]
Latrine	0.06	-0.014	0.139	0.035
	[1.68]	[0.22]	[2.08]*	[0.57]
Child is female	-0.121	-0.117	-0.115	-0.146
	[5.17]**	[2.89]**	[3.40]**	[2.82]**
Child's birth order	0.053	0.044	0.06	0.073
	[4.86]**	[2.76]**	[3.22]**	[3.23]**
Multiple birth	0.531	0.454	0.44	0.877
	[4.76]**	[2.53]*	[3.02]**	[3.36]**
Child's age in months	0.06	0.097	0.051	0.05
	[14.07]**	[9.85]**	[7.87]**	[6.30]**
Child's age squared	-0.001	-0.002	-0.001	-0.001
	[12.74]**	[9.00]**	[7.33]**	[4.95]**
Household size, including visitors	-0.007	0.01	-0.024	-0.016
	[1.21]	[1.22]	[2.50]*	[1.26]
Education attainment of the mother (cf: No education)				
Mother's education, some primary	-0.046	-0.06	-0.074	0.055
	[1.23]	[1.09]	[1.27]	[0.65]
Mother's education, primary school graduate	-0.126	-0.11	-0.192	0.015
	[2.97]**	[1.45]	[3.42]**	[0.16]
Mother's education, some secondary	-0.065	-0.192	0.053	-0.068
	[0.92]	[1.77]	[0.58]	[0.43]
Mother's education, completed secondary school and above	-0.255	-0.101	-0.449	-0.193
	[2.85]**	[0.69]	[3.29]**	[0.92]
Mother's age at child's birth	-0.029	-0.028	-0.03	-0.033
	[6.76]**	[4.12]**	[4.17]**	[3.57]**
Marital status of the mother (cf: Married monogamously)				
Mother never married at time of birth	0.09	0.126	-0.049	0.307
	[1.01]	[1.01]	[0.32]	[1.51]
Mother formerly married	0.096	-0.005	0.178	0.138
	[1.92]	[0.06]	[2.13]*	[1.32]
Mother in polygamous household	0.093	0.076	0.138	0.025
	[2.57]*	[1.31]	[2.54]*	[0.35]
District averages for access to health services				
Year/district average, any vaccination	0.428	0.599	0.171	0.844
	[2.54]*	[2.06]*	[0.71]	[1.96]
Year/district average, all vaccinations	0.216	0.075	0.292	-0.653
	[1.91]*	[0.35]	[1.77]*	[1.95]
Year/district average, tetanus toxoid	-0.093	-0.168	0.019	-0.321
	[0.74]	[0.59]	[0.11]	[1.54]
Year/district average, any prenatal care	-0.265	-0.103	-0.47	0.233
	[1.55]	[0.29]	[1.86]*	[0.98]
Year/district average, any birth attendant	-0.346	-0.415	-0.354	-0.137
	[3.76]**	[2.58]*	[2.28]*	[0.82]
Cluster/Community average for access to health services				
Cluster average, use of modern contraception	-0.206	-0.099	-0.129	-0.492
	[1.60]	[0.35]	[0.65]	[2.43]*
Cluster average, rehydration knowledge (birth past 5 yrs)	-0.281	-0.04	-0.512	-0.397
	[2.48]*	[0.26]	[1.77]*	[1.89]*
Year2000	0			
	[0.01]			
Year2006	-0.158			
	[2.16]*			
m1μ	0.053	0.707	-0.584	0.544
	[0.26]	[1.70]	[-1.54]	[1.26]
m2μ	0.865	1.525	0.243	1.341
	[4.20]**	[3.65]**	[0.64]	[3.13]**
Number of observations	*11,648*	*4,497*	*4,908*	*2,243*

T-statistics in brackets * significant at 5%; ** significant at 1%

8.0 References

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