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ABSTRACT

This study examines the biological, social, and environmental determinants of low birth weight and stunting, using data from the 2005-06 Zimbabwe Demographic and Health Survey (ZDHS). In Zimbabwe the prevalence of stunting among children age 0-59 months has increased over the past decade, from 21% in the 1994 ZDHS to 28% in 2005-06. More than one infant in every 10 has low birth weight. Understanding the factors that contribute to high prevalence of low birth weight and stunting is important for child development and child survival programming and intervention.

The study sample consists of 5,231 children who were born within the five years preceding the 2005-06 ZDHS and whose mothers were interviewed in the survey. Analyses focus on children age 0-59 months who were weighed at birth (for analyses of birth weight) and children age 6-59 months whose weight and height were measured at the time of survey (for analyses of stunting). Multiple logistic regression analysis was used to assess the independent association of each explanatory variable with the likelihood of a child having low birth weight or being stunted.

Our results show that of multiple-birth children, 60% have low birth weight and at the time of the survey 58% are stunted. Higher maternal body mass index and birth spacing are protective against stunting. After controlling for characteristics of the mother and the child, no household or socioeconomic and environmental characteristics are significantly associated with low birth weight. Among the younger children age 6-23 months the odds of being stunted increase 11% with each additional month of age, whereas among the older children age 24-59 months each additional month is associated with a 2% decrease in the odds. Also, the determinants of stunting are stronger and more significant among younger than older children.

Low birth weight children are more likely to be stunted in early childhood. Vitamin A supplementation is protective against stunting among older children even after controlling for immunization. Older children living in a household with access to a toilet are less likely to be stunted, after controlling for other covariates, including access to a protected water source, maternal education, and household wealth status. In a sub-analysis of youngest children age 6-23 months, there is no significant association between the adequacy of feeding practices and stunting.

Our findings suggest that interventions to address child undernutrition should begin before childbirth and continue through early childhood. Efforts to improve maternal nutrition, family planning, and antenatal care as well as access to Vitamin A supplementation and the sanitary environment are important, and all play key roles at different stages of a child's early life.

INTRODUCTION

In this study we examine the biological, social, and environmental determinants of low birth weight and stunting, using data from the 2005-06 Zimbabwe Demographic and Health Survey (ZDHS). Undernutrition among young children is a complex problem, with varying biological, behavioral, socio-cultural, and economic causes (UNICEF, 1990) and with a wide range of consequences (Mason, 2000). Undernutrition, although preventable using proven interventions, remains one of the greatest contributors to the morbidity and mortality of children under age five in Zimbabwe and many other developing countries (Caulfield et al., 2004; Pelletier et al., 1993).

The process of becoming undernourished begins during the prenatal period, when maternal health and nutrition as well as the genetic and constitutional characteristics of the fetus influence fetal growth and development. Children thus can be prenatally disposed to growing poorly postnatally; low-birth-weight babies have been shown to have poorer weight and linear growth in early childhood than those with normal birth weight (Christian, 2009; Adair, 1989).

Thereafter, different biosocial exposures stemming from interactions with the mother, the household, and the immediate environment determine children's nutrient intake, as well as their ability to utilize nutrients, thereby influencing their growth. A number of previous studies have observed the crucial roles of maternal and neonatal care, breastfeeding, appropriate complementary feeding, health care, and sanitation in the continuum from child growth to child survival (Bhutta et al., 2008a; Bhutta et al., 2008b; Haines et al., 2007; Adm et al., 2005; Jones et al., 2003; Esrey and Habicht, 1986).

Preventing or mitigating the effects of undernutrition depends both on understanding its biosocial causes within a given context and on intervening at the right time. One critical window of opportunity for improving childhood nutrition is before age 24 months, where most of the growth faltering has been found to occur worldwide (Shrimpton et al., 2001). Another window, which few studies have examined, is the prenatal period. In a recent review of the causes of undernutrition, Christian (2009) emphasized the need for more research on the contribution of prenatal factors, including inadequate maternal nutrition and low birth weight, to childhood wasting and stunting, so that appropriate interventions can be targeted to the appropriate life stages.

Zimbabwe has seen a moderate increase in the prevalence of stunting, from 21% in the 1994 ZDHS to 28% in the 2005-06 ZDHS, and the proportion of infants with low birth weight remains above 10% (Central Statistics Office (CSO) [Zimbabwe] and Macro International Inc., 2007). Understanding the factors that contribute to these high levels of stunting and low birth weight is important for effective child development and child survival programming and intervention. This is particularly important given that Zimbabwe has experienced economic crises in the last decade, which have led to deterioration in social and economic conditions, as well as in health service delivery.

METHODS

Study Design

This study uses data from the 2005-06 ZDHS, which collected information from a nationally representative probability sample of 9,285 households in all 10 provinces of Zimbabwe. Two-stage cluster sampling was used, with an overall household response rate of 95%. Data were collected on characteristics of households, women of reproductive age, and children under age five within the households. More details about survey design, management, quality control, and overall findings are provided in the 2005-06 ZDHS report (Central Statistics Office (CSO) [Zimbabwe] and Macro International Inc., 2007).

We used data on 5,231 children who were born within the five years preceding the ZDHS and whose mothers were interviewed in the survey. We further restricted our analyses to children who were weighed at birth (for birth weight analyses), children age 6-59 months whose height and weight were measured at the time of survey (for stunting analyses), and the youngest children age 6-23 months (for analyses involving infant and young child feeding (IYCF)).

Measurement and Data Analysis

For children who were weighed at birth, the survey asked mothers to show the health card on which the birth weight was recorded. For mothers who did not have the health card, birth weight was based on mother's recall. Birth weights were recorded in grams to the nearest 10g. In the ZDHS data, however, even for children whose birth weights were taken from health cards, there was considerable heaping on birth weights ending in 100g rather than the nearest 10g, indicating that many health workers recorded to the nearest 100g. Low birth weight, one of the response variables in our analysis, was defined as a weight at birth of less than 2,500g.

Anthropometric measurements were obtained for all children under age five living in the sampled households. We classified children as being stunted (the second response variable) if they were below -2.0 height-for-age Z-scores relative to the recent World Health Organization (WHO) standards (WHO Multicentre Growth Reference Study Group, 2006).

We used multiple logistic regression analysis to assess the strength of association of each explanatory variable with the likelihood of a child having low birth weight or being stunted, after adjusting for other covariates. Using a sub-sample of youngest children born within the 24 months preceding the survey and for whom 24-hour diet recall information was collected, we conducted an additional logistic regression analysis to assess the association between appropriate IYCF and stunting. Results of the regression analyses are presented in the form of odds ratios (OR), with 95% confidence intervals (CI) and *p*-values. We used Hosmer-Lemeshow and Pearson's goodness-of-fit tests to check the fit of the logistic regression models.

The multivariate analyses presented are based on a final sample size of 3,748 children age 0-59 months for low birth weight, 3,530 children age 6-59 months for stunting, and 1,269 children age 6-23 months for the sub-group analysis involving IYCF, after excluding observations with missing values in the predictor variables. In the ZDHS some groups of respondents were over-sampled or under-sampled. Therefore, in all our analyses we used weights to compensate for this. A level of $p < 0.05$ was considered statistically significant, and all statistical analyses were conducted using Stata 10.0 (Stata Corporation, 2007).

Covariates

Biological attributes at birth: The biological attributes at birth are those that cause poor developmental outcomes for the fetus or predispose the infant to growth faltering in early life.

These include maternal attributes as well as the child's. In our analysis, child-level covariates include birth weight (<2,500g, 2,500-3499g, ≥3,500g, not measured), birth order (1, 2–3, 4–5, ≥ 6), and sex (boy, girl). Maternal covariates include mother's age at each child's birth (15–17, 18–24, 25–34, 35–49), birth spacing (< 18 months, 18–23 months, 24-35 months, ≥ 36 months, no preceding birth), and body mass index (BMI = weight kg/height m^2) [classified as underweight (BMI < 18.5 kg/m^2), normal (BMI 18.5–24.9 kg/m^2), overweight (BMI 25.0–29.9 kg/m^2), obese (BMI ≥ 30.0 kg/m^2)].

Postnatal biological determinants: These are factors that cause or are associated with growth faltering in early life. The variables in our analyses include the child's age, breastfeeding initiation (within 1 hour of birth, between 1–6 hours of birth, ≥ 7 hours after birth/never), and breastfeeding duration (currently breastfeeding, breastfed for ≥ 6 months, breastfed for < 6 months, never breastfed).

The appropriateness of IYCF was assessed for youngest children age 6-23 months, using a summary indicator that reflects the adequacy of feeding practices. Diet data in the ZDHS are based on recall of foods consumed by the child over the 24 hours preceding the interview. Based on these data, the IYCF indicator takes into account the extent to which minimum standards were met with respect to food diversity (i.e., the number of food groups consumed), feeding frequency (i.e., the number of times the child was fed), as well as breastfeeding and the consumption of milk and milk products (World Health Organization, 1998). Breastfed children were considered as having been fed appropriately if they consumed at least three food groups and received food or liquids other than breast milk at least twice per day in the case of infants age 6-8 months, and at least three times per day in the case of children age 9–23 months. Non-breastfed children were classified as appropriately fed if they consumed four food groups, including milk and milk products, and were fed at least four times per day.

Children age 12 months or older were classified as immunized if they received all the basic vaccinations, partially immunized if they received some vaccinations, or not immunized if they did not receive any vaccinations.

Household and environmental characteristics: The source of drinking water often determines the quality of the water that children and other household members consume. In our study, sources that are likely to be of suitable quality (such as, piped water, borehole, and protected well) were classified as "improved sources", and sources not of suitable quality (such as open well, pond, and stream) as "non-improved sources". An exception was that if water treatment was practiced in the household, a classification of "improved source" was given, regardless of the source of the water.

Sanitary conditions were classified on the basis of type of toilet facility (classified as improved if household has a pit latrine with a slab or flush toilet, and non-improved if no toilet facility is present or open pit is used), as well as whether the toilet facility was used by only one household (improved) or shared with other households (non-improved). The proper disposal of children's feces is important in preventing the spread of disease. If feces are left uncontained, disease may spread by direct contact or through indirect contamination. Child's stool was considered appropriately contained if the child used a toilet or latrine, the stool was put or rinsed into a toilet or latrine, or the stool was buried.

Other risk factors and confounding variables included: wealth quintile (based on household ownership of certain durable assets); mother's education (no education, primary, secondary, higher); residence (urban, rural); and region (Bulawayo, Manicaland, Mashonaland

Central, Mashonaland East, Mashonaland West, Masvingo, Matabeleland North, Matabeleland South, Midlands, Harare).

Selection Bias

In this study the analysis of stunting was restricted to children of interviewed mothers, and the analysis of low birth weight was further restricted to children who were weighed at birth. To ascertain whether these exclusion criteria lend themselves to selection bias we examined the characteristics of the included and excluded children (see Appendix Table 1 and Appendix Table 2). Children whose mothers were interviewed did not differ from those whose mothers were not interviewed in terms of their height-for-age Z-score, sex, or urban/rural residence. However, children of interviewed mothers were significantly younger and also differed by household wealth status, although there was no clear pattern by the latter characteristic. The differences between children who were weighed at birth and those who were not weighed at birth were more significant. Those who were not weighed at birth were significantly more likely to be stunted, born of older, less-educated mothers, and belong to rural and poorer households than children who were weighed at birth.

Ethical Considerations

This study is based on secondary analysis of survey data. Before the 2005-06 ZDHS was conducted, ethical and institutional review board (IRB) approvals were obtained from the Medical Research Council of Zimbabwe, Macro International, and the Centers for Disease Control and Prevention (CDC). Informed consent was obtained from all survey respondents prior to data collection.

RESULTS

Characteristics of the Sample

Table 1 shows general demographic and socioeconomic characteristics of children under age five (0-59 months) whose mothers were interviewed in the 2005-06 ZDHS. Among this sample, 28% of the children either were not weighed at birth or had missing values for birth weight. The distribution of the sample is as expected, with an almost equal proportion of boys and girls, and the age groups of children are equally represented, with each six-month grouping representing roughly 10% of the sample. About a third of the children are first-born, and the proportion of multiple births is only 3%. The sample is predominantly rural, and most mothers are literate and were 18-34 at the time of child's birth.

Table 1: Sample characteristics of children age 0-59 months whose mothers were interviewed, ZDHS 2005-06

Characteristic	N	%
Child characteristics:		
Sex		
Male	2,668	51.0
Female	2,563	49.0
Age		
<6 months	536	10.2
6-11 months	558	10.7
12-23 months	1,104	21.1
24-35 months	1,022	19.5
36-59 months	2,011	38.4
Birth weight		
<2500g	565	10.8
2500-3499g	2,140	40.9
≥3500g	1,042	19.9
Not weighed/DK/missing	1,483	28.4
Type of birth		
Single	5,075	97.0
Multiple	156	3.0

(Cont'd)

Table 1 – cont'd

Characteristic	**N**	**%**
Child's birth order		
1	1,654	31.6
2-3	2,207	42.2
4-5	886	16.9
6+	484	9.3
Months since preceding birth		
<18 months	131	2.5
18-23 months	236	4.5
24-35 months	956	18.3
≥36 months	2,242	42.9
No preceding birth	1,665	31.8
Maternal characteristics:		
Mother's age at child's birth		
<18 years	368	7.0
18-24 years	2,449	46.8
25-34 years	1,922	36.7
≥35 years	492	9.4
Mother's Body Mass Index (BMI) (kg/m^2)		
<18.5	377	7.2
18.5-24.9	3,121	59.7
25.0-29.9	732	14.0
≥30.0	212	4.1
Pregnant/birth in last 2 months/missing	789	15.1
Mother's education		
No education	213	4.1
Primary	1,922	36.8
Secondary	2,972	56.8
Higher	124	2.4
Mother's work status		
Currently working	1,852	35.4
Not currently working	3,379	64.6
Household characteristics:		
Wealth quintiles		
Lowest	1,296	24.8
Second	1,093	20.9
Middle	911	17.4
Fourth	1,091	20.9
Highest	839	16.1
Residence		
Urban	1,513	28.9
Rural	3,718	71.1

(Cont'd)

Table 1 – cont'd

Characteristic	N	%
Province		
Manicaland	679	13.0
Mashonaland Central	585	11.2
Mashonaland East	387	7.4
Mashonaland West	519	9.9
Matabeleland North	340	6.5
Matabeleland South	243	4.6
Midlands	774	14.8
Masvingo	790	15.1
Harare	666	12.7
Bulawayo	248	4.7
Total	**5,231**	**100.0**

Prevalence of Low Birth Weight and Stunting

Table 2 shows the prevalence of low birth weight and stunting by key characteristics of the child, mother, and household among children whose mothers were interviewed. For low birth weight, only those children who were weighed at birth are included. Among this sample the prevalence of stunting is 32% and the prevalence of low birth weight is 16%. However, 28% of the children either were not weighed at birth or had missing values for birth weight. Of particular interest are the findings that, of multiple-birth children, 60% have low birth weight (< 2,500 g), while 58% are stunted at the time of the survey. Similarly, higher proportions of children of mothers with low BMI (<18.5 kg/m^2) have low birth weight compared with children of mothers in the normal-to-high BMI categories. The prevalence of low birth weight is higher among girls (17%) than boys (13%), while the prevalence of stunting is higher among boys (37%) than girls (31%). The prevalence of both low birth weight and stunting is greater in households with unimproved sanitary facilities.

Table 2: Prevalence of low birth weight (<2500g) and stunting (height-for-age Z-score<-2.0) by selected sample characteristics among children age 0-59 months whose mothers were interviewed, ZDHS 2005-06

	Percent low birth weight (<2500g)[a]			Percent stunted (height-for-age Z-score<-2.0)[b]		
Characteristic	**N**	**%**	**P-value**	**N**	**%**	**P-value**
Child characteristics:						
Sex						
Male	1,888	13.3	0.008	1,975	36.5	0.000
Female	1,860	17.0		1,930	30.7	
Age						
<6 months	369	10.8	0.267	375	15.3	0.000
6-11 months	392	15.8		433	23.9	
12-23 months	788	15.5		860	39.1	
24-59 months	2,198	15.5		2,237	36.5	
Birth weight						
<2500g	-	-	-	395	41.4	0.000
2500-3499g	-	-	-	1,638	31.6	
≥3500g	-	-	-	786	27.7	
Not weighed/DK/missing	-	-	-	1,086	38.2	
Type of birth						
Single	3,640	13.7	0.000	3,812	33.0	0.000
Multiple	108	60.4		93	58.3	
Months since preceding birth						
<18 months	73	17.1	0.000	76	30.5	0.118
18-23 months	123	16.0		178	32.0	
24-35 months	592	10.9		724	36.3	
≥36 months	1,599	13.7		1,740	34.5	
No preceding birth	1,361	18.4		1,186	31.2	
Child's birth order						
1	1,350	18.1	0.001	1,179	31.1	0.463
2-3	1,613	12.7		1,648	35.2	
4-5	547	14.4		704	34.8	
6+	238	16.1		374	32.4	
Maternal characteristics:						
Mother's age at child's birth						
<18 years	263	19.0	0.089	255	37.6	0.231
18-24 years	1,798	15.3		1,767	32.6	
25-34 years	1,402	14.8		1,486	34.7	
≥35 years	285	11.8		396	31.6	
Mother's Body Mass Index (BMI) (kg/m^2)						
<18.5	243	21.0	0.000	295	35.6	0.026
18.5-24.9	2,226	15.7		2,394	35.2	
25.0-29.9	594	11.7		568	28.4	
≥30.0	182	9.0		158	33.6	
Pregnant/birth in last 2 months/missing	503	15.9		490	30.7	

(Cont'd)

Table 2 – cont'd

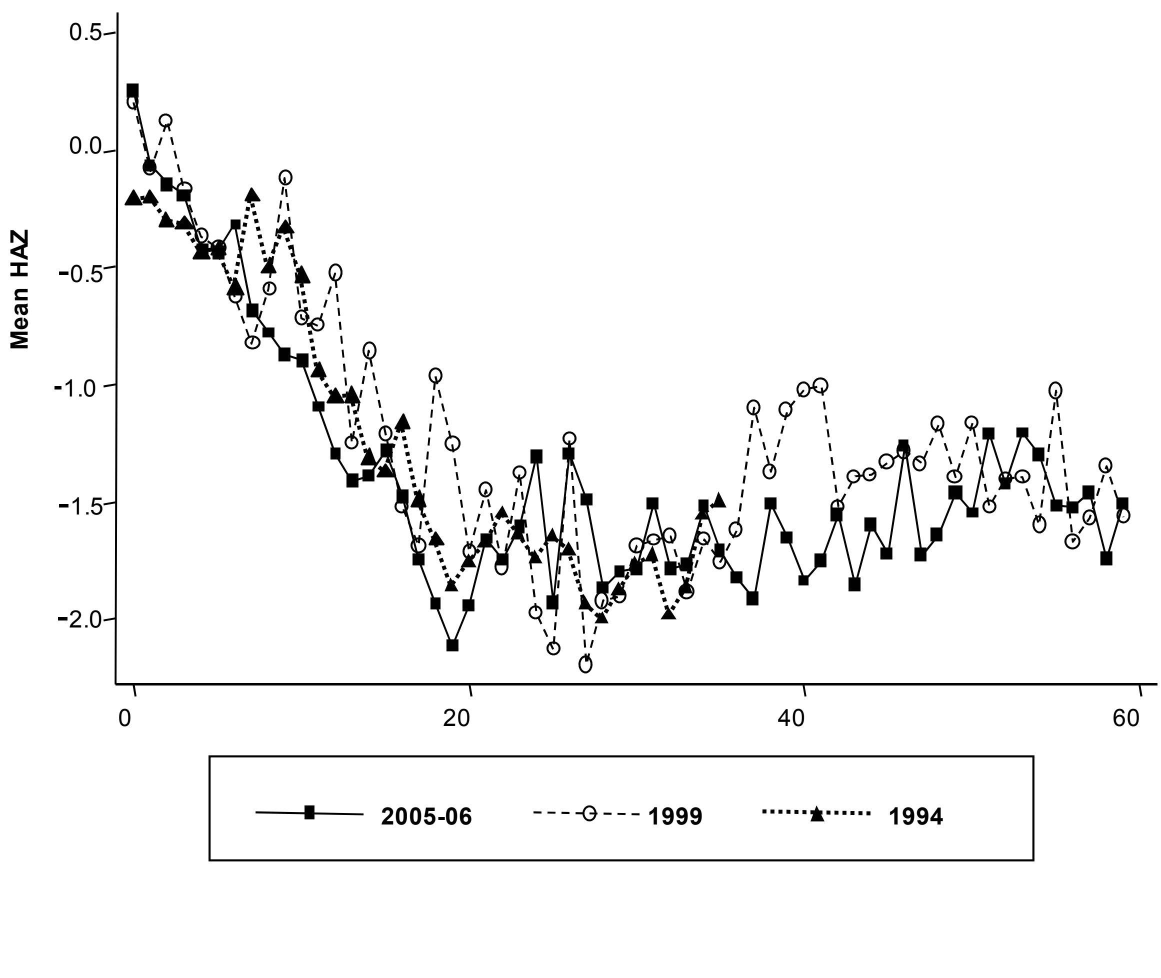
Characteristic	Percent low birth weight (<2500g)[a] N	%	P-value	Percent stunted (height-for-age Z-score<-2.0)[b] N	%	P-value
Mother's education						
No education	67	16.1	0.360	185	35.6	0.000
Primary	1,085	15.7		1,459	34.4	
Secondary	2,477	15.0		2,177	33.6	
Higher	119	10.4		84	15.2	
Mother's work status						
Currently working	1,344	15.0	0.835	1,370	32.5	0.329
Not currently working	2,404	15.1		2,534	34.2	
Household and environmental characteristics:						
Wealth quintiles						
Lowest	635	17.2	0.202	1,008	33.9	0.002
Second	673	15.8		846	38.7	
Middle	685	14.4		723	35.5	
Fourth	957	15.2		773	30.9	
Highest	798	13.3		555	26.7	
Access to safe water						
Non-improved	702	16.9	0.097	1,019	34.6	0.360
Improved	3,045	14.7		2,886	33.3	
Sanitary conditions						
Non-improved	2,208	16.4	0.003	2,573	35.3	0.001
Improved	1,539	13.3		1,332	30.3	
Disposal of children's stools						
Not contained	597	18.8	0.000	898	32.1	0.841
Contained	2,737	13.7		2,847	34.4	
Other/missing	414	19.1		160	29.2	
Residence						
Urban	1,431	14.6	0.578	1,018	27.7	0.000
Rural	2,316	15.4		2,887	35.7	
Province						
Manicaland	440	13.9	0.139	502	39.6	0.018
Mashonaland Central	381	15.6		478	39.3	
Mashonaland East	292	12.6		296	37.7	
Mashonaland West	329	14.2		359	33.6	
Matabeleland North	226	16.4		278	32.8	
Matabeleland South	174	10.3		197	30.9	
Midlands	510	18.3		582	32.0	
Masvingo	523	14.6		614	31.2	
Harare	632	14.9		436	27.2	
Bulawayo	239	17.9		162	27.9	
Total	**3,748**	**15.5**		**3,905**	**31.9**	

[a] Birth weight columns include only children who were weighed at birth and may include children who were no longer living.

[b] Stunting includes only children who were measured at the time of interview.

The trend in linear growth of children by age from the 1994, 1999, and 2005-06 ZDHS surveys conducted is illustrated in Figure 1. In the three surveys the mean height-for-age Z-scores decrease from around 0 at birth to 2 standard deviations below the reference median value (-2 Z-scores) at age 20-23 months. Thereafter, there is slight improvement in mean height-for-age Z-scores (from -2 to -1.5 Z-scores) between 24 and 59 months, indicating that catch-up growth is inadequate.

Figure 1: Mean height-for-age Z-scores (HAZ) by child's age in the 1994, 1999, and 2005-06 ZDHS



Multivariate Analysis

Low birth weight:

Table 3 shows results of multiple logistic regression analysis of low birth weight among children age 0-59 months whose mothers were interviewed and who were weighed at birth. The most salient determinant of low birth weight after controlling for other covariates is multiple-birth status. Multiple-birth children are 11 times more likely to have a low birth weight than singleton births (OR = 10.80; $p<0.001$). Higher maternal BMI is associated with lower likelihood of low birth weight. Compared with birth spacing of less than 18 months since the preceding birth, only one category of birth spacing, 24-35 months, is associated with a significantly lower probability of being low birth weight (OR = 0.50; $p<0.05$). Also, girls are significantly more likely to have low birth weight than boys (OR = 1.33; $p<0.05$). Controlling for the characteristics of the mother and child, none of the household socioeconomic or environmental characteristics is significantly associated with low birth weight.

Table 3: Determinants of low birth weight among children age 0-59 months whose mothers were interviewed and who were weighed at birth, ZDHS 2005-06

Explanatory variable	OR	95% CI		P-value
Child characteristics:				
Sex				
Male^R	1.00			
Female	1.33	1.06	1.67	0.013
Type of birth				
Single^R	1.00			
Multiple	10.80	6.36	18.33	0.000
Months since preceding birth				
<18 months^R	1.00			
18-23 months	0.84	0.38	1.88	0.676
24-35 months	0.50	0.26	0.99	0.046
≥36 months	0.64	0.33	1.22	0.176
No preceding birth	1.06	0.55	2.03	0.866
Child's birth order				
1-3^R	1.00			
4+	1.12	0.84	1.50	0.449
Maternal characteristics:				
Mother's Body Mass Index (BMI) (kg/m^2)				
<18.5^R	1.00			
18.5-24.9	0.64	0.42	0.97	0.035
25.0-29.9	0.51	0.32	0.81	0.005
≥30.0	0.46	0.21	1.01	0.053
Pregnant/birth in last 2 months/missing	0.66	0.42	1.04	0.071
Mother's education				
No education^R	1.00			
Primary	0.93	0.47	1.86	0.843
Secondary	0.89	0.42	1.86	0.760
Higher	0.70	0.20	2.39	0.566
Mother's work status				
Currently working^R	1.00			
Not currently working	0.97	0.77	1.24	0.819
Household and environmental characteristics:				
Wealth quintiles				
Lowest^R	1.00			
Second	0.92	0.63	1.35	0.681
Middle	0.92	0.62	1.36	0.686
Fourth	0.82	0.48	1.38	0.451
Highest	0.75	0.40	1.39	0.363

(Cont'd)

Table 3 – cont'd

Explanatory variable	**OR**	**95% CI**		**P-value**
Access to safe water				
Non-improved[R]	1.00			
Improved	0.90	0.67	1.20	0.458
Sanitary conditions				
Non-improved[R]	1.00			
Improved	0.84	0.66	1.07	0.155
Disposal of children's stools				
Not contained[R]	1.00			
Contained	0.76	0.55	1.06	0.109
Other/missing	0.96	0.63	1.46	0.837
Residence				
Urban[R]	1.00			
Rural	0.93	0.58	1.51	0.773
Province				
Manicaland[R]	1.00			
Mashonaland Central	1.04	0.67	1.62	0.845
Mashonaland East	0.85	0.49	1.48	0.564
Mashonaland West	0.98	0.60	1.61	0.951
Matabeleland North	1.08	0.67	1.74	0.745
Matabeleland South	0.76	0.43	1.34	0.342
Midlands	1.18	0.79	1.76	0.409
Masvingo	0.90	0.55	1.48	0.686
Harare	1.33	0.83	2.14	0.239
Bulawayo	1.59	0.99	2.54	0.053
Number of children		**3,748**		

Note: Analysis in this table includes children who are not currently living, but who were weighed at birth.

[R] Reference category

Stunting:

We also conducted multiple logistic regression analysis to assess independent relationships between stunting and selected characteristics of the child, child feeding practices and immunization, maternal characteristics, and household and environmental characteristics. Table 4 presents separate models for children age 6-23 months and 24-59 months and a combined model for all children age 6-59 months. As expected, stunting is inversely related to birth weight. Boys and multiple birth-children are significantly more likely to be stunted than girls and singleton births. These relationships are slightly attenuated among children age 24 -59 months compared with children age 6-23 months. The relationship between child's age and stunting is not consistent between the two age groups. Among children age 6-23 months, the odds of being stunted increase by 11% with each additional month of age, whereas at age 24-59 months each additional month is associated with a 2% decrease in the odds. This is consistent with the trends depicted in Figure 1. The net effect is that age is not significantly associated with stunting among all children age 6-59 months.

Among the younger group of children (age 6-23 months), contrary to expectation, delayed initiation of breastfeeding (more than seven hours after birth instead of within one hour) is associated with a lower likelihood of being stunted (albeit not statistically significant, at p=0.055). Among the older group (age 24-59 months), however, children who have been breastfed but for less than six months are significantly less likely to be stunted compared with those who have never been breastfed. Receipt of Vitamin A supplementation is protective against stunting, independent of immunization status, which itself is not significantly associated with stunting.

Table 4: Determinants of stunting (height-for-age Z-score<-2.0) of children age 6-59 months whose mothers were interviewed, ZDHS 2005-06

	6-23 months				24-59 months				All children 6-59 months			
Explanatory variable	**OR**	**95% CI**		**P-value**	**OR**	**95% CI**		**P-value**	**OR**	**95% CI**		**P-value**
Child characteristics:												
Sex												
Male[R]	1.00				1.00				1.00			
Female	0.58	0.42	0.78	0.000	0.80	0.66	0.97	0.026	0.74	0.64	0.86	0.000
Age in months (continuous)	1.11	1.08	1.14	0.000	0.98	0.97	0.99	0.000	1.00	0.99	1.01	0.988
Birth weight												
<2500g[R]	1.00				1.00				1.00			
2500-3499g	0.44	0.26	0.75	0.002	0.93	0.64	1.36	0.709	0.69	0.50	0.96	0.027
≥3500g	0.37	0.19	0.72	0.003	0.62	0.40	0.96	0.031	0.56	0.39	0.80	0.002
Not weighed/DK/missing	0.69	0.40	1.20	0.190	1.03	0.71	1.48	0.885	0.89	0.64	1.24	0.488
Type of birth												
Single[R]	1.00				1.00				1.00			
Multiple	3.72	1.51	9.15	0.004	2.37	1.17	4.79	0.016	2.40	1.31	4.41	0.005
Months since preceding birth												
<18 months[R]	1.00				1.00				1.00			
18-23 months	1.14	0.27	4.86	0.861	1.07	0.52	2.20	0.860	1.19	0.63	2.25	0.581
24-35 months	1.95	0.62	6.15	0.255	1.06	0.52	2.12	0.879	1.35	0.76	2.41	0.301
≥36 months	1.84	0.57	5.93	0.308	1.03	0.54	1.98	0.929	1.30	0.75	2.25	0.346
No preceding birth	1.87	0.60	5.82	0.279	0.81	0.41	1.60	0.547	1.12	0.64	1.96	0.683
Child feeding and immunization:												
Initiation of breastfeeding												
Within 1 hour of birth[R]	1.00				1.00				1.00			
Between 1 - 6 hours of birth	0.96	0.67	1.36	0.798	0.95	0.73	1.25	0.721	0.96	0.79	1.17	0.705
6 hours or more after birth	0.63	0.39	1.01	0.055	1.04	0.75	1.44	0.809	0.88	0.68	1.14	0.336
Breastfeeding duration												
Never breastfed[R]					1.00							
Breastfed for <6months					0.15	0.03	0.83	0.030				
Breastfed for >=6months					0.72	0.38	1.35	0.306				
Currently breastfeeding					0.91	0.34	2.42	0.847				

(Cont'd)

Table 4 – cont'd

Explanatory variable	6-23 months				24-59 months				All children 6-59 months			
	OR	95% CI		P-value	OR	95% CI		P-value	OR	95% CI		P-value
Vitamin A supplementation												
Never received[R]					1.00							
Ever received					0.74	0.58	0.94	0.015				
Immunization												
Not immunized[R]					1.00							
Partially immunized					0.75	0.55	1.03	0.071				
Fully immunized					0.92	0.71	1.20	0.558				
Maternal characteristics:												
Mother's age at child's birth												
<18 years[R]	1.00				1.00				1.00			
18-24 years	0.68	0.38	1.23	0.200	0.83	0.54	1.27	0.384	0.77	0.56	1.06	0.105
25-34 years	0.74	0.33	1.64	0.455	0.82	0.49	1.37	0.449	0.81	0.54	1.23	0.323
≥35 years	0.99	0.41	2.41	0.988	0.59	0.35	1.00	0.051	0.67	0.43	1.05	0.080
Mother's Body Mass Index (BMI) (kg/m^2)												
<18.5[R]	1.00				1.00				1.00			
18.5-24.9	1.06	0.67	1.69	0.793	0.92	0.58	1.45	0.725	1.01	0.74	1.38	0.943
25.0-29.9	0.81	0.44	1.50	0.502	0.82	0.48	1.40	0.468	0.83	0.59	1.19	0.313
≥30.0	1.64	0.64	4.18	0.303	1.09	0.55	2.18	0.805	1.25	0.74	2.11	0.399
Pregnant/birth in last 2 months/missing	0.83	0.35	1.93	0.662	1.01	0.61	1.67	0.966	1.19	0.81	1.76	0.379
Mother's education												
No education[R]	1.00				1.00				1.00			
Primary	1.13	0.52	2.46	0.762	1.17	0.64	2.15	0.600	1.05	0.66	1.68	0.828
Secondary	1.63	0.74	3.59	0.225	1.16	0.51	2.62	0.724	1.20	0.68	2.14	0.526
Higher	0.27	0.05	1.31	0.103	0.61	0.19	1.94	0.399	0.45	0.18	1.10	0.080
Mother's work status												
Currently working[R]	1.00				1.00				1.00			
Not currently working	0.96	0.67	1.38	0.830	1.09	0.86	1.38	0.489	1.05	0.88	1.25	0.589

(Cont'd)

Table 4 – cont'd

Explanatory variable	6-23 months				24-59 months				All children 6-59 months			
	OR	95% CI		P-value	OR	95% CI		P-value	OR	95% CI		P-value
Household and environmental characteristics:												
Wealth quintiles												
Lowest[R]	1.00				1.00				1.00			
Second	1.36	0.87	2.13	0.180	0.99	0.74	1.33	0.954	1.17	0.93	1.46	0.182
Middle	1.00	0.58	1.73	0.990	1.03	0.74	1.43	0.876	1.00	0.77	1.30	0.999
Fourth	0.82	0.48	1.41	0.473	0.84	0.51	1.38	0.496	0.88	0.63	1.22	0.429
Highest	0.71	0.32	1.56	0.395	0.99	0.54	1.80	0.970	0.92	0.59	1.43	0.708
Access to safe water												
Non-improved[R]	1.00				1.00				1.00			
Improved	1.30	0.91	1.87	0.152	0.97	0.74	1.26	0.794	1.05	0.86	1.29	0.635
Sanitary conditions												
Non-improved[R]	1.00				1.00				1.00			
Improved	1.08	0.73	1.61	0.694	0.72	0.55	0.93	0.014	0.82	0.68	1.00	0.052
Disposal of children's stools												
Not contained[R]	1.00				1.00				1.00			
Contained	1.25	0.77	2.01	0.362	1.43	1.10	1.86	0.007	1.35	1.03	1.76	0.028
Residence												
Urban[R]	1.00				1.00				1.00			
Rural	1.20	0.61	2.34	0.595	1.23	0.74	2.03	0.418	1.21	0.80	1.83	0.370
Province												
Manicaland[R]	1.00				1.00				1.00			
Mashonaland Central	0.73	0.43	1.24	0.239	1.14	0.61	2.15	0.684	0.94	0.63	1.42	0.784
Mashonaland East	0.84	0.49	1.44	0.528	1.20	0.77	1.88	0.419	0.96	0.67	1.38	0.832
Mashonaland West	0.79	0.42	1.48	0.459	0.95	0.58	1.55	0.828	0.83	0.56	1.24	0.363
Matabeleland North	0.78	0.43	1.43	0.425	0.97	0.58	1.62	0.900	0.77	0.52	1.16	0.210
Matabeleland South	1.01	0.58	1.76	0.983	0.72	0.41	1.28	0.264	0.75	0.50	1.13	0.172
Midlands	0.68	0.38	1.22	0.195	0.81	0.52	1.25	0.334	0.73	0.51	1.06	0.097
Masvingo	0.50	0.27	0.92	0.025	0.98	0.63	1.54	0.933	0.71	0.47	1.05	0.088
Harare	0.63	0.30	1.34	0.230	0.89	0.50	1.61	0.709	0.72	0.45	1.16	0.182
Bulawayo	0.91	0.43	1.95	0.818	0.82	0.41	1.63	0.567	0.80	0.47	1.34	0.393
Number of children	**1,293**				**2,230**				**3,530**			

Note: Analysis in this table is limited to children with a valid height-for-age Z-score.
[R] Reference category

Access to improved sanitation and proper disposal of the youngest child's stool have conflicting independent associations with stunting among the older group of children. On the one hand, children from households with improved sanitation are less likely to be stunted. On the other hand, children from households where the youngest child's stool was properly contained are more likely to be stunted, even after controlling for other covariates, including sanitation.

Among a subset of the youngest children age 6-23 months, we explored the association between a summary measure of appropriate IYCF and stunting (results not shown). Surprisingly, the analysis suggests that children who were fed following all recommended practices are more likely to be stunted, after controlling for the other covariates presented in Table 4. The relationship is not statistically significant, however, (OR = 1.36; p=0.072).

DISCUSSION

Principal Findings

Our study results, based on analysis of the 2005-06 ZDHS, highlight some modifiable factors that are significantly associated with the attained growth of newborns and young children age 6-59 months. These include both prenatal and postnatal factors. The study demonstrates that the determinants of stunting vary substantially by children's age. The relationships appear stronger among younger children (age 6-23 months), when most of the linear growth faltering occurs, than among older children (age 24-59 months). Among the younger children, the odds of being stunted increase by 11% with each additional month of age, whereas among the older children each additional month is associated with a 2% decrease in the odds. This finding is consistent with an analysis of growth faltering worldwide, using the NCHS reference data, that revealed that linear growth faltering is most pronounced at age 0-23 months (Shrimpton et al., 2001). Thereafter, child growth plateaus, with very little catch-up growth.

The age-specificity of determinants is also consistent with findings from an observational study in Mozambique (Sahn and Alderman, 1997) and a longitudinal study in the Philippines (Adair and Guilkey, 1997). These age-related findings highlight the need to examine the determinants of nutritional status by children's age and to design strategies that prevent early growth faltering, when the effects of the determinants are most pronounced.

Constitutional/prenatal factors: The patterns of growth faltering begin before an infant is born and continue through the child's early life. Maternal nutrition and health care during pregnancy are the strongest determinants of fetal growth and birth weight (Mishra et al., 2005; Ramakrishnan, 2004). In our study mother's BMI has a positive relationship with birth weight, as does birth spacing, evidence of an intergenerational cycle of undernutrition (Victora et al., 2008). We also found other non-modifiable factors that influence birth weight independently of other factors, notably that female and multiple-birth infants are lighter at birth. The challenge of fetal nutrition becomes more pronounced in the case of multiple pregnancies due to an increased demand for nutrition.

Low-birth-weight infants are usually characterized by frailty and difficulty in thriving and are therefore predisposed to poor growth attainment. In an analysis of the longitudinal Philippines study (Adair, 1989), and consistent with the findings of our study, significant length differences were demonstrated at 12 months between infants with low birth weight and those with normal birth weight. Our study found that multiple birth status was also associated with greater risk of stunting, even after controlling for birth weight.

Postnatal factors: In the postnatal period, factors including childcare and feeding and the health and sanitary environment determine the growth and development of the child. Our study found complex relationships between these factors and the likelihood of stunting. Delayed initiation of breastfeeding is associated with lower likelihood of stunting. Also, we found no significant association between a summary indicator of appropriate infant and young child feeding and the likelihood of stunting. This is also contrary to our finding that early breastfeeding, compared with not breastfeeding at all, is protective against stunting among older children.

Because it is implausible that either early breastfeeding initiation or appropriate feeding can cause stunting, it is more probable that some unobserved measure of health or frailty may influence how the mother chooses to feed her child, thereby obscuring any positive effects on growth and nutritional status (Ntab et al., 2005; Briscoe et al., 1990). As such, these findings may be due to “reverse causality”.

Studies of the association between Vitamin A supplementation and child growth have yielded inconsistent results. One of the few studies demonstrating an effect showed growth improvements due to supplementation only among children with clinical Vitamin A deficiency (West et al., 1997). More recently and similar to our findings, in Indonesia better nutritional status and health indicators were observed in children age 12-59 months who had received a Vitamin A capsule in the six months preceding data collection for the Indonesian Nutritional Surveillance System (Berger et al., 2007). One explanation for this finding, as suggested by Berger et al. (2007), is that receiving Vitamin A supplementation may be a proxy for general health-seeking behavior. In our study no significant association is observed between stunting and partial receipt of immunization (another proxy for health-seeking behavior), suggesting that a significant negative association between stunting and Vitamin A supplementation may reflect actual benefits of Vitamin A supplementation.

Consistent with studies from other countries (Esrey, 1996), we found that older children living in a household with access to improved sanitation are less likely to be stunted, after controlling for other covariates including access to a protected water source, maternal education, and household wealth status. An unexpected finding, however, is that the contained disposal of child's stool is associated with stunting, and the effect is significant even after controlling for sanitation and other factors. The association between contained stool disposal and stunting is not affected by the availability of a toilet in the household. It is difficult to draw inferences from this finding, given that the ZDHS did not collect information on handwashing after fecal contact, which has been demonstrated to be an effective public health intervention (Curtis and Cairncross, 2003; Scott et al., 2003; Curtis et al., 2001).

In the literature, the relationship between stool disposal and child health is unclear. A study of hospital admissions for diarrhea and dysentery in Burkina Faso showed that "it is not where a child defecates that is important, but what a mother does with the stool and whether or not stool is visible in the yard" (Traore et al., 1994). It is also possible that reported stool disposal behavior is a marker for other unmeasured factors or behaviors that may intervene to put children at risk of being stunted. For example, having contact with stool that is not followed by handwashing before child contact or food handling and preparation is likely to be more harmful than the uncontained disposal of stool itself. The uncertainty reflected in the literature and in our own study findings underscores the need for the meaning of "proper disposal" of children's stool to be better defined and studied in the DHS and elsewhere.

Limitations

There was some selection bias in this study, particularly in studying birth weight as a response variable. Children who were not weighed at birth had significantly lower height-for-age Z-scores (HAZ) than those who were weighed. Since our study found that low birth weight is a strong predictor of stunting, it is therefore likely that children who were not weighed were lighter at birth than those who were weighed. Given that almost a third of infants were not weighed at birth, it is probable that the overall prevalence of low birth weight is underestimated in the 2005-06 ZDHS. Also, children who were not weighed at birth were born of older, less-educated mothers and belonged to more rural, and poorer households than children who were weighed at birth. It is likely that the exclusion of these children, who are also more likely to have low birth weight, biases the observed relationships between these maternal and socio-demographic variables and low birth weight towards the null.

Another limitation of this study is the cross-sectional nature of the data, which allows us to observe associations but does not indicate the direction of causality. Also, stunting is the outcome of chronic or long-term exposures to factors or environments that impede growth. Although current practices and living environments are likely to be representative of past exposures, the findings should be interpreted with caution. Further compounding this limitation is the potential for respondents' recall bias in some of the measures related to nutritional status, such as breastfeeding.

Implications

Our findings suggest that opportunities for interventions to combat child undernutrition appear before the child's birth and continue through infancy and early childhood. Programs that lead to improvements in maternal nutrition, family planning, and antenatal care are required in order to improve pregnancy outcomes, including birth weight. Thereafter, care of infants with low birth weight, access to Vitamin A supplementation, and improvements in the sanitary environment all are important and play key roles at different stages of a child's early life (Humphrey, 2009; Bhutta et al., 2008a). The role of breastfeeding and infant and young child feeding in improving child growth needs to be studied further in this context, paying attention to maternal practices and motivations for these practices, in order to ascertain the extent to which our findings may be influenced by reverse causality. Within the context of Zimbabwe's weakened health delivery system, specific focused interventions are required to prevent and reduce prevalent stunting.

REFERENCES

Adair, L. S. (1989) Growth of Filipino infants who differ in body proportions at birth. *Am J Hum Biol,* 1**,** 673-682.

Adair, L. S., Guilkey, D. K. (1997) Age-specific determinants of stunting in Filipino children. *J Nutr,* 127**,** 314-20.

Adm, T., Lim, S. S., Mehta, S., Bhutta, Z. A., Fogstad, H., Mathai, M., Zupan, J., Darmstadt, G. L. (2005) Cost effectiveness analysis of strategies for maternal and neonatal health in developing countries. *BMJ,* 331**,** 1107-1110.

Berger, S. G., De Pee, S., Bloem, M. W., Halati, S., Semba, R. D. (2007) Malnutrition and morbidity are higher in children who are missed by periodic Vitamin A capsule distribution for child survival in rural Indonesia. *J Nutr,* 137**,** 1328-1333.

Bhutta, Z. A., Ahmed, T., Black, R. E., Cousens, S., Dewey, K., Giugliani, E., Haider, B. A., Kirkwood, B., Morris, S. S., Sachdev, H. P., Shekar, M. (2008a) What works? Interventions for maternal and child undernutrition and survival. *Lancet,* 371**,** 417-40.

Bhutta, Z. A., Ali, S., Cousens, S., Ali, T. M., Haider, B. A., Rizvi, A., Okong, P., Bhutta, S. Z., Black, R. E. (2008b) Alma-Ata: Rebirth and Revision 6: Interventions to address maternal, newborn, and child survival: what difference can integrated primary health care strategies make? *Lancet,* 372**,** 972-989.

Briscoe, J., Akin, J., Guilkey, D. (1990) People are not passive acceptors of threats to health: Endogeneity and its consequences. *Int J Epidemiol,* 19**,** 147-153.

Caulfield, L. E., De Onis, M., Blossner, M., Black, R. E. (2004) Undernutrition as an underlying cause of child deaths associated with diarrhea, pneumonia, malaria, and measles. *Am J Clin Nutr,* 80**,** 193-8.

Central Statistics Office (CSO) [Zimbabwe] and Macro International Inc. (2007) Zimbabwe Demographic and Health Survey 2005-06. Calverton, Maryland, CSO and Macro International Inc.

Christian, P. (2009) Prenatal origins of undernutrition. *Nestle Nutr Workshop Ser Pediatr Program,* 63**,** 59-73; discussion 74-7, 259-68.

Curtis, V., Cairncross, S. (2003) Effect of washing hands with soap on diarrhoea risk in the community: a systematic review. *Lancet Infect Dis,* 3**,** 275-281.

Curtis, V., Kanki, B., Cousens, S., Diallo, I., Kpozehouen, A., Sangare, M., Nikiema, M. (2001) Evidence of behaviour change following a hygiene promotion programme in Burkina Faso. *Bull World Health Organ,* 79**,** 518-527.

Esrey, S. A. (1996) Water, waste, and well-being: a multicountry study. *Am J Epidemiol,* 143**,** 608-623.

Esrey, S. A., Habicht, J. P. (1986) Epidemiologic evidence for health benefits from improved water and sanitation in developing countries. *Epidemiol Rev,* 8**,** 117-128.

Haines, A., Sanders, D., Lehmann, U., Rowe, A. K., Lawn, J. E., Jan, S., Walker, D. G., Bhutta, Z. (2007) Achieving child survival goals: potential contribution of community health workers. *Lancet,* 369**,** 2121-2131.

Humphrey, J. H. (2009) Child undernutrition, tropical enteropathy, toilets, and handwashing: Making the linkages. *Lancet,* 374, 1032-1035.

Jones, G., Steketee, R. W., Black, R. E., Bhutta, Z. A., Morris, S. S., Bellagio Child Survival Study Group. (2003) How many child deaths can we prevent this year? *Lancet,* 362**,** 65-71.

Mason, J. B. (2000) How nutrition improves and what that implies for policy decisions. UNICEF, New York, and World Bank, Washington. DC, Paper prepared for World Bank-UNICEF Nutrition Assessment.

Mishra, V., Thapa, S., Retherford, R. D., Dai, X. (2005) Effect of iron supplementation during pregnancy on birthweight: evidence from Zimbabwe. *Food Nutr Bull,* 26**,** 338-47.

Ntab, B., Simondon, K. B., Milet, J., Cisse, B., Sokhna, C., Boulanger, D., Simondon, F. (2005) A young child feeding index is not associated with either height-for-age or height velocity in rural Senegalese children. *J Nutr,* 135**,** 457-464.

Pelletier, D. L., Frongillo, E. A., Jr., Habicht, J. P. (1993) Epidemiologic evidence for a potentiating effect of malnutrition on child mortality. *Am J Public Health,* 83**,** 1130-3.

Ramakrishnan, U. (2004) Nutrition and low birth weight: from research to practice. *Am J Clin Nutr,* 79**,** 17-21.

Sahn, D. E.,Alderman, H. (1997) On the determinants of nutrition in Mozambique: The importance of age-specific effects. *World Development,* 25**,** 577-588.

Scott, B., Curtis, V.,Rabie, T. (2003) Protecting children from diarrhoea and acute respiratory infections: the role of handwashing promotion in water and sanitation programmes. *WHO Regional Health Forum,* 7**,** 42-47.

Shrimpton, R., Victora, C. G., De Onis, M., Lima, R. C., Blossner, M.,Clugston, G. (2001) Worldwide timing of growth faltering: implications for nutritional interventions. *Pediatrics,* 107**,** 1-7.

Traore, E., Cousens, S., Curtis, V., Mertens, T., Tall, F., Traore, A., Kanki, B., Diallo, I., Rochereau, A., Chiron, J. P.,Megraud, F. (1994) Child defecation behaviour, stool disposal practices, and childhood diarrhoea in Burkina Faso; results from a case-control study. *J Epidemiol Community Health,* 48**,** 270-275.

UNICEF. (1990) Strategy for improved nutrition of children and women in developing countries*.* New York, N.Y., UNICEF.

Victora, C. G., Adair, L., Fall, C., Hallal, P. C., Martorell, R., Richter, L. and Sachdev, H. S. (2008) Maternal and child undernutrition: consequences for adult health and human capital. *Lancet,* 371**,** 340-357.

West, K. P., Leclerq, S. C., Shrestha, S. R., Wu, L. S. F., Pradhan, E. K., Khatry, S. K., Katz, J., Adhikari, R., Sommer, A. (1997) Effects of vitamin A on growth of vitamin A-deficient children: field studies in Nepal. *J Nutr,* 127**,** 1957-1965.

WHO Multicentre Growth Reference Study Group (2006) WHO child growth standards: Length/height-for-age, weight-for-age, weight-for-length, weight-for height and Body Mass Index-for-age: Methods and development. Geneva, Switzerland, World Health Organization.

World Health Organization (1998) Complementary feeding of young children in developing countries: a review of current scientific knowledge. Geneva, Switzerland, World Health Organization.

Appendix Table 1: Comparison of selected characteristics of children age 0-59 months whose mothers were interviewed with those whose mothers were not interviewed, ZDHS 2005-06

Characteristic	Mother interviewed		Mother not interviewed		P-value
	Mean	SD	Mean	SD	
Height-for-age Z-score (HAZ)	-1.39	1.59	-1.41	1.82	0.452
Child's age (years)	1.93	1.42	2.72	1.17	0.000
	%	N	%	N	
Sex					
Male	49.7	1,933	49.6	507	0.955
Female	50.3	1,954	50.4	515	
Household wealth quintiles					
Lowest	24.6	957	23.3	238	0.036
Second	22.6	878	24.1	246	
Middle	19.4	756	23.3	238	
Fourth	19.7	764	15.4	157	
Highest	13.7	533	14.0	143	
Residence					
Urban	25.0	972	22.2	227	0.165
Rural	75.0	2,915	77.8	795	
Number of children	**3,887**		**1,022**		

Note: Table only includes children with a valid height-for-age Z-score.

Appendix Table 2: Comparison of selected characteristics of children age 0-59 months of mothers who were interviewed by whether they were weighed at birth, ZDHS 2005-06

Characteristic	Weighed at birth		Not weighed at birth		P-value
	Mean	SD	Mean	SD	
Height-for-age Z-score (HAZ)	-1.33	1.60	-1.49	1.54	0.002
Child's age (months)	29.09	16.86	27.70	18.22	0.257
Mother's age at child's birth (years)	25.03	6.00	26.49	7.27	0.000
	%	N	%	N	
Child's Sex					
Male	50.4	1,420	51.1	555	0.694
Female	49.6	1,399	48.9	531	
Child's birth order					
1	35.0	988	17.6	191	0.000
2-3	42.8	1,205	40.8	443	
4-5	15.8	444	23.9	260	
5+	6.5	182	17.7	192	
Mother's education					
No education	1.9	55	12.0	130	0.000
Primary	30.5	858	55.4	601	
Secondary	64.7	1,825	32.4	352	
Higher	2.9	81	0.3	3	
Mother's work status					
Currently working	35.5	1,001	34.0	369	0.610
Not currently working	64.5	1,818	66.0	717	
Wealth quintiles					
Lowest	17.7	500	46.8	508	0.000
Second	18.8	529	29.2	317	
Middle	19.9	560	15.0	163	
Fourth	24.5	690	7.6	83	
Highest	19.1	540	1.4	15	
Residence					
Urban	34.9	983	3.2	35	0.000
Rural	65.1	1,836	96.8	1,051	
Number of children	**2,819**		**1,086**		

Note: Table only includes children with a valid height-for-age Z-score.