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Determinants of Children's Nutritional Status in Kenya: Evidence from Demographic and Health Surveys

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This paper uses a pooled sample of the 1998 and 2003 Demographic and Health Survey data sets for Kenya to analyse the determinants of children's nutritional status. We investigate the impact of child, parental, household and community characteristics on children's height and on the probability of stunting. Descriptive and econometric analysis, augmented by policy simulations, is employed to achieve the objectives of the study. In estimation, we control for sample design and possible heterogeneity arising from unobserved community characteristics correlated with children's nutritional status and its determinants. The key findings are that boys suffer more malnutrition than girls, and children of multiple births are more likely to be malnourished than singletons. The results further indicate that maternal education is a more important determinant of children's nutritional status than paternal education. Household assets are also important determinants of children's nutritional status but nutrition improves at a decreasing rate with assets. The use of public health services, more-so modern contraceptives, is also found to be an important determinant of child nutritional status. Policy simulations affirm the potential role of parental, household and community characteristics in reducing long-term malnutrition in Kenya and suggest that the correct policy mix would make a substantial reduction in the current high levels of malnutrition. Our findings suggest that, if Kenya is to achieve her strategic health objectives and millennium development target of reducing the prevalence of malnutrition, strategies for poverty alleviation, promotion

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of post secondary education for women and provision of basic preventive health care are critical concerns that need to be addressed.

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1. Introduction

In Kenya, child mortality rates and malnutrition remain high in spite of the government's commitment to create an enabling environment for the provision of quality health care and reduction of mortality and malnutrition levels. Under-five mortality rates remain above 100 per 1,000 live births while infant mortality rates are well above 60. In addition, about 30% of under-five children suffer from chronic malnutrition (stunted), almost 6% are severely malnourished (wasted), while 20% are underweight. The prevalence of these problems is most critical in rural areas, drought stricken areas and among poor households (CBS, MOH and ORC Macro, 2004). Efforts to reduce child mortality rates and malnutrition continue to be challenged by the HIV/AIDS scourge that has led to increased number of orphaned children who are at increased risk of malnutrition. Nutritional deficiencies contribute to high rates of disability, illness and death. They also affect the long-term physical growth and development of children, and may lead to high levels of chronic illness and disability in adult life. In addition, high rates of malnutrition jeopardise future economic growth by reducing the intellectual and physical potential of the entire population.

In its efforts to ensure health for all Kenyans, the Ministry of Health's strategic plan (1999–2004) aimed, among other targets, at reducing malnutrition among under-five year olds by 30%; reducing the proportion of under-five morbidity and mortality rates attributable to key childhood diseases and malnutrition from 70% to 40% and eliminating vitamin A deficiency in under-five year olds. However, the achievement of these targets continues to be undermined by lack of progress in key determinants of children malnutrition, morbidity and mortality. There is need to address the immediate causes and underlying basic factors of malnutrition if Kenya is to achieve nutritional well-being and reach functional and productive capacity in the population.

This paper investigates the determinants of children's nutritional status in Kenya using the 1998 and 2003 demographic and health survey (DHS) data. We focus on nutritional status as a non-money-metric measure of poverty, which is a recent innovation in the literature (Sahn and Stifel, 2002a). The study focuses also on the impact of child, household and community characteristics. We further simulate the impact of changes in policy variables on children's nutritional status, focusing on household assets, parental education and access to health care services.

The novelty of the paper lies in three key contributions: first, as far as we know, this paper presents a first attempt to explain child nutrition in Kenya and addresses non-monetary poverty measures (nutritional status as a measure of capability deprivation). Previous literatures in Kenya have concentrated on money-metric measures, focusing on measurements and determinants of income poverty. There are a number of other advantages of using nutrition instead of income as a measure of poverty: (i) individual well-being in the form of nutritional status can be directly observed as opposed to household well-being; (ii) money-metric comparisons of welfare over time are hampered by the absence of reliable and verifiable deflators, and information collected in surveys is often inadequate to solve this problem; (iii) budget surveys that differ in instrument design, recall periods and even the nature of interviewer training have large systematic differences in the accuracy of measuring household expenditures. Measuring height is easy and consistent and therefore overcomes this difficulty (Sahn and Stifel, 2002a). A second novelty of this paper is that it explains nutritional status using both children's heights (haz scores) and the probability of stunting. While most studies in the literature use heights (and other anthropometrics) to explain nutritional status, there are threshold effects around a -2 haz score than anywhere else in the haz distribution, making it important to study stunting as an outcome.[1] A third contribution of the paper is in policy simulations that underscore the importance of policy in improving

[1] Nutritionists argue that variations in haz scores above -2 do not matter much for policy but scores below -2 matters because they are associated with increased risk of mortality and poorer cognitive development (we are grateful to an anonymous referee for this insight).

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children's nutritional status in Kenya. Though most studies draw policy recommendations based on estimated coefficients, our policy simulations suggest that basing policy conclusions on signs and magnitude of coefficients/marginal effects would exaggerate the impact of explanatory variables and therefore mislead policy interventions.

The rest of the paper is structured as follows: the next section presents the analytical framework. Section 3 presents the data; Section 4 presents the empirical results, while Section 5 concludes.

2. Analytical Framework

Studies of determinants of children's nutritional status follow theories of human capital investments and the household production framework (Becker, 1965; Strauss and Thomas, 1995). The basic idea of the household model is that households allocate time and goods to produce commodities some of which are sold on the market, some consumed at home and some for which no market exists at all. The households face preferences that can be characterised by the utility function U which depends on consumption of a vector of commodities, X, and a vector of leisure, L:

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

The production function for the consumption good depends on a vector of household input supplies. The household chooses the optimal consumption bundle, given this production function and a budget constraint, which states that given market prices and wages, total consumption, including the value of time spent in leisure activities, cannot exceed full income. Strauss & Thomas (1995) have shown that the household model can be modified to model human capital outcomes by relaxing the assumption of perfect substitutability between home produced and market goods. This is because, in reality, most human capital outcomes cannot be purchased in the market and the household production framework also lenders itself to the integration of biological, demographic and economic considerations.

Child nutrition can be thought of as being generated by a biological production function in which a number of input allocations such

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as nutrient intake and general care result from household decisions. Households therefore choose to maximise child nutrition given the resources and information constraints they face. To model child nutrition, equation (1) can be modified to include supply of child growth (*N*), by assuming that good nutritional status is desirable in its own right and that households make consumption decisions on the basis of reasons other than child growth (Pitt and Rozenzweig, 1995). Equation (1) can therefore be modified to obtain:

$$U = u(X, L, N) \qquad (2)$$

The corresponding budget constraint can also be modified to include inputs into a child health production function and the resulting constrained utility function solved for the optimal quantities of child nutrition supplied to the market. Guided by the underlying literature and evidence (Strauss and Thomas, 1995; Thomas *et al.*, 1996), the reduced form nutritional production function allows us to estimate the following equation for each child:

$$N_i = f\,(W_i, H_j, Z_k, \varepsilon_\mathrm{i}) \qquad (3)$$

where *N* is a measure of child nutritional status (two measures are used: height for age scores and the likelihood of being stunted). *W* is a vector of child (*i*)-specific characteristics: age, birth order, gender of the child and whether a child is of multiple birth or a singleton. *H* is a vector of household (*j*)-specific characteristics: parental characteristics (mother's height, parental age and education), structure of the household (share of adult women and household size) and assets (Sahn and Stifel, 2002b). In the absence of expenditure or income data, we use the asset index to proxy household welfare (Sahn and Stifel, 2003). *Z* is a vector of community (*k*)-level characteristics included to capture the access to public health care services, water and sanitation (Strauss and Thomas, 1995). ε is the child-specific disturbance term.

3. The Data

The analysis in this paper is based on a pool of the 1998 and 2003 DHS data sets. The DHS are nationally representative samples of women aged 15–49 and their children. The two surveys, although

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relatively comparable, differ in a number of ways: the 1998 DHS collected information on 7,881 women aged 15–49 and 5,672 children aged <60 months from 8,380 households in the months of February to July 1998. The kids data, however, focused on 3,531 children aged <36 months. The 2003 KDHS covered 8,195 women aged 15–49 and 5,949 children aged <60 months from 8,561 households in the months of April to August 2003. The surveys collected information relating to demographic and socio-economic characteristics for all respondents and more extensive information on pre-school children.

The DHS utilised a two-stage sample design. The first stage involved selecting sample points (clusters) from a national master sample maintained by Central Bureau of Statistics (CBS); the fourth National Sample survey and Evaluation Programme (NASSEP IV). The 1998 DHS selected 536 clusters, of which 444 were rural and 92 urban from seven out of the eight provinces in Kenya and covered 33 districts. In 2003, a total of 400 clusters, 129 urban and 271 rural, were selected, drawn from all eight provinces and 69 districts. For 2003, 65 of the districts were taken from the seven provinces sampled in the earlier surveys, but the sample is equally representative due to creation of new districts from previously surveyed districts. From the selected clusters, the desired sample of households was selected using systematic sampling methods.

4. Results and Discussion

4.1. Descriptive Statistics

The 1998 data set did not collect information on health care usage for children aged >60 months in 1998. To make the data comparable for the two surveys, we therefore base our analysis on children aged <36 months in the two survey periods. After making this adjustment and further cleaning the data to remove children with missing values for nutritional indicators, our sample narrowed down to 2,914 and 2,956 children in 1998 and 2003, respectively. The descriptive statistics for the key variables from the two data sets are presented in Table 1. The distribution of children across 1-year age groups is almost similar in the two surveys with 33% and 36% children aged <12 months and 35% and 34% aged between 12 and 24 months in 1998 and 2003, respectively.

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Table 1: *Descriptive Statistics*

Variable	1998		2003		Pooled sample	
	Mean	SD	Mean	SD	Mean	SD
Age of child in months	17.39	10.02	16.91	10.10	17.14	10.06
Birth order	3.53	2.47	3.57	2.46	3.56	2.46
Child is of multiple birth	0.03	0.23	0.04	0.27	0.04	0.25
Male child dummy	0.51	0.50	0.50	0.50	0.51	0.50
Share of women aged 15–49 years	0.24	0.10	0.24	0.10	0.24	0.10
Household size	6.19	2.64	6.04	2.43	6.11	2.54
Mothers age	27.28	6.44	27.45	6.53	27.37	6.49
Mothers height	160.00	6.29	159.77	6.46	159.88	6.38
Mothers years of primary education	6.23	2.72	5.99	2.95	6.11	2.85
Mothers years of post primary education	0.84	1.67	0.76	1.71	0.80	1.69
Heads years of primary education	6.13	3.01	6.51	2.72	6.33	2.87
Heads years of post primary education	1.22	1.94	2.02	3.33	1.63	2.78
Age of house hold head	39.00	12.97	38.01	12.48	38.49	12.72
Asset index	−0.12	0.78	−0.17	0.80	−0.15	0.79
Haz (height for age *z*-score)	−1.182	1.65	−1.184	1.55	−1.19	1.60
Waz (weight for age *z*-score)	−0.93	1.41	−0.86	1.40	−0.90	1.41
Whz (weight for height *z*-score)	−0.24	1.33	−0.15	1.29	−0.19	1.31
Probability child is stunted	0.33	0.47	0.35	0.48	0.34	0.47

In general, Table 1 indicates robustness of the two data sets across all variables though some variables show modest variations between the two years. The data indicate that mean asset index[2] fell

[2] The asset index can be defined as:

$$A_i = \sum_k \tau_k \alpha_{ik}$$

where A_i is the asset index for household i, the α_{ik}'s are the k individual assets recorded in the survey for that household, and the τ_k's are the weights. Most studies use the standardised first principal component of the variance covariance matrix of the observed household assets as weights, allowing the data to determine the relative importance of each asset, based on its correlation with the other

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from −0.12 in 1998 to −0.17 in 2003, implying that on average Kenyan households were worse off in terms of asset poverty in 2003 compared with that in 1998. The nutritional status of children aged 0–35 months in our samples is indicated in the last three rows of Table 1. The measure for chronic under nutrition; height for age scores (*haz*) ranged from −5.98 to 5.96 and −5.93 to 5.88 in 1998 and 2003, respectively. The corresponding mean scores for these two periods are estimated to be −1.182 and −1.184, respectively. This implies that there was no difference in the levels of chronic under nutrition between 1998 and 2003.

A further analysis of the data (results not presented) shows lower *z*-scores for boys than for girls indicating that boys are more likely to suffer chronic and acute under nutrition as well as being underweight than girls. This finding is consistent with other studies on nutritional status of children in Africa (Ssewanyana, 2003). The data also suggest that mean scores for chronic under nutrition and under weight decline with an increase in the level of mothers' education (Silva, 2005). A tabulation of the *z* scores by age of the child suggests that malnutrition increases with age except for children aged 24–35 months. This is probably explained by the ceasing of breast feeding and weaning especially for children aged 12–24 months. After the first 2 years, a child is likely to get more nutrients from a wider range of foodstuffs than at a more tender age. The distribution of children below −2*z* scores by age group follows an inverted 'U' shape.

Other highlights from the data include that boys and children from female-headed households appear to be at a relative disadvantage in nutrition compared with girls and children from

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assets following Filmer & Pritchett (2000). This study uses the factor analysis approach to derive the index following Sahn & Stifel (2002a, 2003). This approach is similar to principal components but has certain statistical advantages and assumes that the one common factor that best explains the variance in the ownership of a set of assets is a measure of economic well-being (Sahn and Stifel, 2002a). The assets that are included in the analysis are ownership of a radio, TV, refrigerator, bicycle, a motorcycle, a car, the household's source of drinking water (piped or surface water relative to well water); the household's toilet facilities (flush or no facilities relative to latrine facilities); the household's floor material (low quality relative to higher quality); and the years of education of the household head to account for household's stock of human capital. The scoring coefficients from the factor analysis are applied to each household to estimate its wealth index and will rank the households on a −1 to 1 scale.

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Table 2: *Community and Environmental Variables: Non-Self Cluster Shares*

Variable	1998		2003		Pooled sample	
	Mean	SD	Mean	SD	Mean	SD
Children received all vaccinations	0.41	0.23	0.45	0.24	0.43	0.24
Mothers used professional pre-natal care	0.75	0.19	0.88	0.16	0.82	0.19
Expectant mothers received tetanus toxoid	0.73	0.2	0.86	0.16	0.80	0.19
Women used professional birth care	0.35	0.26	0.42	0.30	0.39	0.29
Women using modern contraception	0.26	0.19	0.25	0.19	0.26	0.19
Households with traditional toilet	0.16	0.36	0.17	0.37	0.17	0.33
Households with piped water	0.80	0.31	0.76	0.35	0.78	0.34

male-headed households, respectively. Urban children are less likely to be stunted or wasted than rural children, probably reflecting differences in sanitation and access to health care, as well as possible self-selection of parents into urban areas. An analysis of the levels of malnutrition by asset index quintiles suggests that under nutrition declined linearly with assets.

To assess the impact of availability of health care on children's nutritional status, we generate a vector of community level variables as proxies.[3] We focus on six variables, namely the share of children who were fully immunised; the share of children who had at least one immunisation vaccine; the share of women who used modern contraceptive methods; the share of women who received professional pre-natal and birth care (doctor, midwife or nurse) and the share of pregnant women who received tetanus toxoid. The sample characteristics for the community variables are presented in Table 2.[4] The results indicate that except for use of modern

[3] Individual level variables such as whether a child is fully immunized or not or whether a woman used modern contraception are arguably endogenous because they depend on among other factors household characteristics. To make these variables exogenous, we use the non-self cluster shares or local community shares of each of these variables.

[4] We also estimated non-self cluster shares for households with access to piped water, toilet facilities and material of housing. These variables can be seen as measures of the environmental/sanitation quality of the residence of the child

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contraception that recorded a minor decline, the use of other health care services improved in 2003. The data, however, suggest low access to/utilisation of health care services as depicted by low immunisation coverage and the use of modern contraception.

4.2. Regression Results

4.2.1. Introduction

To explain children's nutritional status, we use survey regressions rather than ordinary least squares methods to control for sample design used in the data collection procedure. Survey regression takes care of three important sample characteristics: sampling weights, clustering and stratification (Stata Corp., 1999). Failure to include sampling weights gives estimators that are biased and affect standard error of the estimates. Further, because of the sampling design, observations in a cluster are not independent and using ordinary least squares will give very small standard errors. Accounting for clustering is therefore necessary to adjust the standard errors for design effects. The DHS data collection procedures do not use purely random sampling methods. Instead, different groups of clusters are sampled separately. Since sampling is done independently across strata, the resulting standard errors will be smaller than normal. Therefore, applying survey regression techniques to the DHS produces the correct standard errors.

In addition, we control for unobservable community level characteristics that may be correlated with observable determinants of/and/or child nutritional status by introducing dummy variables for each of the sample clusters into the model. This controls for the community-fixed effects, eliminating any bias from unobserved community-level heterogeneity, provided such heterogeneity enters the nutritional function linearly.

Another estimation issue worth mentioning is that the nutritional status of a child is a function of two main inputs: food and health status. The common practice in the literature is to proxy food/nutrient intake by per capita household expenditure due to paucity of

and are therefore expected to affect child nutritional status (Strauss and Thomas, 1995).

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information on actual food/nutrient intakes. Likewise, health inputs are generally difficult to measure and may be proxied by days of illness per child or whether a child caught a particular illness or not. Where such information is available, both per capita expenditure and illness have to be instrumented because they are jointly determined. If this is not feasible, simple reduced forms of nutritional status models are estimated. We follow the latter approach due to difficulties in obtaining the relevant data for nutrient intake and health inputs.

4.2.2. Correlates of Chronic Malnutrition: Height for Age Scores and Stunting

The estimated reduced form models explaining the determinants of child nutritional status measured by height for age (*haz* scores) and stunting (measured by a dummy variable equal to 1 if haz is less than -2, otherwise 0) are presented in Table 3. Four different model results are presented: models (1) and (2) are regressions with controls for cluster-fixed effects for haz scores and the probability of stunting, respectively; models (3) and (4) are regressions without controls for cluster-fixed effects. We discuss the results concurrently. For all models, controlling for the community-fixed effects has little impact on the betas (but does not affect the levels of significance) of some variables. The explanatory powers of the models, however, differ slightly, which is expected because of the cluster share variables in the non-fixed effects model. Comparing results of with and without controls for cluster-fixed effects models suggests that there are no important unobserved community-level characteristics that are correlated with the determinants of child nutritional status omitted from the model. The explanatory power of the model is consistent with other studies on nutritional status, that is, the R^2 values are quite low. The Chow tests as well as the test for joint significance of all variables for all models (results not presented), however, suggest that the variables are jointly significant in explaining chronic malnutrition.

4.2.3. Child Characteristics

The results suggest that most variables for child characteristics are important determinants of chronic nutrition. The age of the child is inversely related to chronic malnutrition and thus young children

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Table 3: *Determinants of Chronic Malnutrition*

Variable	Cluster fixed effects		No fixed effects		
	Model 1	Model 2	Model 3	Model 4	
	Haz scores	Stunting	Haz scores	Stunting	Marginal effects
Child characteristics					
Age of child in months	−0.0474 [23.21]***	0.0481 [14.98]***	−0.0465 [21.02]***	0.0306 [14.48]***	0.011
Birth order	−0.0244 [1.45]	0.0487 [1.91]*	−0.02 [1.01]	0.031 [1.77]*	0.011
Child is of multiple birth	−0.6132 [7.41]***	0.4001 [3.27]***	−0.6168 [5.12]***	0.3382 [3.48]***	0.121
Male child dummy	−0.1892 [4.66]***	0.3093 [4.98]***	−0.1908 [4.25]***	0.2015 [5.29]***	0.072
Household characteristics					
Share of women aged 15−49 years	−0.1763 [0.71]	−0.2212 [0.57]	−0.2884 [1.09]	−0.16 [0.70]	−0.057
Household size	−0.0225 [2.25]**	0.0061 [0.40]	−0.0147 [1.08]	0.0055 [0.55]	0.002
Mothers age	0.0211 [3.61]***	−0.0251 [2.80]***	0.0147 [2.10]**	−0.0141 [2.44]**	−0.005
Mothers height	0.0385 [11.77]***	−0.0331 [6.47]***	0.04 [10.47]***	−0.0241 [7.48]***	−0.009
Mothers years of primary education	0.0084 [0.87]	0.0114 [0.79]	0.0049 [0.48]	0.0016 [0.18]	0.001
Mothers years of post primary education	0.0475 [3.05]***	−0.0748 [2.84]***	0.0544 [3.23]***	−0.0464 [2.84]***	−0.017
Heads years of primary education	0.0036 [0.41]	−0.0301 [2.25]**	0.0058 [0.61]	−0.0198 [2.37]**	−0.007

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Heads years of post primary education	0.0285 [3.03]***	−0.0331 [2.18]**	0.0159 [1.61]	−0.0131 [1.36]	−0.005
Age of house hold head	0.0027 [1.41]	−0.0005 [0.17]	0.0021 [0.97]	−0.001 [0.53]	−0.0003
Asset index	0.2557 [4.26]***	−0.393 [4.13]***	0.3509 [4.99]***	−0.225 [3.52]***	−0.081
Asset index squared	−0.0338 [1.23]	0.1041 [2.31]**	−0.0856 [2.70]***	0.0637 [2.54]**	0.023
Health care utilisation and environmental variables					
Children received all vaccinations			−0.0386 [0.31]	0.0392 [0.40]	0.014
Mothers used professional pre-natal care			0.0131 [0.06]	0.2256 [0.96]	0.081
Expectant mothers received tetanus toxoid			−0.2531 [1.16]	−0.05 [0.22]	−0.018
Women used professional birth care			0.1424 [1.34]	−0.1443 [1.62]	−0.052
Women using modern contraception			0.6118 [3.52]***	−0.1728 [1.23]	−0.062
Households with piped water			−0.0139 [0.14]	0.1033 [1.14]	0.037
Households with traditional toilet			−0.2478 [2.76]***	0.1523 [1.87]*	0.055
Constant	−6.9004 [12.69]***		−6.7624 [10.03]***	2.9679 [5.38]***	
Observations	5734	5550	5575	5593	
Number of cluster	532	478			
R^2	0.15		0.17		

Absolute values of *t*-statistics are in brackets.
*Significant at 10%; **significant at 5%; ***significant at 1%.

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are less likely to be stunted than older children. This result is also supported by dummies for child age (not presented), which indicated that all child age groups relative to age 12–24 months have significant coefficients, but which clearly decline with age in terms of magnitudes and levels of significance. As children grow older, weaning and less breast milk make them more vulnerable to malnutrition. But once children are completely weaned, they are likely to get adequate nutrients from regular food intake, thereby improving their nutritional status. These findings support Shrimpton *et al.* (2001) who show that although children's height fall sharply from birth to 24 months, the process of stunting continues at a much slower rate after the 24th month. Birth order is inversely correlated with nutritional status, but the coefficients are insignificant, except for the stunting model without controls for fixed effects. A height of a child is likely to be 0.02 z-scores less as the order of birth rises, and the probability of stunting increases by about 0.01 points (estimated marginal effects from model 4). Children of multiple births are likely to be more malnourished than singletons. The height of a child born of a multiple birth is likely to be about 0.6 z-scores lower than for children born of single births. Model 4 suggests that stunting increases by 0.12 points if a child is of a multiple birth compared with singletons. This could be explained by low birth weight, inadequate breast feeding and competition for nutritional intake, which tend to afflict children of multiple births more than singletons. Male children are more likely to be malnourished than female children. The height of a boy child is likely to be 0.19 z-scores lower than that of a girl. The marginal effects for stunting suggest that the probability of a boy being stunted is 0.07 higher than that of a girl, all other factors held constant. This implies the absence of physiological impact on gender-specific nutrition status.

4.2.3. Household Characteristics

Household level variables include share of adult women, household size, mothers' characteristics, household head characteristics and the household asset index variable. Mother's age is a positive and significant determinant of children's height, and the reverse is observed for stunting, suggesting that children's nutritional status improves with the age of the mother. This result is consistent with most studies on child health, which suggest that children born of young mothers,

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more so teenage mothers, are more likely to suffer ill health than children born of adult women. Mother's height is also positively correlated with children height, but negatively correlated with the probability of stunting. Height captures both the genetic effects and the effects resulting from family background characteristics not captured by maternal education.[5] Maternal education is positively related to nutritional outcomes, but the coefficients for years of primary education are insignificant. Coefficients for post primary education are much larger than the same for children's heights. Maternal education improves nutrition through altering the household preference function and also through better child care practices. The results suggest the importance of human capital investments in improving children's nutritional status. The importance of human capital investments is supported by the post primary education of the household head (coefficient significant in the fixed effects model). The magnitudes of the coefficients and marginal effects, however, suggest that mothers' education is more important than fathers' education in the determination of a child's nutritional status. This result is consistent with some studies on nutrition (Sahn and Alderman, 1997; Sahn and Stifel, 2002b; Webb and Block, 2004).

Household assets have a strong significant correlation with children's heights and the probability of stunting. The results portray an inverted U-shaped relationship with nutritional status, and imply that child nutrition improves at a decreasing rate with assets. This finding supports the results of Sahn & Stifel (2003), who show that the asset index is a valid predictor of child nutrition. The magnitude of the coefficient suggests that an increase in the asset index by 1 unit would increase children's height by between 0.2 and 0.3 *z*-scores. Though the asset index cannot be measured in cardinal units like income and expenditure, it is a good proxy for the well-being of household and children. Our results do not concur with studies that find a weak correlation between wealth and children's health (see, for instance, Haddad *et al.*, 2003). The marginal effect of assets on the probability of stunting is, however, quite modest.

[5] Most literature suggests a U-shaped relationship with chronic malnutrition, implying that genetics and phenotype play an important role in affecting the stature of children (Sahn, 1994). We dropped the quadratic term for mother's height because of very low betas and insignificant results. However, joint test for significance of the linear and quadratic term shows that the variables are jointly significant at all conventional levels of testing {$F(2,824) = 62.79$}. The same is observed for the linear and quadratic term of mother's age.

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4.2.4. Health Care Variables

The variables that proxy the availability of health care are cluster-level shares of individual responses on the use of vaccination, prenatal jab of tetanus toxoid, prenatal and delivery care by a professional (doctor, mid-wife or nurse), and the use of modern contraception methods. Cluster-level shares are used instead of the individual responses to control for endogeneity of individual level data on service use.[6] The results show that only the cluster share usage of modern contraception methods is significantly correlated with children's height. The coefficient is also very large, suggesting that an increase in cluster share usage of modern contraception by 1% would increase children's heights by 0.58 z-scores. The impact of contraception is expected to be through the impact on fertility (increased birth interval) that allows a mother more time for breast feeding (Ssewanyana, 2003). Modern contraception could also be a proxy for the general availability of health services. None of the health care variables have a significant impact on the probability of stunting. We suspect that high unobserved correlation between cluster level variables could account for the insignificance of the other variables (and unexpected signs of some of the variables).[7] That health care is indeed important for children's health is supported by a test for joint significance of the variables with the expected impacts, which show that the health care variables are jointly significant $\{F(5{,}821) = 4.21\}$ at all conventional levels of testing. In addition, summing the coefficients of the variables for health care services shows that modern health care would increase children's height by 0.53 z-scores.

4.2.5. Environmental Factors

The environmental/sanitation determinants: cluster shares of households with piped water, and proportion with toilet facilities

[6] Though it could be argued that the mean values of community health care variables may reflect the demand structure in the community and may therefore not be purely exogenous, they are uncorrelated with other variables observed at the household/individual level and therefore this is the best approach to treat these in absence of other measures of health care services such as prices and physical distance.

[7] It happens that clusters where one service is available may have all other services. For instance, a cluster with a modern health care facility will have facilities for vaccination, prenatal and birthing care as well as family planning services. However, examination of the correlation matrix does not support this expectation and this is why all variables are retained in the model.

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turn out to be either insignificant or to have the unexpected sign. Though some studies have found environmental factors to matter (Silva, 2005), our findings are not uncommon in the literature (see, for instance, Christiaensen and Alderman, 2004). Strauss and Thomas (1995) also review evidence that the environmental factors may be uncorrelated with children's health states. The argument is that while these variables are environmental indicators, they may not measure well the quality of the environment that children grow up in due to unobserved attributes of water and sanitation.

4.2.6. Other Variables

In addition to the above variables, we tested for the impact of several other variables. To save on space and degrees of freedom, these variables are dropped from the model but are available from the authors upon request. The variables include measures of fertility preferences, occupation of the household head, regional and survey year dummies. We also tested the impact of a number of interaction terms namely: parental education and gender of the child, assets and gender of the child, parental age and region of residence and asset index interacted with rural area dummy. None of the interaction terms are significant either individually or jointly.

To save on space, the results by area of residence (rural/urban) and by gender of the child are also not presented but are available from the authors. The results by area of residence show that child characteristics, mothers age and post primary education, assets and access to modern contraception are much more important determinants of children's heights in rural than in urban areas, but, in most instances, the reverse is observed for the probability of stunting. The results by gender of child suggest that except for the magnitudes of a few coefficients, there are no major differences in the main determinants of child nutritional status for boys and girls.

4.3. Policy Simulations

We use the results of models (3) and (4) in Table 3 and the corresponding variable means to simulate the impact of various policy changes on children's nutritional status. While the regression results show the impact of the regressors on the mean *z*-scores, of relevance to policy is to improve nutritional status for the severely

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malnourished children. Raising the living standards for children at the lowest end of the distribution, improving education of their parents and access to health care are the major policy concerns that could be expected to have an impact on children's health. Therefore, we simulate policies based on these options, holding all other variables at their mean levels.

The mean asset index for both years is negative, implying that on average households in Kenya deplete rather than accumulate assets. Looking at the distribution of households by asset quintiles, our interest is to improve the welfare of the poor children, and estimate the impact on nutrition of such a policy change. In particular, we assign all household below the median level of assets the median level (−0.443). This raises the mean level of assets from −0.13 to −0.07 (Table 4). The predicted impact of such a policy change would be to increase the base mean *haz* score from −1.19 to −1.16. This means that, on average, heights would improve by only 0.03 standard deviations (a 2.9% improvement) of the US National Centre for Health Statistics (NCHS) distribution of healthy children's heights. The impact of such a policy would be to reduce the probability of stunting from 0.34 to 0.33 (a 2.4% improvement). This predicted change is quite small given that this simulation assumes a major improvement in the distribution of income, which may not be feasible to attain even with improvements in household welfare. A more realistic scenario would therefore result in less improvement in nutritional status. The implication of this finding is that improvements in household well-being in Kenya will lead to a relatively small reduction in stunting.

The second set of simulations focus on the impact of improving parental education. Focus is on two cases: where mothers have at least full secondary education. The results suggest that equipping all mothers with at least complete secondary education would have a substantial impact on children's nutrition. Both children's height and the probability of stunting would improve by about 18%. These results affirm the importance of maternal education in improving children's health and shows that targeting women through secondary and post secondary education would make an enormous contribution towards the achievement of MDGs on nutrition. However, it is important to note that Kenya adopted free primary education (FPE) in 2003. Thus, children who enrolled for

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Table 4: *Simulating Impact of Policy on Children's Nutrition*

Proposed policy scenario	Haz scores		Stunting	
	Predicted mean[a]	Predicted % change	Predicted mean[a]	Predicted % change
1 Increase household assets of the poorest to the median level	−1.16 [0.65]	2.87	0.33 [0.14]	2.37
2 All mothers at least complete secondary education	−1.01 [0.63]	17.64	0.29 [0.13]	17.86
3 All household heads at least complete primary education	−1.18 [0.65]	0.80	0.33 [0.14]	3.49
4 All mothers use modern contraception	−0.94 [0.63]	27.08	0.29 [0.14]	14.33
All above simulations combined	−0.72 [0.61]	65.76	0.23 [0.12]	46.11
5 Give all clusters with below mean (%) use of modern contraception the mean level	−1.14 [0.65]	4.20	0.33 [0.14]	1.41
6 Give all clusters with low usage of modern contraception the highest provincial mean level	−1.07 [0.64]	11.09	0.33 [0.14]	3.53

Base rate mean haz score = 1.19 [0.74]; base rate mean stunting = 0.34.
[a]Standard errors in parenthesis.

primary education under FPE will complete primary education in 2011 and secondary education in 2015—the MDG target year. If all girls enrolled for primary education with the FPE, and assuming 100% completion rates, then Kenya would have to wait for close to two decades (for these girls to mature into motherhood) to enjoy this improvement in children's nutritional status. Attainment of full secondary education will require a much longer time horizon than primary education and concerted policy efforts towards completion rates at all levels. This is because even as the government

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moves towards the intended free secondary schooling, it is only children who successively complete primary education that may enrol in secondary school. If all household heads were to have at least full primary education by 2015, this would have a very modest impact (0.8% improvement in heights, but a 3.5% reduction in the probability of stunting) on nutritional status. This supports regression results and other studies that have shown that maternal education is a much more important determinant of nutritional status than paternal education.

Turning to the usage of health care, the regression results suggest that the use of modern contraceptives is one of the most important variables that affect children's nutritional status. At present, the government health facilities offer free family planning services. However, the mean usage is still very low at only 26%. Simulation results suggest that if all mothers were to use modern contraception, children' height would rise by 27%, but the probability of stunting would fall by only 14%. However, evidence shows that there is still unmet demand (almost 40%) and persistent contraceptive stock-out (UNDP, GOK and GOF, 2005). This suggests that advocacy on the importance of using modern family planning, combined with increased access and improved quality of service provision would play an important role in improving children's nutritional status.

A combination of all the above-simulated scenarios (median asset level; all fathers/mothers to have at the minimum complete primary/secondary education; and all mothers use modern contraception), suggests that if these were to be achieved, nutritional status would improve by 66% (children's height would increase by 0.47 *z*-scores). The impact on the probability of stunting is more modest as the results suggest that the proposed changes would reduce the probability of stunting from 0.34 to 0.23 (a 46% improvement in nutritional status). However, our analysis does not incorporate many policy relevant variables such as quality of medical care and impact of HIV/AIDS among other factors. This suggests that a more comprehensive policy package is vital and would have a substantial effect of improving nutritional status.

How effective would be policies focusing on health care provision? To answer this question, we focus on policies related to improvement of usage of health care services at the cluster level. First, focusing on usage of modern contraception, we simulate the impact of providing all disadvantaged clusters the mean coverage

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(only 26%). This would raise the cluster share of women using modern contraception to 34%, improve the *z*-sores by 4.2% but reduce the probability of stunting by only 1.4%. An alternative scenario is where there is improved usage in the disadvantaged clusters to reach the province with the highest coverage (Central province with 43%). If family planning campaigns were intensified so as to push usage in the lowest clusters to 43%, the mean share of women using modern contraceptives would increase from 26% to 45%. This would increase children's heights by 0.12 *z*-scores (11%) and reduce the probability of stunting by 3.5%.

5. Conclusion

This paper investigates the determinants of child nutritional status in Kenya using the 1998 and 2003 DHS data sets. We investigate the impact of child, household and community characteristics on children's heights and stunting as an outcome. In estimation, we control for sample design and possible heterogeneity arising from unobserved community characteristics correlated with children's nutritional status and its determinants. The paper makes three important contributions to the existing literature. First, we are not aware of any paper that explains nutrition using nationally representative data for Kenya. Secondly, there are distinct advantages of using nutritional status as a measure of deprivation than income measures of poverty. Three policy simulations help to assess the potential impact of policy-relevant variables, which would otherwise be misled by relying on estimated marginal effects and coefficients. Furthermore, although it is argued that information is lost in converting a dependent variable into a categorical variable, the simulations suggest that the emphasis of policy interventions would differ depending on whether heights or stunting as an outcome is the dependent variable.

The results show that most child characteristics are important and significant determinants of nutritional status. Specifically, older children, children of multiple births, boys and children of higher birth order are more likely to suffer malnutrition than their counterparts. The results also show that household size is inversely related to children's nutritional status, suggesting competition for food among siblings. Children's nutritional status improves with the age of the mother, suggesting the importance

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of reducing teenage births. Mother's height is also positively correlated with children's nutrition, suggesting the importance of genetics and phenotype in influencing the stature of children. Maternal education is positively related to nutritional outcomes. The coefficients for maternal education suggest the importance of human capital investments in improving children's nutritional status. Mothers' education is more important than fathers' education in determination of a child's nutritional status. Household assets portray a strong significant inverted U-shaped relationship with children's nutritional status, implying that nutrition improves at a decreasing rate with assets.

The cluster share usage of modern contraception methods is significantly correlated with children's height. The impact of contraception is expected to be through lower fertility that allows a mother more time for breast feeding. Modern contraception could also be a proxy for the general availability of health care services. All health care variables are, however, jointly significant in explaining child nutrition. Even after accounting for sample design and unobserved heterogeneity across clusters, we do not uncover any important effect of environmental factors on children's nutritional status.

The policy simulations focused on the impact of changes in household assets, parental education and access to health care services. For household assets, we take a scenario that improves the welfare of the poor children by assigning all households below the median level of assets the median level. The predicted impact of such a policy change would be to increase children's height by 2.5% (a rather modest improvement given that such a scenario assumes a major improvement in the distribution of income). The policy simulations for maternal education suggest that equipping all mothers with secondary and post secondary education would increase heights/lower the probability of stunting by about 18%. The simulations further show that paternal education has a lower impact than maternal education. These results suggest the importance of targeting women through secondary and post secondary education in support of millennium development goals for child health.

Simulations for health care services focus on improved cluster level coverage/usage of services. The results suggest that if all mothers were to use modern contraception, children' height would rise by 27%, while the probability of stunting would fall

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by 14%. However, in spite of free family planning services in Kenya, the mean usage is still very low. This suggests that advocacy on the importance of using modern family planning would play an important role in improving children's nutritional status. Improvement in quality of services and also increased access are issues that need to be addressed.

The simulation results suggest that if Kenya is to achieve her health sector strategic objective and millennium development goal target of reducing malnutrition by 30% in 2015, policies and strategies for poverty alleviation, promotion of post secondary education and provision of basic health care are critical. Our results, however, do not incorporate many policy-relevant variables such as quality and access to medical care and impact of HIV/AIDS among other factors. This suggests that a comprehensive policy package would make an important contribution towards achievement of the MDG target of reducing long term malnutrition in Kenya.

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