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AN ASSESSMENT OF THE QUALITY OF DHS ANTHROPOMETRIC DATA, 2005-2014

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An Assessment of the Quality of DHS Anthropometric Data, 2005-2014

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The DHS Program assists countries worldwide in the collection and use of data to monitor and evaluate population, health, and nutrition programs. For additional information about the DHS Program contact: DHS Program, ICF International, 530 Gaither Road, Suite 500, Rockville, MD 20850, USA. Phone: +1 301-407-6500; fax: +1 301-407-6501; email: reports@dhsprogram.com; Internet: www.dhsprogram.com.

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Preface

The Demographic and Health Surveys (DHS) Program is one of the principal sources of international data on fertility, family planning, maternal and child health, nutrition, mortality, environmental health, HIV/AIDS, malaria, and provision of health services.

One of the objectives of The DHS Program is to continually assess and improve the methodology and procedures used to carry out national-level surveys as well as to offer additional tools for analysis. Improvements in methods used will enhance the accuracy and depth of information collected by The DHS Program and relied on by policymakers and program managers in low- and middle-income countries.

While data quality is a main topic of the DHS Methodological Reports series, the reports also examine issues of sampling, questionnaire comparability, survey procedures, and methodological approaches. The topics explored in this series are selected by The DHS Program in consultation with the U.S. Agency for International Development.

It is hoped that the DHS Methodological Reports will be useful to researchers, policymakers, and survey specialists, particularly those engaged in work in low- and middle-income countries, and will be used to enhance the quality and analysis of survey data.

Sunita Kishor
Director, The DHS Program

Abstract

This methodological report examines the quality of anthropometric data from 52 DHS surveys conducted between 2005 and 2014. The analysis includes height, weight, and age measurements of children under five years of age as well as three nutritional status indices—height-for-age (HAZ), weight-for-age (WAZ), and weight-for-height (WHZ)—that follow WHO guidelines. The data quality indicators used to investigate the measurements include: standard deviation of z-scores; heaping of measures of height, weight, and age; and the percentage of extreme cases flagged during data processing. In addition, linear regressions of the z-scores were conducted to examine the amount of heterogeneity in z-scores that can be explained by covariates, including cluster-level variation. The findings identified surveys that have outperformed others in terms of anthropometric data quality along with surveys that have been deficient in data quality. Based on the results, recommendations were made that will improve the quality of anthropometric data in future surveys.

KEY WORDS: Anthropometry, stunting, wasting, underweight, nutritional status, z-score, Demographic and Health Surveys, data quality.

Executive Summary

Providing reliable estimates of anthropometric indicators such as the prevalence of stunting, wasting, and underweight among children is important for monitoring global progress toward the goals of eradicating hunger, reducing health inequalities, and assessing the progress of short- and long-term nutrition and health interventions. The collection of anthropometric data has been a key component of the Demographic and Health Surveys (DHS) since 1986. To date, DHS has collected height and weight data for more than three million children and adults in 238 surveys in 77 countries. The DHS Program regularly conducts further analyses of the quality of data from these surveys to identify areas for future improvement. The current methodological report examines the quality of anthropometric data from the most recent survey conducted in 52 DHS countries between 2005 and 2014. Data quality was assessed using multiple indicators that are already included in DHS field check tables plus new indicators suggested in the literature. These indicators include the standard deviations of the WHO z-scores known as HAZ (height-for-age), WAZ (weight-for-age), and WHZ (weight-for-height); heaping of height, weight, and age; and flagged cases identified through data processing and WHO limits regarding extreme values. Based on the results, recommendations were made of ways to improve the quality of anthropometric data in future DHS surveys.

The 52 countries whose data were analyzed vary substantially in terms of their anthropometric indicators but also in terms of the data quality indicators examined. Some countries appeared to perform poorly on several of the data quality indicators, particularly Albania and Benin, while other countries such as Colombia, Honduras, and Peru were identified as having high quality data. Of particular concern is the higher variability in the standard deviations for children at younger ages, which may be due to the difficulty of measuring very young children lying down in contrast to measuring older children standing up. This observation draws attention to the need for more focused effort in training on *length* measurements of children under two years of age in future DHS surveys.

Linear regressions for each of the z-scores showed similarities in relationships with several covariates. In most surveys, the z-scores had positive significant relationships with *perceived size at birth* (average and large versus small size at birth as the reference category) and *mother's weight* according to her BMI (normal and above versus thin as the reference category). The percentage of variation explained by such variables was usually less than 10%.

A separate regression for the HAZ z-score was estimated for each of the 52 countries by adding the cluster as a fixed-effect categorical covariate, in addition to the other covariates in the first regression. The results showed that the R-squared value increased substantially for most countries after the addition of the cluster

variable. This increase indicates a high level of heterogeneity across or between the clusters. The finding is likely due to variations in heterogeneity from one cluster to another, but it could also be due to variations in the quality of measurements taken by different fieldwork teams. However, the cluster variable did not explain a large portion of the variability in the HAZ z-scores for all surveys. In some surveys, a high standard deviation of z-scores is more likely due to either within-cluster heterogeneity or measurement error versus between cluster variability.

The inclusion of the following information when presenting anthropometry data has been recommended by WHO: general characteristics of the population; sample size; measurement methods; method of determining age; percentage of excluded data; prevalence based on fixed cutoff; confidence intervals of the prevalence estimates; mean z-scores with 95% confidence intervals; standard deviations of z-scores; and frequency distribution plots against the reference distribution. In DHS surveys all the indicators are already included in the main survey reports except SDs of the z-scores and frequency distribution plots. There remains a need for well-defined and internationally accepted criteria to assess anthropometry data quality. It should also be recognized that direct information on the quality of anthropometric measurements is only a subset of the information that is needed to assess the overall quality of a population-based survey.

Recommendations to improve the quality of DHS anthropometric data include more training on measurement of children, especially younger children, and identifying new types of equipment to accurately measure the height/length of children, including digital and lightweight measuring boards.

1. Introduction

In 2012, the World Health Organization (WHO) member states endorsed six World Health Assembly global targets for improving maternal, infant, and young child nutrition by 2025 (World Health Organization 2014a). These targets include three anthropometric indicators of nutritional status: stunting, wasting, and overweight. The recently developed Sustainable Development Goals (SDG) also reinforced the Millennium Development Goals (MDG) of ending hunger and improving food security and nutrition. About this time, WHO released a new action-oriented slogan, "what is measured gets done" (World Health Organization 2014b), and it became apparent that providing reliable estimates of anthropometric indicators such as the prevalence of stunting, wasting, and underweight among children is important for monitoring global progress toward the goals of eradicating hunger, reducing health inequalities, and assessing the progress of short- and long-term nutrition and health interventions.

As highlighted by the first Global Nutrition Report released in 2014, "nutrition is central to sustainable development" (International Food Policy Research Institute 2014, p3). It is important to monitor the healthy growth of children, especially in the first years of life. Undernourished children are not only at risk of death and disease but also are unable to reach their full cognitive potential. Anthropometric indicators can also be used as proxy measures of child health inequalities and economic development (International Food Policy Research Institute 2014).

Between 1990 and 2015 one of the nutrition targets set by MDG 1 was to reduce by half the proportion of people who suffer from hunger (United Nations 2014). One of the indicators used for this target is the prevalence of underweight among children under five. This target has almost been met, but in 2012 there were still an estimated 99 million children under five years who were underweight (United Nations 2014). The recently developed Sustainable Development Goals (SDG) recommend changing the undernutrition indicators to stunting and wasting in children under five years of age (Schmidt-Traub et al. 2015).

The term "anthropometry" is derived from the Greek words "anthropos" and "metron," meaning "human measurement." Anthropometric data collection has been a key component of Demographic and Health Surveys since 1986. To date, DHS has collected height and weight data for more than 3 million children and adults in 238 surveys in 77 countries. In DHS surveys, anthropometric data are collected by measuring the height and weight of children under the age of five who stayed in the household the night before the survey. In early surveys the measurements of children were limited to the children of interviewed mothers, but since 1997 this limitation has been removed. To ensure the production of high quality anthropometric data, DHS provides interviewers with extensive training on how to obtain and record height and weight measurements as well as the birthdate, including day of birth. Other efforts to achieve high data quality include field check tables, multiple layers of supervision, and field visits as part of the standard DHS protocol. The DHS program has also begun using Computer Assisted Personal Interviews (CAPI) in several countries, enabling real-time data quality assessment.

DHS regularly conducts further analyses of the quality of data to identify areas for future improvements. In 2008 an assessment of the data quality of health and nutrition indicators was conducted by Pullum (2008) for surveys implemented between 1993 and 2003. That methodological report included anthropometry data quality assessment indicators, mainly investigating missing or flagged values of height/length and weight; it did not include a detailed examination of the z-scores.

The current methodological report examines the quality of anthropometric data from 52 countries that had a recent DHS survey (between 2005 and 2014). Data quality will be assessed using multiple indicators already included in the DHS field check tables and new indicators suggested in the literature (Crowe et al. 2014; Mei and Grummer-Strawn 2007; World Health Organization 1995). Based on the results, recommendations will be made to further improve anthropometric data quality in the surveys.

1.1 Growth Reference Standards and Flags

To obtain anthropometric indicators on stunting, underweight, wasting, and overweight of children from height/length, weight and/or age, WHO growth reference standards are used to compute three nutritional scores described as z-scores. These z-scores are the HAZ (height-for-age), WAZ (weight-for-age), and WHZ (weight-for-height). Low values on these scales (below standard cutoffs) identify stunting, underweight, and wasting, respectively.

Heuristically, each z-score is calculated by comparing the child's height/length or weight with the median value in the reference population. The difference is divided by the standard deviation of the reference population (WHO Multicentre Growth Reference Study Group 2006) as shown in the formula below. The actual computation of z-scores is substantially more complicated however, and requires the use of reference lists of coefficients.

$$\text{Z-score} = \frac{\text{Individual value of the child} - \text{median value of children in the reference population}}{\text{Standard deviation of the reference population}}$$

From 1997 to 2006, the reference population used by DHS for calculating z-scores was the International Growth Reference developed by the National Center for Health Statistics (NCHS) in 1977. In 2006, WHO developed a new standard using a diverse geographic sample of children to replace the NCHS 1977 reference population. The purpose of the WHO 2006 standard was to describe a normal child's growth under ideal child-rearing and environmental conditions (WHO Multicentre Growth Reference Study Group 2006). Comparisons of these two reference populations using longitudinal data revealed that the WHO 2006 Standard provided higher stunting and overweight estimates for all ages and higher underweight and wasting estimates for children in infancy. It provided a better tool for monitoring the rapid and changing rate of growth in early infancy (de Onis et al. 2006). The WHO 2006 Standard was adopted internationally and has been used by DHS since 2007. In order to allow for comparability with previous years, z-scores according to the WHO 2006 standard have been calculated for all previous surveys and are available on the DHS website.

After obtaining the z-scores according to the reference population, data sets are cleaned by flagging cases with z-scores beyond specified lower or upper cutoffs and excluding them from the computation of prevalence of stunting, etc. The purpose of flagging is to eliminate extreme values that are most probably due to measurement errors or data-entry errors. Alternative cutoff values could be used for flagging the data. The most commonly used flags were specified as part of the WHO (2006) growth standards. Other flags include the SMART flags and the WHO 1995 flexible criteria (the same as the NCHS cleaning criteria) (Crowe et al. 2014). These flags are summarized in the table below.

Flags used in cleaning anthropometric data prior to computing malnutrition indicators

	Flagged cases			
Cleaning method	**HAZ**	**WAZ**	**WHZ**	**Reference mean**
WHO (2006) growth standards	<-6 or >6	<-6 or >5	<-5 or >-5	Growth standards reference population
SMART flags	<-3 or >3	<-3 or >3	<-3 or >3	Survey sample
WHO 2005 Flexible criteria	<-4 or >3	<-4 or >4	<-4 or >4	Survey sample

Source: (Crowe et al. 2014)

A study by Crowe et al. (2014) on data from 21 DHS countries compared the effect of using these different flags on the estimated prevalence of stunting and other nutrition indicators. The findings showed that SMART flags are the least inclusive, resulting in the lowest reported malnutrition prevalence. The WHO 2006 flags are the most inclusive, resulting in the highest reported prevalence (Crowe et al. 2014). DHS has used the WHO 2006 flags since it started using the WHO 2006 reference population to compute the z-scores.

1.2 Anthropometry Data Quality Measures

The quality of anthropometric measurements cannot be captured with just a single indicator. One data quality assessment tool is the standard deviation (SD) of anthropometric z-scores (Mei and Grummer-Strawn 2007). Mei and Grummer-Strawn (2007) showed that the SDs of the z-scores computed for 51 DHS surveys were relatively stable and did not vary with the z-score means; i.e., the means appeared to be independent of the SDs (Mei and Grummer-Strawn 2007). This finding indicates that the SD can be used to measure data quality in various countries and settings. However, using the SD alone may be misleading because it is a measure of both heterogeneity in the population (with respect to factors that affect nutrition) and data quality. Unlike the populations of countries in which DHS surveys are implemented, the reference population used to compute the z-score is very homogeneous (again, with respect to factors that affect nutrition) while other populations are expected to be much more heterogeneous (WHO Multicentre Growth Reference Study Group 2006). The WHO technical report on the use and interpretation of anthropometry recommends using several indicators and tools for anthropometric data quality assessment, including general characteristics of the population, sample size, survey design, measurement methods, method of determining age, proportion of missing data due to likely error and the exclusion criteria (i.e. flags), as well as the mean and SD of the z-scores (World Health Organization 1995). In addition, the WHO technical report suggests that if the HAZ distribution is found to decrease with increasing age, one may reasonably assume that the measurements of infant length are of poor quality (World Health Organization 1995). Heaping[1] and digit preference regarding height and weight measures can also be used to measure data quality (Siegel, Swanson, and Shryock 2004). Age is another key factor in the assessment of nutritional status of children. Computing the correct age of the child can be very challenging. If the exact birth date of the child is not known, an event calendar is required to estimate the date of birth as accurately as possible. Computing heaping of age in months can help assess the quality of the data on children's age.

Some researchers have created scoring options by using multiple indicators to assign quality labels to data. For example, ENA software used by SMART surveys conducts plausibility checks on anthropometry data to assess the quality of the data (Jaysaekaran 2012; Standardized Monitoring and Assessment of Relief and Transitions (SMART) 2015). Similarly, an unpublished study from Harvard included an index to assess the quality of anthropometry data (Corsi and Subramanian 2014).

1.3 Other Sources of Anthropometric Data

A decade ago DHS was the only source of national-level anthropometry data for developing countries. Currently, in addition to DHS, anthropometric data are also available from the National Nutrition Surveys (NNS), UNICEF Multiple Indicator Cluster Surveys (MICS), and the World Bank Living Standards Measurement Study (LSMS). NNS usually employ the Standardized Monitoring and Assessment of Relief and Transitions (SMART) methodology in their data collection and analysis, designed for obtaining

[1] Heaping is a departure from a uniform distribution across final digits that indicates a preference for one or more digits, such as 0 and 5, in the reporting of height and weight, over others.

anthropometric estimates in emergency settings (Standardized Monitoring and Assessment of Relief and Transitions (SMART) 2006). As in DHS, NNS and MICS measure the height and weight of children under five years of age to assess nutritional status. The methodologies and data collection procedures are similar but differ in some respects (Hancioglu and Arnold 2013). For instance, nutritional status is reported for de jure (usual residents) children in MICS and de facto (slept in household last night) children in DHS. The overall length of interviewer training is typically longer in DHS (4 weeks) than in MICS (3 weeks), and the typical duration of fieldwork is 1-2 months longer for DHS surveys than for MICS surveys.

SMART surveys were initially designed to collect anthropometric measures rapidly and in emergency settings, but the SMART methodology is now being used in national surveys and non-emergency settings in some countries; an example is the Tanzania 2014 NNS (Tanzania Food and Nutrition Centre 2014). The SMART methodology uses ENA software to enter data which highlights cases that have extreme z-scores, based on the WHO criteria (Jaysaekaran 2012; Standardized Monitoring and Assessment of Relief and Transitions (SMART) 2006). While SMART surveys focus on obtaining nutrition and anthropometric data on the child (plus mortality data), DHS and MICS surveys are much broader in scope and include other data on population and health as well as background information on the household and the parents of the child. Also, some of the data collection procedures differ. For example, in DHS and MICS surveys the child's age is computed from the interview date and the birth date. In contrast, NNS surveys do not usually include the date of birth of the child, instead using an estimated age in months. In another example, following WHO guidelines, whether the child is measured lying down (length) or standing up (height) is determined in DHS by the child's age. Children under 24 months of age are measured lying down and older children are measured standing up. In the SMART methodology this is determined by the child's height; children under 87 cm are measured lying down (Jaysaekaran 2012).

2. Methods and Data

2.1 Data

Data from 52 countries that have completed a recent (2005-2014) DHS survey were used for analysis. These countries are listed in Table 1 in the results section along with their sample sizes and year of the survey implementation. In each survey, height/length and weight measurements of all children in the household under age five years (60 months) are taken. Height/length measurements are typically carried out using an Infant/Child/Adult Shorr Board while weight is measured using a SECA digital scale. In DHS, measurers are trained to measure the length of children under 24 months lying down and the height of children 24 months or older standing up. The measurer records whether the child was measured lying down or standing up. During data processing, if a child below age 24 months was measured standing up, 0.7 cm is added to the height; if a child age 24 months or older was measured lying down, 0.7 cm is subtracted from the length. This is a standard adjustment made by MICS and SMART, as well as DHS. Z-scores are computed based on these measurements using the WHO 2006 standards.

DHS interviewers are trained to measure height/length and weight according to the internationally recommended standard protocol (ICF international 2012). At least three days of training on anthropometric measurements is provided, which includes a standardization exercise (repeated measurements of the same child) for the measurers and the equipment. Special emphasis is given to the assessment of age. During the fieldwork, team supervisors and editors are trained to pay attention to the out-of-range height and weight values and are instructed to provide feedback to the measurers in the field if they identify issues with the anthropometry data. Extensive field monitoring is also carried out by staff from the central survey office and DHS staff and consultants. Field check tables are run periodically for paper-based surveys, and can be run in near real-time for CAPI surveys. The field check tables are used to assess the quality of the data, and feedback to the teams is provided promptly if any issues are identified, but interviewers and supervisors are not provided with any feedback as to whether the z-scores themselves are out of range. We now consider selected indicators that are used to assess anthropometry data quality; these indicators are part of the standard DHS field check tables.

2.2 Methods Used for Assessing Data Quality in This Analysis

2.2.1 Standard deviations of z-scores

In addition to presenting a description of the estimates for stunting, underweight, wasting and overweight from the 52 DHS countries, the mean and standard deviation (SD) of each z-score were examined. Additionally, the SD of the z-scores for children under age two years and two years and over were compared to examine the effect of measuring children standing up versus lying down. All measures and estimates were obtained for de facto children using sampling weights.

2.2.2 Height/length, weight and age heaping and flagged cases

Data quality checks include examining the heaping for height, weight, and the age of children in months, and the percentage of flagged cases in the data. Three indices were used to examine heaping for height and weight: the percentage of observations with final digit 0 or 5 minus the expected percentage (a difference); the ratio of observed cases with final digit 0 or 5 to the expected number (a ratio); and Myers' Blended Index, which detects any pattern of digit preference, not just a preference for terminal digits 0 or 5. Myers' Index was also calculated for the age in months of the child.

Myers' Blended Index is virtually identical to Whipple's Index and the Index of Dissimilarity as a measure of how much an observed distribution across terminal digits 0,…, 9 differs from a uniform distribution in which each digit would be equally likely. It will identify disproportionate use of 0 or 5 or even numbers, etc. The adjective "Blended," which is often omitted, describes a minor adjustment to compensate for the possible impact that genuine non-uniformity in the full (multi-digit) distribution of age, etc., could have on the terminal digit. These indices can be interpreted as the percentage of observations that would have to be shifted from over-reported to under-reported digits in order to achieve a uniform distribution. The ideal value of the index is 0.

Two main flags are applied to DHS data. The first refers to values that fall outside the WHO limits described above for each z-score. A high percentage of flagged cases can indicate measurement error, especially in conjunction with other data quality measures. The second flag in DHS data is assigned to recorded height values falling outside of plausible limits, which are specified to be 45-110 cm for children measured lying down, and 65-120 cm for children measured standing up.

2.2.3 Regressions of z-scores

In addition to the data quality checks above, linear regressions were performed for the 52 DHS countries using the stratified sample design for each country and each z-score index. The strata were assumed to be combinations of locality (urban/rural) and region for each country. The regression models were fitted using the z-scores as the outcomes (separate regressions for HAZ, WAZ and WHZ) and several independent variables found to be associated with the anthropometric status of children in the literature (Adair and Guilkey 1997; Mamabolo et al. 2005; Mamiro et al. 2005; Sereebutra et al. 2006; Willey et al. 2009). These independent variables, all of which are categorical, include locality (urban/rural), wealth index (lowest, second, middle, fourth, highest), mother's level of education (none or primary, secondary and higher), father's level of education (none or primary, secondary and higher), mother's work status (currently working or not), mother's body mass index (categorized as thin, normal, overweight, or obese), mother's age when she gave birth to the child (categorized as under 18 years, 18-34 years, 35 years and over), child's birth order (1, 2, 3, 4, or more), child's sex, and mother's perceived size of the child at birth (small, average, large). Because of the high correlations observed between locality and the wealth index, a variable was constructed to combine these two variables to create a joint locality-by-wealth variable with four categories (rural poor, rural non-poor, urban poor, and urban non-poor). The distributions of wealth varied substantially by locality; therefore, to create this variable, respondents from the middle wealth quintile were combined with the lowest two wealth quintiles for urban locality to produce the urban poor category, and for the rural locality they were combined with the highest two wealth quintiles to produce the rural non-poor category. For these regressions, children age 0-59 months of interviewed mothers were selected. The samples differ slightly from those used to illustrate the data quality measures discussed previously, which included all children age 0-59 in the household. The results of the regressions for the 52 countries for each z-score are presented in the Appendices G, H, and I. Summary tables of these regressions are included in the Results section (Section 3) below. In addition, bivariate analyses of the HAZ, WAZ, and WHZ SDs for each category of the covariates used in the regressions were examined.

A second regression model was fitted for the HAZ z-score for each country with the cluster id code added as a categorical covariate in the model. The purpose was to examine the level of heterogeneity across clusters of the HAZ z-scores. For this model the locality variable was removed because each cluster is either entirely rural or entirely urban. The wealth index was included to replace the locality-by-wealth variable in the first model. This second model shows the extent to which variation in the HAZ z-score can be explained by heterogeneity of the children across or between the clusters.

3. Results

3.1 Anthropometric Estimates

Table 1 summarizes the anthropometric estimates of stunting, underweight, wasting, and overweight as well as the means and SDs of the HAZ, WAZ and WHZ for the 52 countries in the analysis. The estimates and sample sizes vary substantially across the countries. Sample sizes of measured de facto children with valid z-scores range from 1,289 in Albania to 46,655 in India. The stunting, underweight, wasting, and overweight estimates also differ greatly, as can be seen more clearly in Figures 1-4 for each of these estimates.

Table 1. Anthropometric indicators of children age 0-59 months using WHO flags, DHS surveys 2005-2014

Country	Survey year	Weighted N	Stunted %	HAZ mean	SD	Under-weight %	WAZ mean	SD	Wasted %	WHZ mean	SD	Over-weight %
Albania	2008-2009	1289	19.3%	-0.40	2.02	5.2%	0.15	1.31	9.1%	0.58	1.86	21.7%
Armenia	2010	1333	19.3%	-0.74	1.64	4.7%	0.05	1.12	4.0%	0.67	1.47	15.3%
Azerbaijan	2006	1979	25.1%	-1.05	1.65	7.7%	-0.41	1.09	6.8%	0.30	1.53	12.9%
Bangladesh	2011	7861	41.3%	-1.68	1.41	36.4%	-1.61	1.15	15.6%	-0.94	1.20	1.5%
Benin	2011-2012	8079	44.6%	-1.61	2.33	21.3%	-0.92	1.49	16.0%	0.03	2.02	17.9%
Bolivia	2008	8422	27.1%	-1.24	1.31	4.3%	-0.27	1.04	1.4%	0.62	1.08	8.5%
Burkina Faso	2010	6994	34.6%	-1.40	1.60	25.7%	-1.27	1.20	15.5%	-0.67	1.38	2.4%
Burundi	2010-2011	3590	57.7%	-2.20	1.38	28.8%	-1.42	1.10	5.8%	-0.21	1.16	2.7%
Cambodia	2010-2011	3975	39.9%	-1.66	1.38	28.3%	-1.44	1.05	10.9%	-0.70	1.13	1.6%
Cameroon	2011	5860	32.5%	-1.26	1.71	14.6%	-0.63	1.31	5.6%	0.13	1.31	6.2%
Colombia	2009-2010	15702	13.2%	-0.83	1.12	3.4%	-0.24	1.00	0.9%	0.32	1.00	4.8%
Comoros	2012	2762	30.1%	-1.16	1.91	15.3%	-0.75	1.33	11.1%	-0.13	1.60	9.3%
Congo Brazzaville	2011-2012	4591	24.4%	-1.02	1.48	11.6%	-0.72	1.11	5.9%	-0.20	1.19	3.3%
Congo Democratic Republic	2013-2014	9030	42.7%	-1.60	1.84	22.6%	-1.09	1.28	7.9%	-0.21	1.32	4.1%
Côte d'Ivoire	2011-2012	3581	29.8%	-1.23	1.60	14.9%	-0.83	1.16	7.5%	-0.18	1.24	3.0%
Dominican Republic	2013	3619	6.9%	-0.30	1.24	3.8%	0.03	1.12	2.0%	0.27	1.18	7.3%
Egypt	2014	13601	21.4%	-0.57	2.02	5.5%	-0.08	1.20	8.4%	0.38	1.66	14.9%
Ethiopia	2011	10883	44.4%	-1.69	1.69	28.7%	-1.33	1.24	9.7%	-0.51	1.20	1.7%
Gabon	2012	3856	16.5%	-0.70	1.48	6.0%	-0.24	1.16	3.3%	0.22	1.24	7.4%
Gambia	2013	3372	24.5%	-1.01	1.55	16.2%	-0.99	1.12	11.5%	-0.60	1.29	2.7%
Ghana	2008	2525	28.0%	-1.08	1.65	13.9%	-0.79	1.20	8.5%	-0.24	1.35	5.3%
Guinea	2012	3531	31.2%	-1.12	1.82	18.0%	-0.87	1.30	9.6%	-0.31	1.36	3.6%
Guyana	2009	1522	18.2%	-0.85	1.44	10.5%	-0.50	1.21	5.3%	-0.03	1.31	6.2%
Haiti	2012	4529	21.9%	-0.97	1.43	11.4%	-0.64	1.18	5.1%	-0.12	1.19	3.6%
Honduras	2011-2012	10167	22.6%	-1.11	1.22	7.0%	-0.42	1.11	1.4%	0.31	1.05	5.1%
India	2005-2006	46655	48.0%	-1.86	1.66	42.5%	-1.78	1.23	19.8%	-1.02	1.29	1.5%
Jordan	2012	5851	7.7%	-0.40	1.18	3.0%	-0.10	1.01	2.4%	0.17	1.08	4.4%
Kenya	2008-2009	5470	35.3%	-1.41	1.59	16.1%	-0.86	1.19	6.7%	-0.09	1.29	4.7%
Kyrgyz Republic	2012	4337	17.7%	-0.80	1.45	3.4%	-0.14	1.02	2.7%	0.44	1.21	8.5%
Lesotho	2009-2010	2086	39.2%	-1.54	1.54	13.2%	-0.72	1.19	3.8%	0.24	1.28	7.2%
Liberia	2013	3520	31.6%	-1.23	1.66	15.0%	-0.84	1.21	6.0%	-0.17	1.21	2.9%
Malawi	2010	4849	47.1%	-1.78	1.61	12.8%	-0.81	1.13	4.0%	0.30	1.29	8.3%
Maldives	2009	2513	18.9%	-0.93	1.43	17.3%	-0.84	1.28	10.6%	-0.45	1.41	5.9%

(Continued…)

Table 1. − *Continued*

Country	Survey year	Weighted N	Stunted %	HAZ mean	SD	Under-weight %	WAZ mean	SD	Wasted %	WHZ mean	SD	Over-weight %
Mali	2012-2013	4857	38.3%	-1.46	1.87	25.5%	-1.23	1.31	12.7%	-0.55	1.36	2.3%
Mozambique	2011	10313	42.6%	-1.68	1.65	14.9%	-0.86	1.17	5.9%	0.17	1.37	7.4%
Namibia	2013	2281	23.7%	-1.09	1.42	13.3%	-0.78	1.14	6.2%	-0.21	1.23	3.4%
Nepal	2011	2485	40.5%	-1.67	1.40	28.8%	-1.42	1.11	10.9%	-0.65	1.13	1.4%
Niger	2012	5481	43.9%	-1.73	1.68	36.4%	-1.60	1.27	18.0%	-0.86	1.38	2.4%
Nigeria	2013	26190	36.8%	-1.38	2.01	28.7%	-1.26	1.42	18.0%	-0.66	1.58	4.0%
Pakistan	2012-2013	3466	44.8%	-1.79	1.72	30.0%	-1.40	1.26	10.8%	-0.51	1.29	3.2%
Peru	2012	9168	18.1%	-1.04	1.08	3.4%	-0.20	1.07	0.6%	0.55	1.01	7.1%
Rwanda	2010-2011	4356	44.2%	-1.76	1.40	11.4%	-0.77	1.07	2.8%	0.35	1.16	6.7%
São Tomé and Príncipe	2008-2009	1544	29.3%	-1.20	1.67	13.1%	-0.70	1.21	10.5%	0.01	1.66	10.5%
Senegal	2012-2013	5829	18.7%	-0.91	1.35	15.7%	-0.92	1.11	8.8%	-0.60	1.11	1.4%
Sierra Leone	2013	5094	37.9%	-1.39	1.93	16.4%	-0.82	1.36	9.3%	-0.01	1.51	7.5%
Swaziland	2006-2007	2940	28.9%	-1.25	1.49	5.4%	-0.29	1.13	2.5%	0.59	1.23	10.8%
Tajikistan	2012	5080	26.2%	-1.14	1.59	12.1%	-0.80	1.16	9.9%	-0.21	1.45	5.9%
Tanzania	2009-2010	7491	42.0%	-1.70	1.42	15.8%	-0.95	1.12	4.8%	0.03	1.22	5.0%
Timor-Leste	2009-2010	8171	58.1%	-2.16	1.83	44.7%	-1.79	1.23	18.6%	-0.78	1.55	4.7%
Uganda	2011	2350	33.4%	-1.41	1.57	13.8%	-0.82	1.15	4.7%	-0.02	1.17	3.4%
Zambia	2007	5602	45.4%	-1.69	1.72	14.6%	-0.83	1.14	5.2%	0.21	1.36	7.9%
Zimbabwe	2010-2011	5260	32.0%	-1.37	1.41	9.7%	-0.66	1.08	3.0%	0.17	1.16	5.5%

Figure 1 shows that the highest percentage of stunted children was found in Timor-Leste and Burundi, both nearly 60%. The lowest percentage of stunted children was found in the Dominican Republic and Jordan, 7% to 8%. The ranking of countries differs according to the anthropometric measure examined. For instance, Burundi had one of the highest levels of stunting but ranked #7 for underweight and #32 for wasting, as shown in Figures 2 and 3, respectively. Such variation can be expected because the different measures capture different aspects of malnutrition: stunting measures chronic malnutrition, wasting measures acute malnutrition, and underweight measures overall malnutrition. Four of the six countries with the highest prevalence of underweight children are in South Asia; in contrast, four of the six countries with the lowest prevalence of underweight children are in Latin America and the Caribbean. The countries with the highest percentages of wasted children were India, Timor-Leste, Niger, and Nigeria, all between 18% and 20%. The percentage of wasted children was lowest in Peru and Columbia, both below 1%.

Figure 1. Percentage of children age 0-59 months who are stunted, DHS surveys 2005-2014

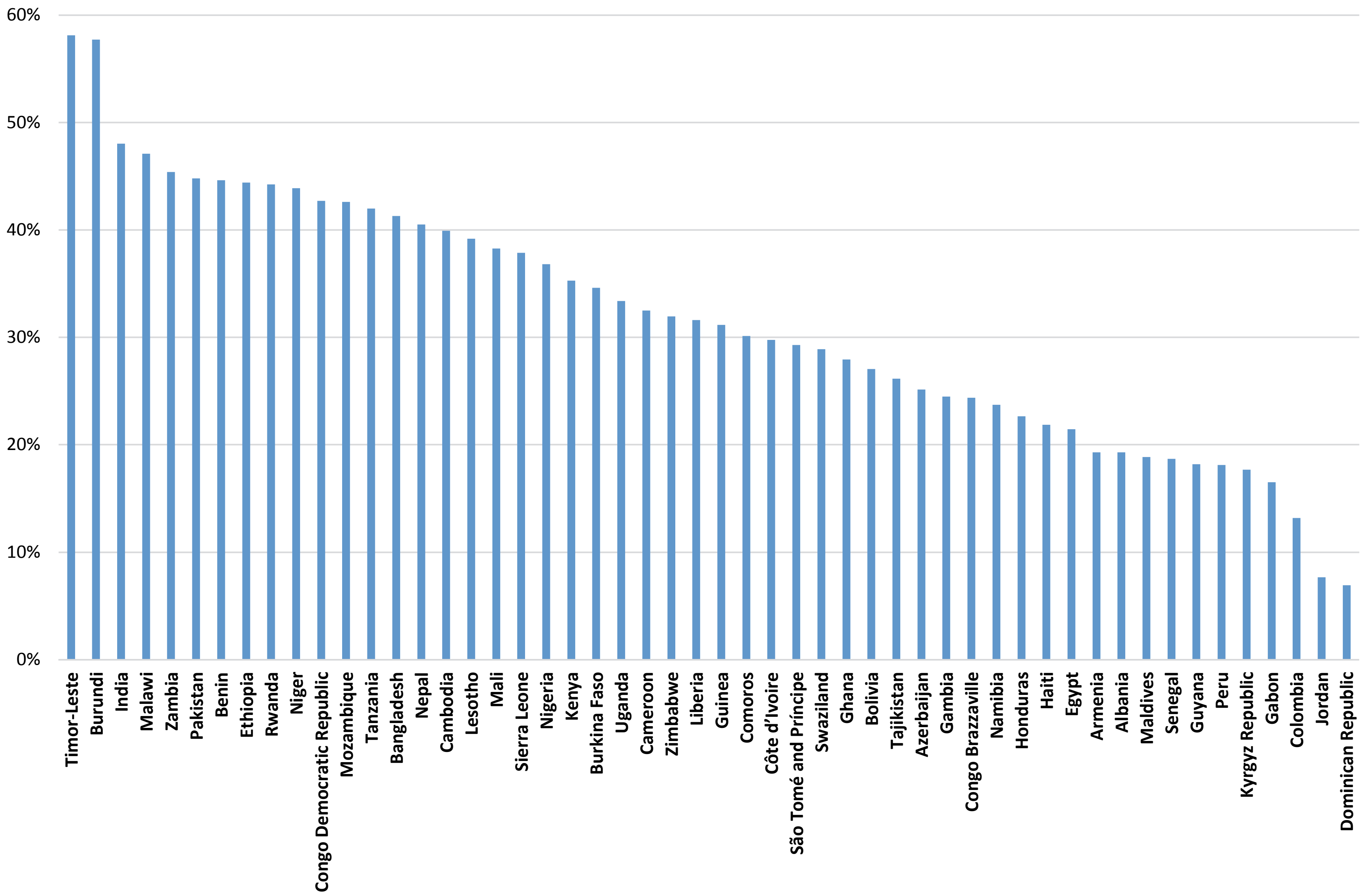


Figure 2. Percentage of children age 0-59 months who are underweight, DHS surveys 2005-2014

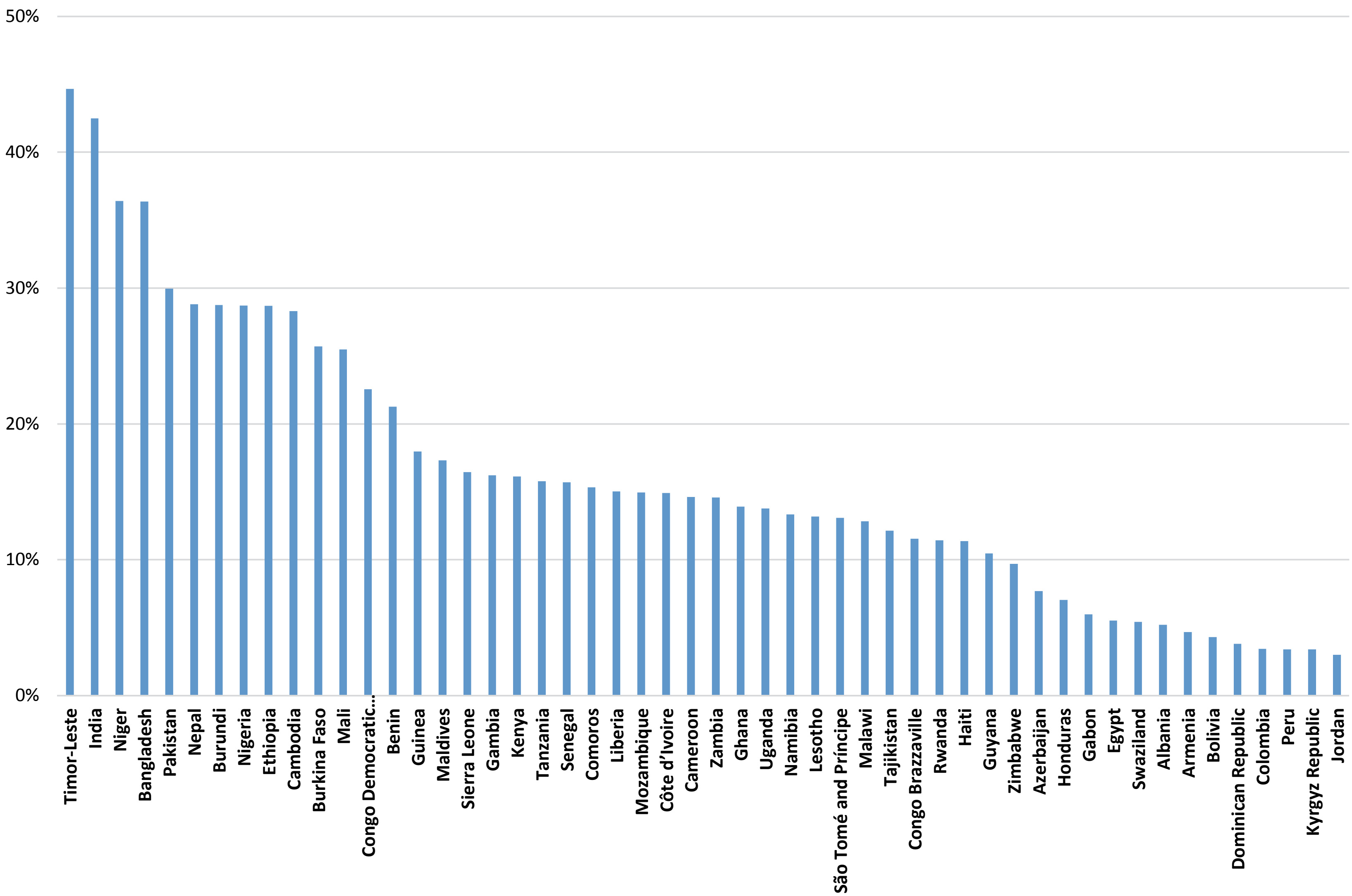
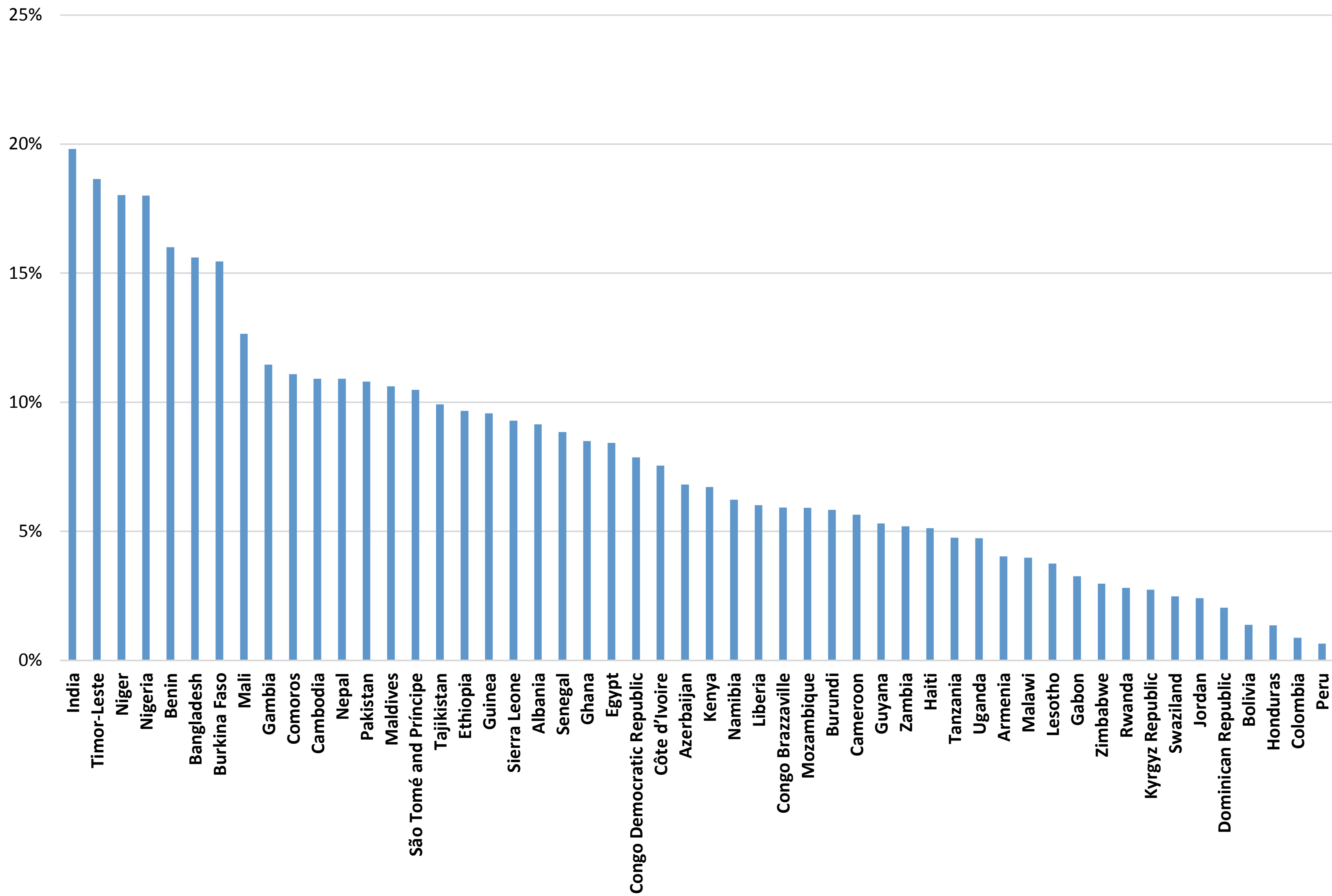
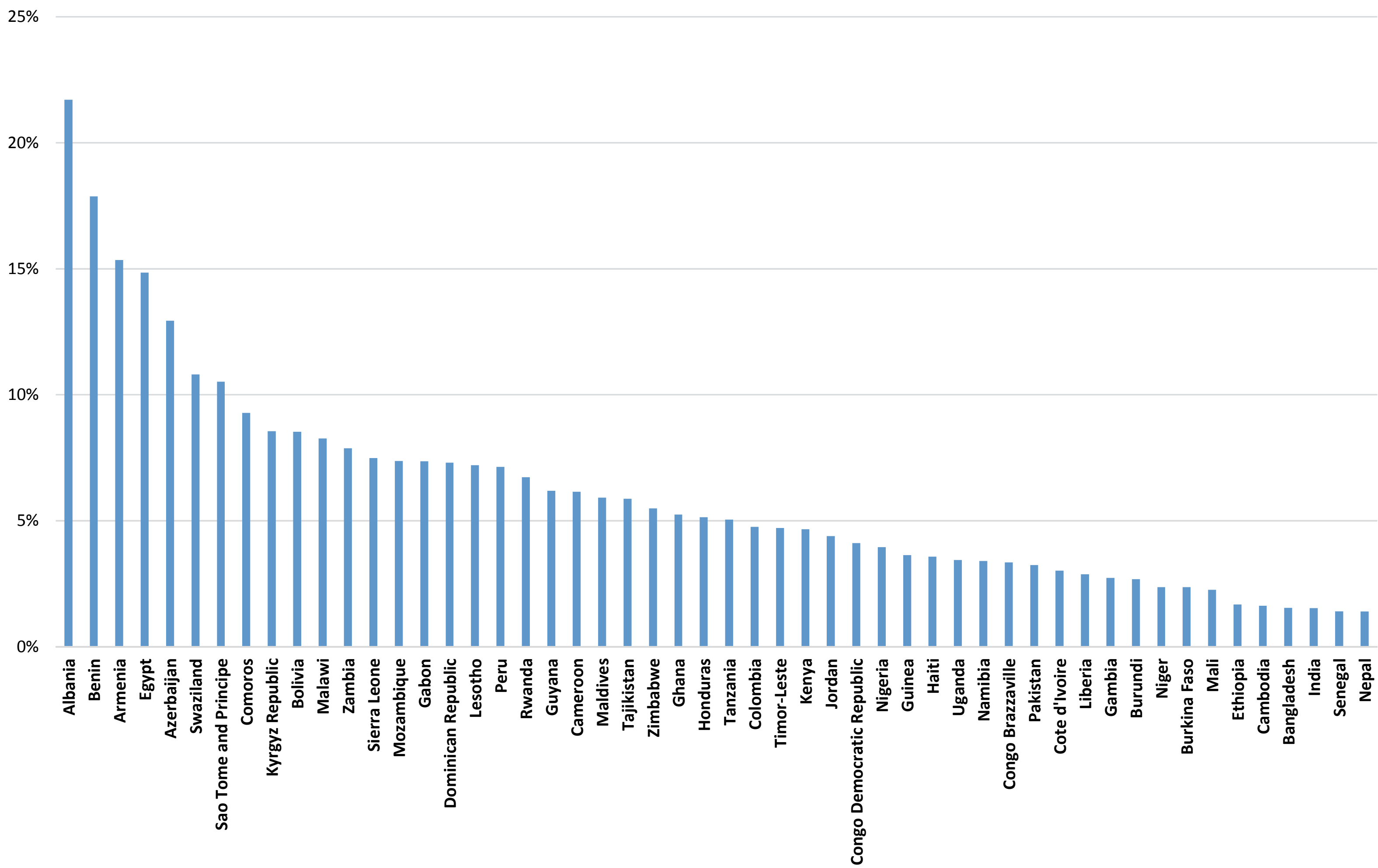


Figure 3. Percentage of children age 0-59 months who are wasted, DHS surveys 2005-2014



The prevalence of overweight children can be high even when there is evidence of insufficient nutrition in the population of children. For instance, Benin was found to have the second highest percentage of overweight children (18% in Figure 4) and also one of the highest percentages of stunting (45% in Figure 1). This seeming contradiction may be due to the heterogeneity of the population, but it may also indicate poor data quality.

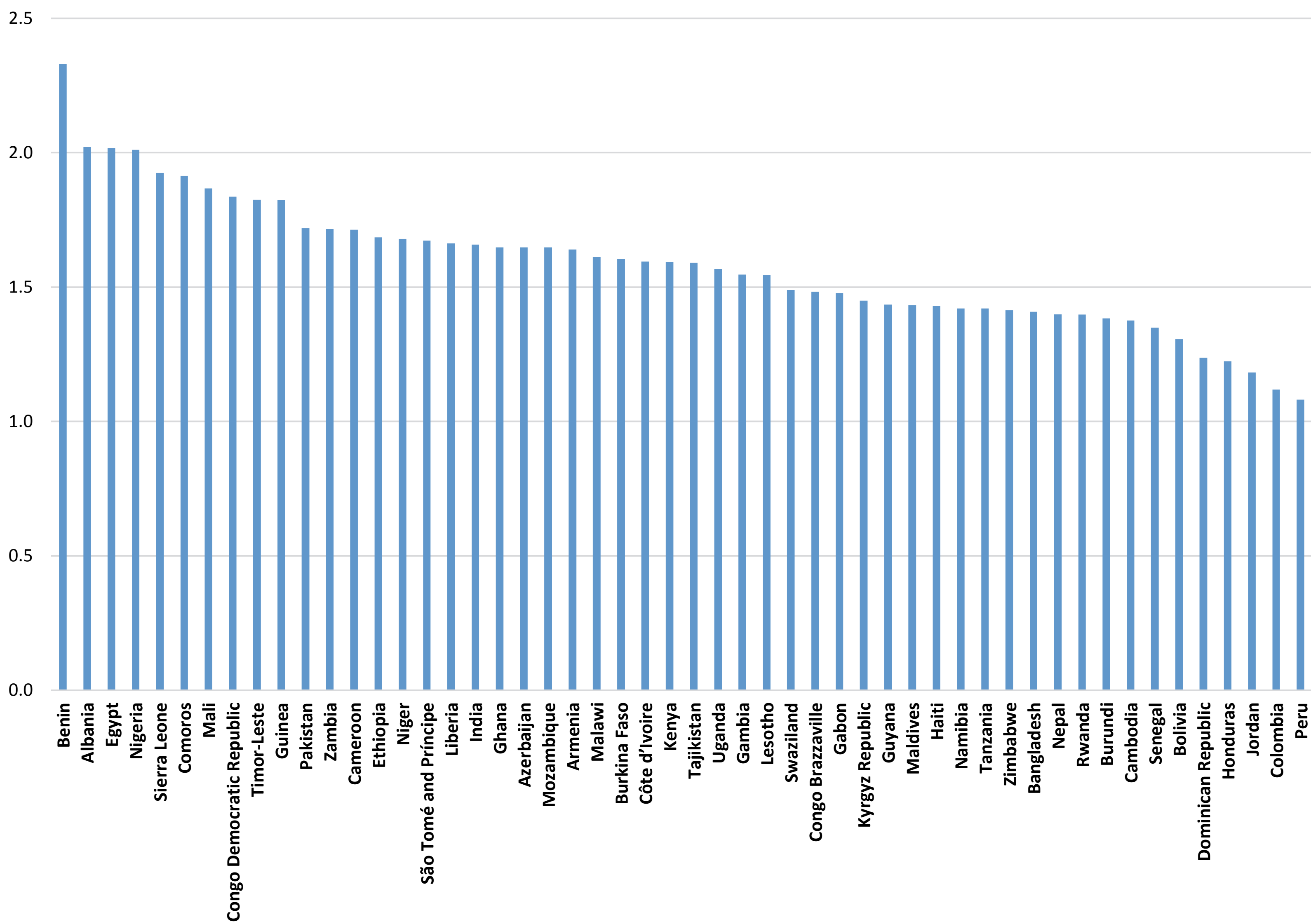
Figure 4. Percentage of children age 0-59 months who are overweight, DHS surveys 2005-2014



3.2 Z-score SDs

Figures 5-7 show the SDs of the HAZ, WAZ, and WHZ z-scores. Benin, Albania, Egypt, and Nigeria were found to have HAZ SDs that were at or above 2. These high SDs can indicate a data quality problem, although population heterogeneity may be another possible explanation. Many other data quality measures need to be assessed in addition to the SD of the z-score. A total of 22 of the 52 countries analyzed had SDs that were below 1.5, with the lowest SDs in Peru and Colombia (SDs near 1.1).

Figure 5. Standard deviations of height-for-age (HAZ) z-scores, DHS surveys 2005-2014



Overall, the WAZ SDs were smaller than the HAZ SDs. For example, Benin had the highest WAZ SD (1.49) but the HAZ SD (2.33) was much higher. Most of the countries (58%) had WAZ SDs below 1.3. Figure 7 shows that the WHZ SDs were also lower than the HAZ SDs; however, the WHZ SD for Benin was above 2. The average standard deviations of the z-scores for the 52 countries were highest for the HAZ (1.58), second highest for the WHZ (1.31), and lowest for the WAZ (1.18)

Figure 6. Standard deviations of weight-for-age (WAZ) z-scores, DHS surveys 2005-2014

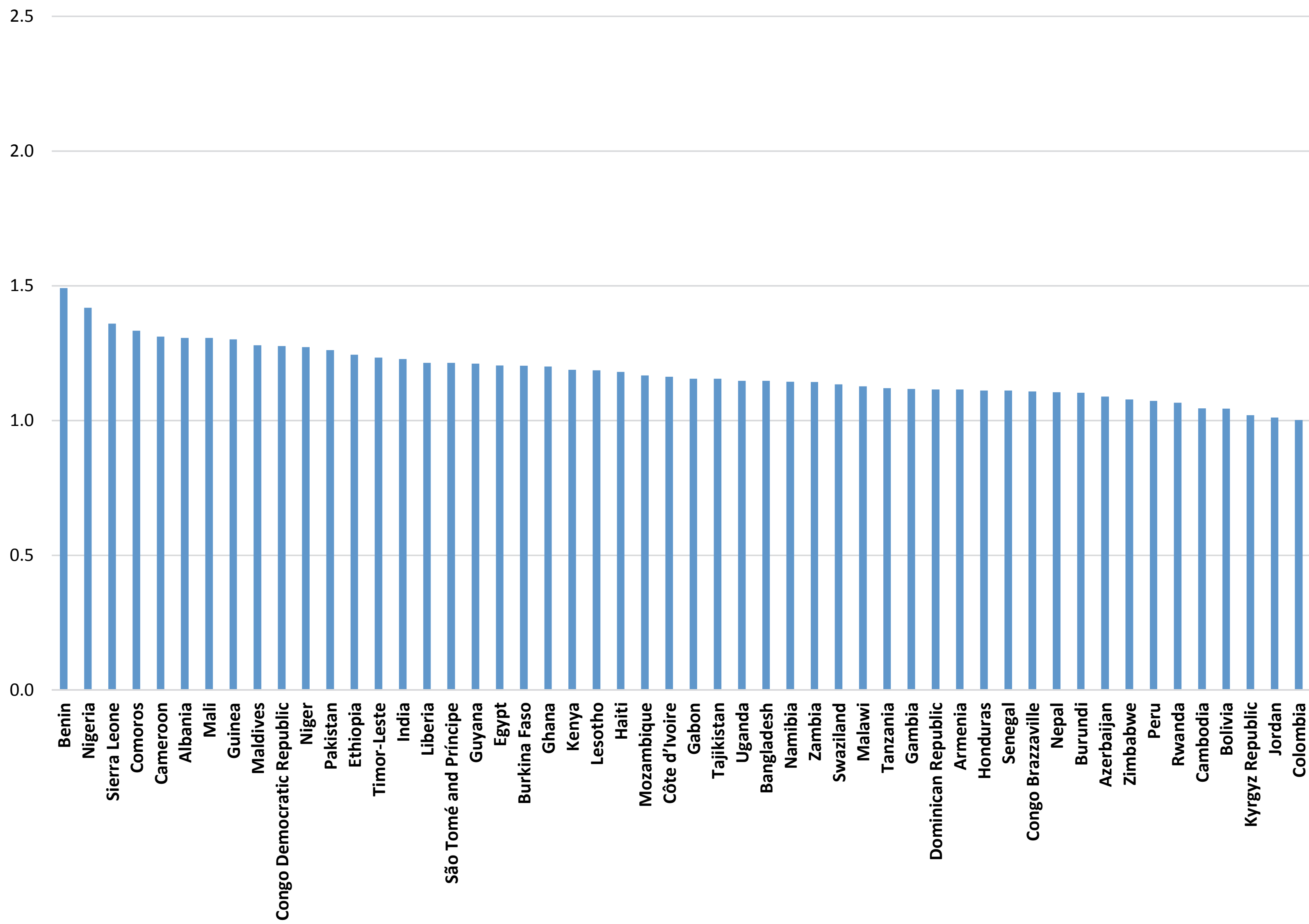
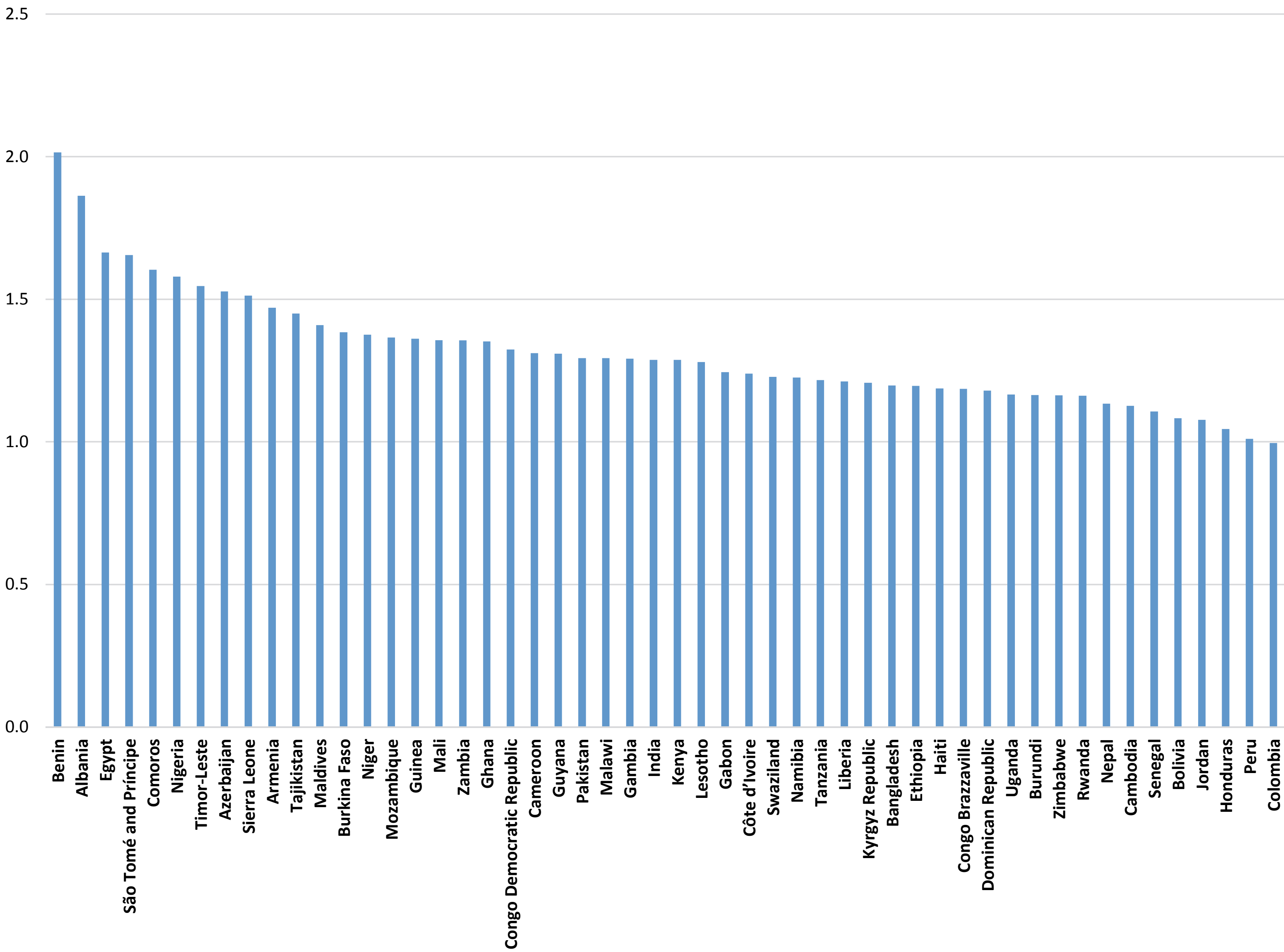


Figure 7. Standard deviations of weight-for-height (WHZ) z-scores, DHS surveys 2005-2014



As described earlier, children under two years of age were supposed to have their height (length) measured lying down, while children two years of age or older were supposed to be measured standing up. A further examination of the HAZ and WHZ z-score SDs (both include height) was performed to compare the SDs for children under two years of age and those age two to four years. Figures 8 and 9 show that the SDs of the HAZ and WHZ z-scores are always higher for children under two years of age except for the WHZ in Armenia. For the HAZ SDs, the largest differences were found for Timor-Leste, São Tomé and Príncipe, Benin, Swaziland, Zambia, Albania, and Lesotho, all of which had a difference of approximately 0.5 between the SDs of the two age categories (see Appendix A). Armenia, Peru, Honduras, Azerbaijan, Niger, and Senegal all had differences of approximately 0.0-0.1 between the two age categories. The largest differences for the WHZ SDs were found for Mozambique, Lesotho, São Tomé and Príncipe, Malawi, Tanzania, Gambia, and Timor-Leste, all of which had a difference of approximately 0.4 between the two age categories (see Appendix B). Eleven countries had a difference of about 0.0-0.1 between the WHZ SDs of the two age groups: Armenia, Benin, Maldives, Colombia, Honduras, Peru, Nigeria, Congo Brazzaville, Egypt, Azerbaijan, and the Dominican Republic. On average, the SDs of the HAZ were 0.29 lower for children age two years and over than for children under two years of age. The average difference in the SDs of the WHZ was slightly lower (0.24).

Figure 8. Standard deviations of height-for-age z-scores (HAZ) for children under 2 years and children 2 years and over, DHS surveys 2005-2014

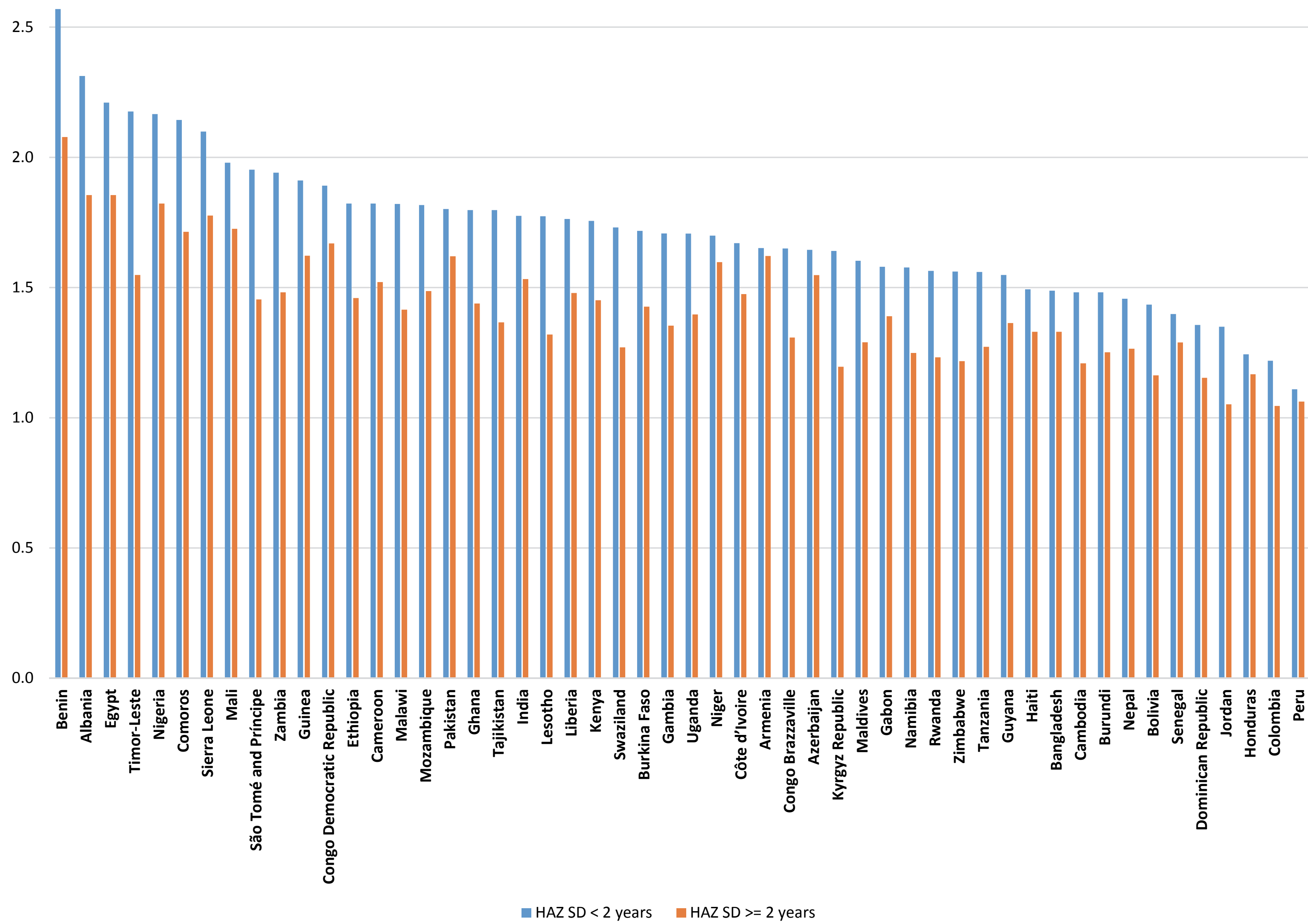
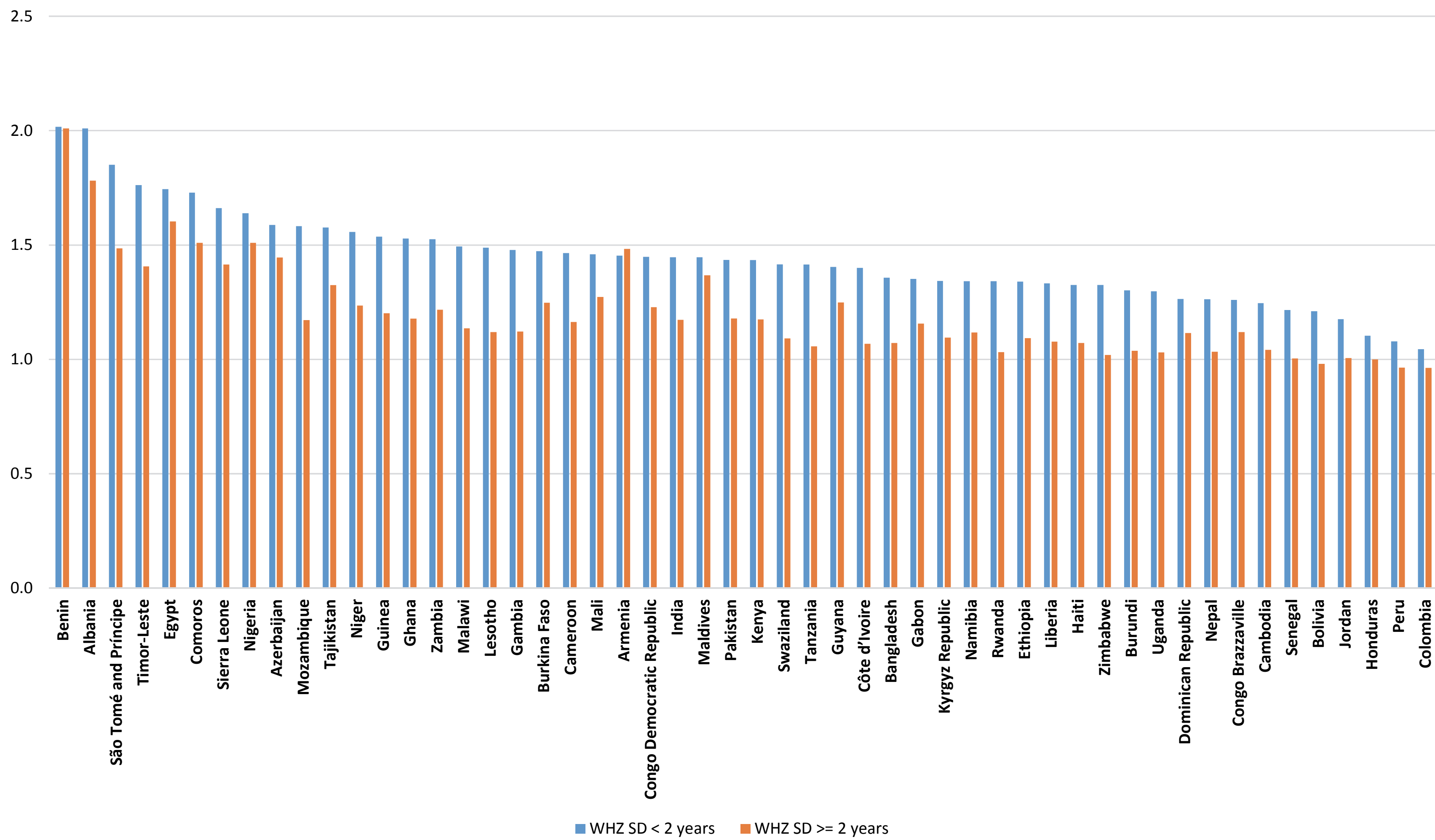


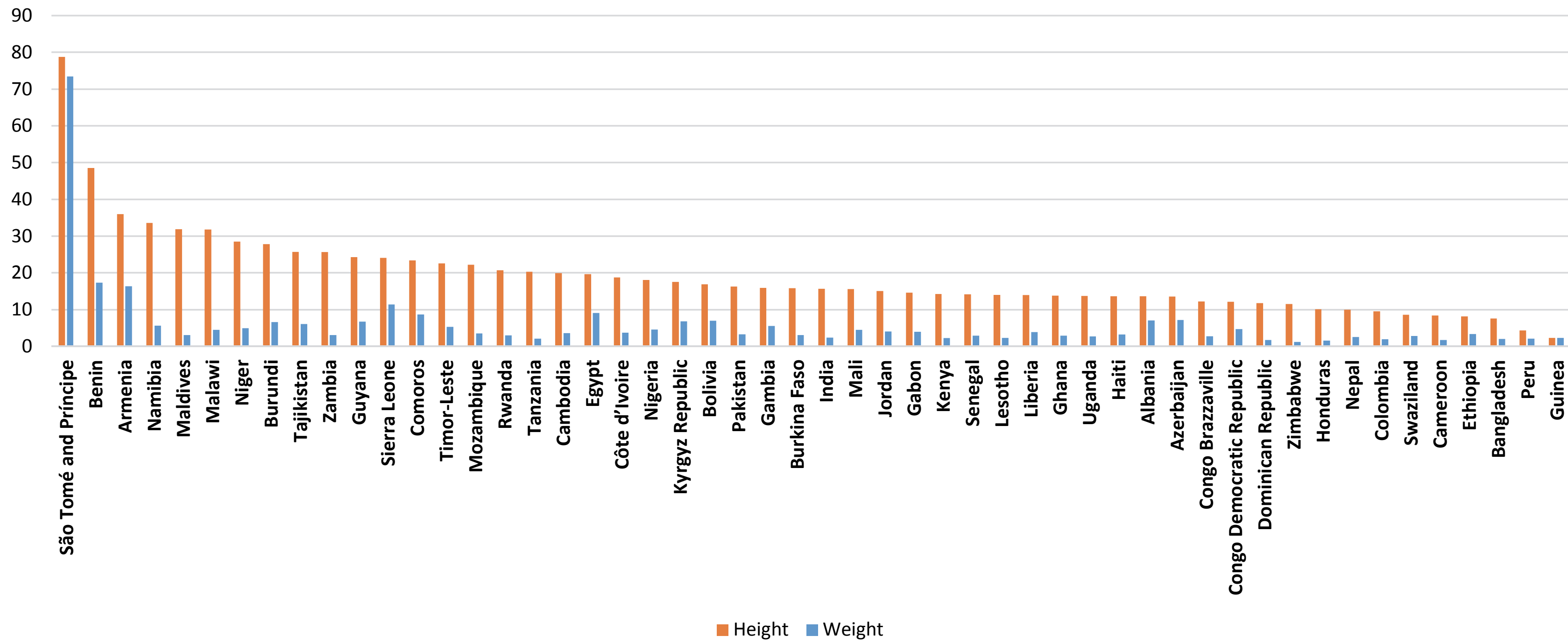
Figure 9. Standard deviations of weight-for-height z-scores (WHZ) for children under 2 years and children 2 years and over, DHS surveys 2005-2014



3.3 Heaping of Height, Weight, and Age

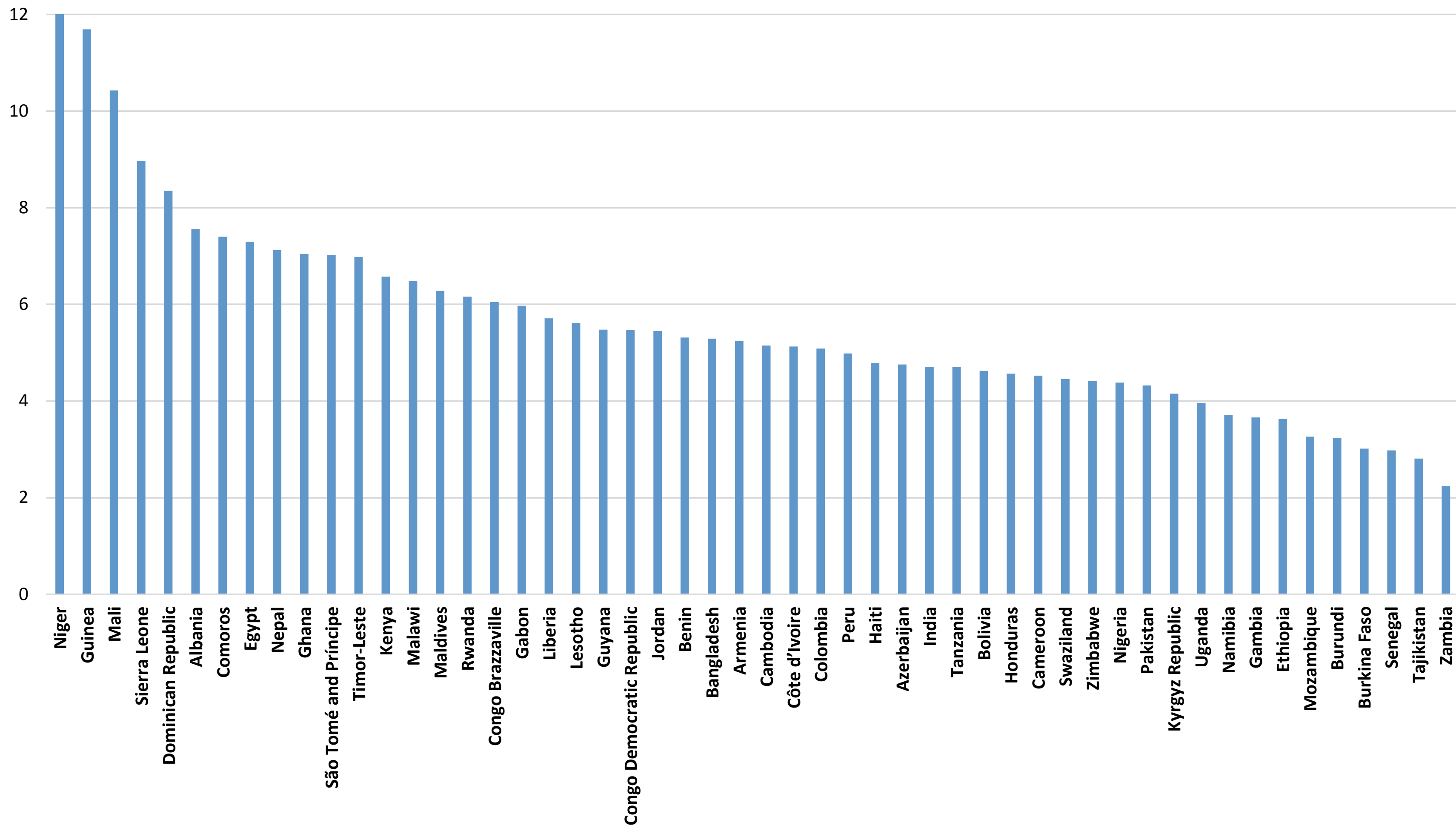
In DHS, weight is measured by a digital scale and recorded to the nearest 0.1 kg while height/length is measured using a wooden measuring board (whether lying down or standing up) and is recorded to the nearest 0.1 cm (or 1 mm). Figure 10 shows the indicator of heaping, Myers' Index, for all the countries. This index should ideally be zero if there were no heaping at all of height and weight measurements. Figure 10 shows that the Myers' index was almost always much higher for height than for weight; the single exception being Guinea, where the index value is the same for height and weight. This was also the case for the other measures of heaping (excess and ratio), as shown in Appendix C, although the differences were smaller for the ratios. São Tomé and Príncipe had the largest amount of heaping for both height and weight, but this was due to removal of the right-most digit during the course of rounding in data processing, and should not be interpreted as heaping during data collection. Most of the countries had a Myers' Index for height in the double digits with only seven countries—Guinea, Peru, Bangladesh, Ethiopia, Cameroon, Swaziland, and Colombia—with Myers' index for height below 10. The Myers' index for weight was greater than 10 for only four countries— São Tomé and Príncipe, Benin, Armenia and Sierra Leone. For the 51 counties other than São Tomé and Príncipe, the average Myers' Index was 17.8 for height and 4.6 percent for weight. This means that there would be no heaping for height if 17.8% of the observations were shifted to over-reported or under-reported digits and no heaping for weight if 4.6% of observations were shifted.

Figure 10. Myers' Index for height and weight for children 0-59 months, DHS surveys 2005-2014



The age of the child is determined in the DHS from the date of interview and the date of birth of each child. As shown in Figure 11 and in Appendix D, the Myers' Index for age was highest in Niger, Guinea and Mali, all of which were above 10, and was lowest in Zambia at 2.2. Myers' Index for age identifies a departure from a uniform distribution across months 0-11 within the separate years of age (0, 1, 2, 3, and 4). A high value on the index may indicate that in some cases the birthdate was not actually known by the respondent, but was recorded by the interviewer on the basis of a stated age such as "2 years", "2 ½ years", etc. In some cases the birthdate is genuinely not known, and a more detailed response would not necessarily be more accurate.

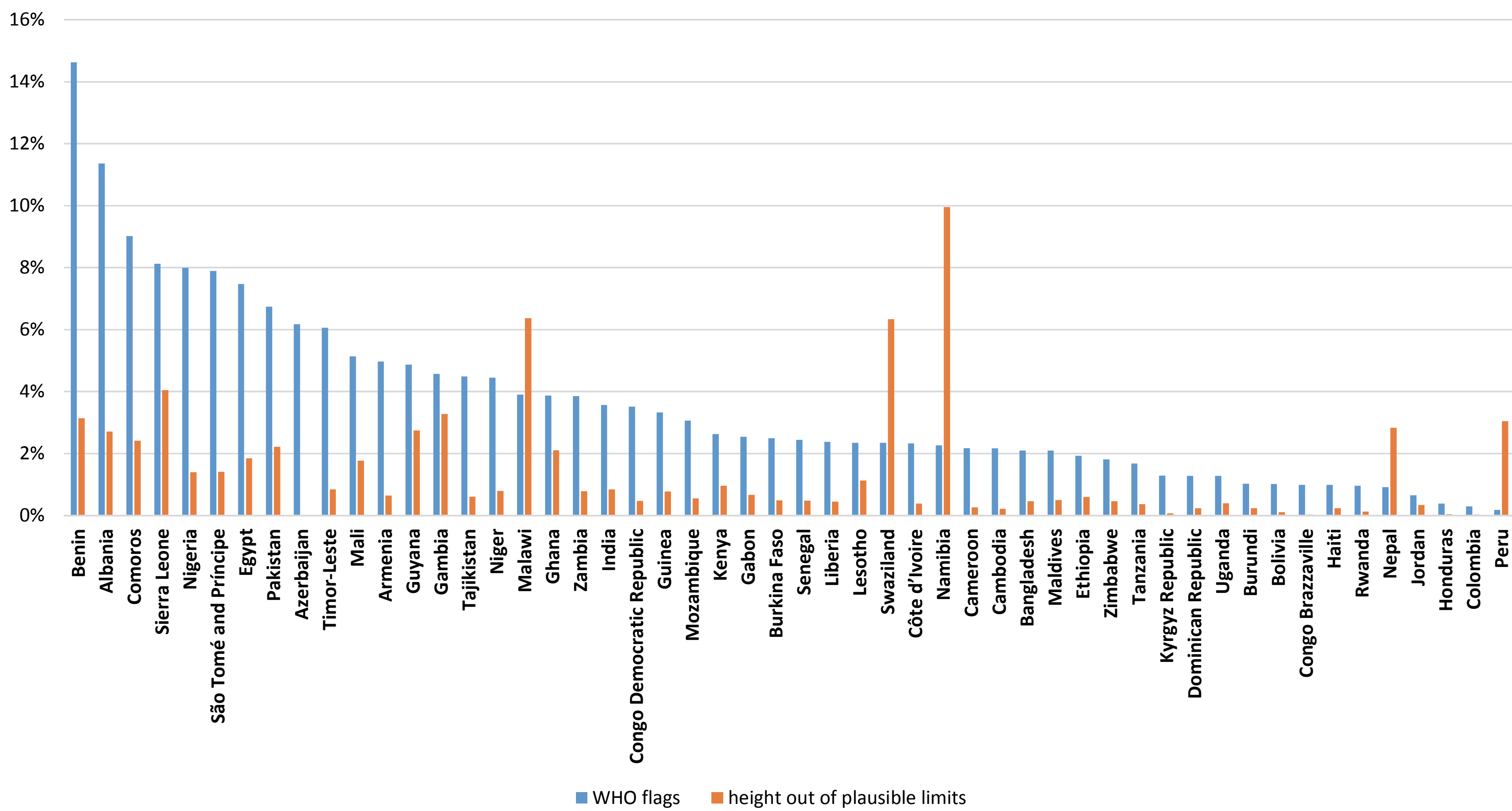
Figure 11. Myers' Index for age for children age 0-59 months, DHS surveys 2005-2014



3.4 DHS Flags

Figure 12 presents two types of flags: WHO flagged cases and cases with height out of plausible limits. WHO flags refers to values that fall outside the WHO limits, i.e., HAZ <-6 or >6, WAZ <-6 or >5 and WHZ <-6 or >5. The second flag in DHS data is assigned to height/length values which are specified to be 45-110 cm for children measured lying down, and 65-120 cm for children measured standing up. These two types of extreme values are most probably due to data measurement errors or data entry errors. As shown in Figure 12 and Appendix E, Benin and Albania had the highest percentage of flagged cases (15% and 11%, respectively). The lowest percentage of flagged cases was found for Peru, Colombia, Honduras, Jordan, and Nepal, all of which were below 1%. The average percentage of WHO flagged cases for the 52 countries was 3.6%. For the second type of flag, the highest percentages were found for Namibia (10%), Malawi (6%), and Swaziland (6%). For this indicator, 35 countries had a value of 1% or less, and the average percentage for the 52 countries was 1.4%.

Figure 12. Percentage of children 0-59 months with WHO flags and flags for height out of plausible limits, DHS surveys 2005-2014



3.5 Summarizing the Data Quality Indicators

The mapping of countries was done to identify the countries that performed best and worst on the 10 selected anthropometry data quality indicators used in this analysis. Table 2 and Table 3 present the countries with the highest values (indicating possible data quality issues) and those with the lowest values (indicating the best data quality) on the 10 data quality indicators discussed in this report. The data quality indicators used were the following: 1) HAZ SD, 2) WAZ SD, 3) WHZ SD, 4) the difference between HAZ SD under 2 years and HAZ SD 2 years and over, 5) the difference between WHZ SD under 2 years and WHZ SD 2 years and over, 6) Myers' Index for height, 7) Myers' Index for weight, 8) Myers' Index for age, 9) WHO flags (values outside the WHO boundaries), and 10) height out of plausible limits. As seen in Tables 2 and 3, there are a few countries that appear repeatedly with high values on the 10 data quality indicators. Those countries that appear in the tables five or more times are indicated in color. In Table 2, Albania and Benin appear in the table eight out of 10 times; Sierra Leone and Comoros appear seven out of 10 times; São Tomé and Príncipe appears six times; and Egypt and Timor-Leste appear five times. These findings indicate that the data quality in these countries is not as good as the data quality in the other countries.

Table 2. Countries with the highest values on the 10 measures of z-score standard deviations, height, weight and age, Myers' index, and flagged cases, ranked from highest to lowest values, DHS surveys 2005-2014

HAZ SD	WAZ SD	WHZ SD	HAZ SD < 2 years - HAZ SD ≥ 2 years	WHZ SD < 2 years - WHZ SD ≥ 2 years	Height Myers' index	Weight Myers' index	Age Myers' index	WHO flags	Height out of plausible limits
Benin	Benin	Benin	Timor-Leste	Mozambique	São Tomé and Príncipe	São Tomé and Príncipe	Niger	Benin	Namibia
Albania	Nigeria	Albania	São Tomé and Príncipe	Lesotho	Benin	Benin	Guinea	Albania	Malawi
Egypt	Sierra Leone	Egypt	Benin	São Tomé and Príncipe	Armenia	Armenia	Mali	Comoros	Swaziland
Nigeria	Comoros	São Tomé and Príncipe	Swaziland	Malawi	Namibia	Sierra Leone	Sierra Leone	Sierra Leone	Sierra Leone
Sierra Leone	Cameroon	Comoros	Zambia	Tanzania	Maldives	Egypt	Dominican Republic	Nigeria	Gambia
Comoros	Albania	Nigeria	Albania	Gambia	Malawi	Comoros	Albania	São Tomé and Príncipe	Benin
Mali	Mali	Timor-Leste	Lesotho	Timor-Leste	Niger	Azerbaijan	Comoros	Egypt	Peru
Congo Democratic Republic	Guinea	Azerbaijan	Kyrgyz Republic	Ghana	Burundi	Albania	Egypt	Pakistan	Nepal
Timor-Leste	Maldives	Sierra Leone	Tajikistan	Guinea	Tajikistan	Bolivia	Nepal	Azerbaijan	Guyana
Guinea	Congo Democratic Republic	Armenia	Comoros	Côte d'Ivoire	Zambia	Kyrgyz Republic	Ghana	Timor-Leste	Albania

Note: Countries that appear five or more times in the table are highlighted in different colors.

Some countries also appear repeatedly in Table 3, which lists the countries that had the lowest values on the 10 data quality indicators. Colombia appears in the table nine out of 10 times, Honduras and Peru appear in the table eight out of 10 times, and Bolivia appears five out of 10 times. These countries appear to have better quality anthropometric data than the other countries in the analysis.

Table 3. Countries with the lowest values on the 10 measures of z-score standard deviations, height, weight and age, Myers' index, and flagged cases, ranked from lowest to highest values, DHS surveys 2005-2014

HAZ SD	WAZ SD	WHZ SD	HAZ SD < 2 years - HAZ SD ≥ 2 years	WHZ SD < 2 years - WHZ SD ≥ 2 years	Height Myers' index	Weight Myers' index	Age Myers' index	WHO flags	Height out of plausible limits
Peru	Colombia	Colombia	Armenia	Armenia	Guinea	Zimbabwe	Zambia	Peru	Azerbaijan
Colombia	Jordan	Peru	Peru	Benin	Peru	Honduras	Tajikistan	Colombia	Colombia
Jordan	Kyrgyz Republic	Honduras	Honduras	Maldives	Bangla-desh	Dominican Republic	Senegal	Honduras	Congo Brazzaville
Honduras	Bolivia	Jordan	Azerbaijan	Colombia	Ethiopia	Cameroon	Burkina Faso	Jordan	Honduras
Dominican Republic	Cambodia	Bolivia	Niger	Honduras	Cameroon	Colombia	Burundi	Nepal	Kyrgyz Republic
Bolivia	Rwanda	Senegal	Senegal	Peru	Swaziland	Banglades h	Mozambiq ue	Rwanda	Bolivia
Senegal	Peru	Cambodia	Bangladesh	Nigeria	Colombia	Peru	Ethiopia	Haiti	Rwanda
Cambodia	Zimbabwe	Nepal	Haiti	Congo Brazzaville	Nepal	Tanzania	Gambia	Congo Brazzaville	Cambodia
Burundi	Azerbaijan	Rwanda	Colombia	Egypt	Honduras	Kenya	Namibia	Bolivia	Dominican Republic
Rwanda	Burundi	Zimbabwe	Pakistan	Azerbaijan	Zimbabwe	Guinea	Uganda	Burundi	Haiti

Note: Countries that appear five or more times in the table are highlighted in different colors.

Comparing the two tables, we note that Benin appears 8 times in Table 2 but also once in Table 3 (for the WHZ SD difference between the two age categories). Similarly, Peru appears once in Table 2 (for the height-out-of-plausible-limits indicator) while it appears 8 times in Table 3, indicating it is a country with very good anthropometric data quality. This finding highlights the importance of using more than one indicator to assess data quality. Relying on just one indicator is not sufficient for drawing conclusions about the quality of anthropometric data from a DHS survey.

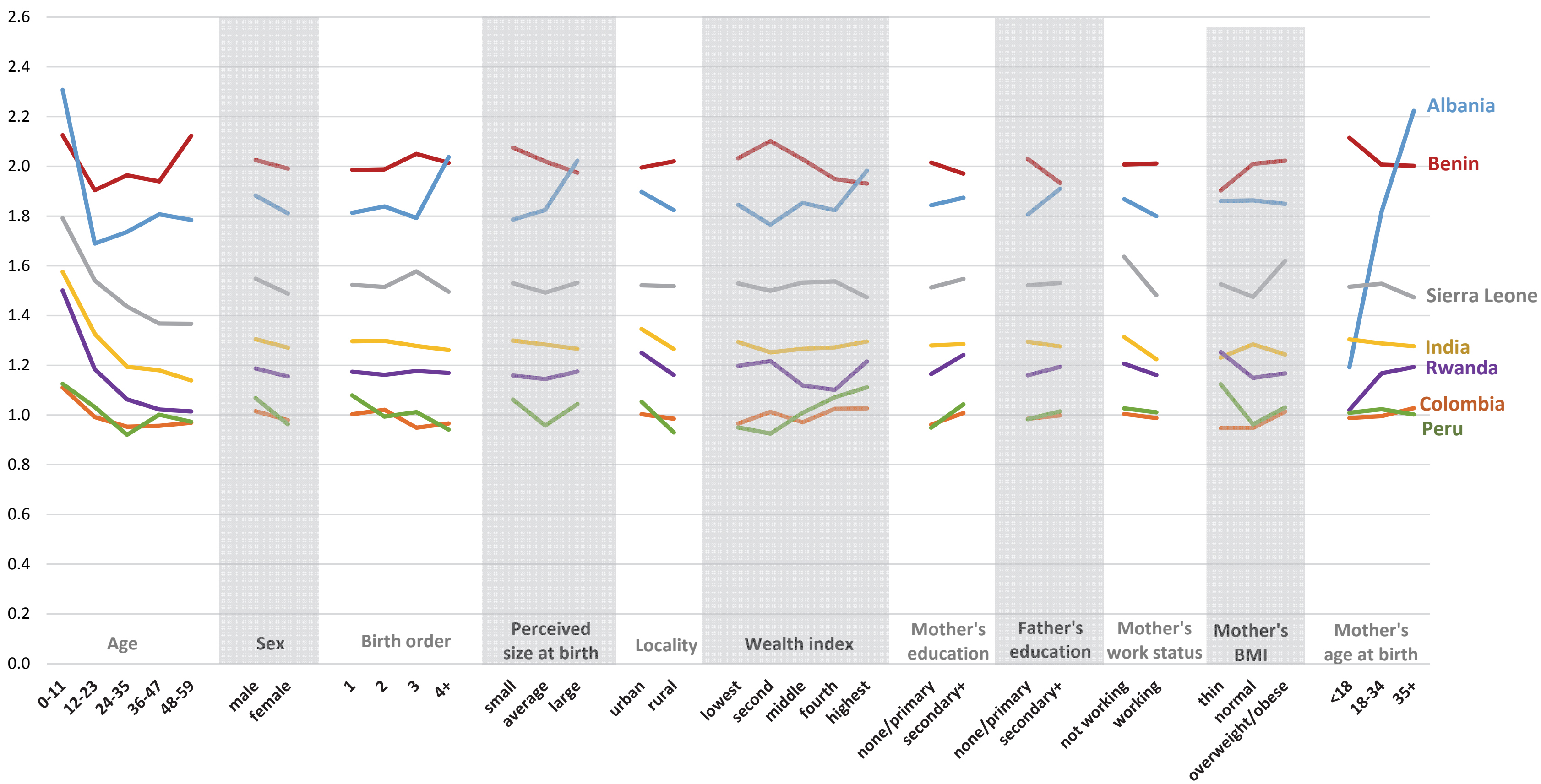
3.6 Bivariate SD Results

The HAZ, WAZ, and WHZ SDs for each category of the covariates used in the regression analysis for Benin, Albania, Sierra Leone, India, Rwanda, Columbia and Peru are presented in Figures 13-15 below and in Appendix F. These countries were selected because of their performance in the data quality indicators examined previously (from low to high performance). As can be seen in the figures, there are large variations in the SDs by age, especially for Benin, Albania and Sierra Leone. A higher SD at lower ages could indicate measurement issues for younger children. Variations in the SDs by the remaining categories were not as large. Exceptions were found in Albania, which had large variations in the SDs of the WAZ by mother's BMI and in the SDs of the WHZ by mother's age at child's birth.

Figure 13. Standard deviations of height-for-age (HAZ) by background variables, DHS surveys 2005-2014

Figure 14. Standard deviations of weight-for-age (WAZ) by background variables, DHS surveys 2005-2014

Figure 15. Standard deviations of weight-for-height (WHZ) by background variables, DHS surveys 2005-2014



3.7 Regression Results

Tables 4-6 summarize the regression results of the HAZ, WAZ, and WHZ for all 52 countries. Linear regressions were performed with the z-score as the outcome variable and selected covariates found to be associated with anthropometric measures in the literature (see Appendices G-I for the regression results for each country). The summaries show the number of countries that are in agreement in terms of the significance and sign of the coefficients. The summaries indicate that most countries have positive and significant associations between the z-scores and the perceived size of the child at birth (average and large versus *small* size at birth as the reference category). This was also the case for associations with the mother's BMI (normal and above versus *thin* as the reference category). For these covariates, the statistically significant coefficients were always positive. For the HAZ and WAZ regressions, many countries also had positive significant coefficients for the categories urban non-poor and rural non-poor versus rural poor as the reference category; only one country had a negative significant coefficient. This pattern was not as consistent in the WHZ regression, and in fact a few countries had a negative significant coefficient for these categories. Most of the coefficients, when significant, were in agreement, i.e., if significant they had the same sign in almost all the countries. Exceptions were mainly found for the coefficients of the work status category (i.e., mother working); however, this coefficient was found to be significant in only a few countries. Most countries did not have significant coefficients for the urban poor category, for mother's age at birth 35 years and over, and for the second and third birth order categories.

Table 4. Summary of HAZ linear regressions for 52 DHS surveys 2005-2014

Covariates	Category	Significant	Within significant coefficients: Positive coefficient	Within significant coefficients: Negative coefficient	Not significant	Total
Locality by wealth (Ref. rural poor)	rural non-poor	28	27	1	24	52
	urban poor	12	12	0	40	52
	urban non-poor	37	37	0	15	52
Education father (Ref. none/primary)	secondary+	22	22	0	30	52
Education mother (Ref. none/primary)	secondary+	28	28	0	24	52
Mother's work status (Ref. not working)	working	9	2	7	43	52
Mother's BMI (Ref. thin)	normal	15	15	0	36	51
	overweight/obese	31	31	0	20	51
Mother's age at birth (Ref. 18-34 years)	less than 18 years	24	0	24	28	52
	35 years and above	7	6	1	45	52
Child's birth order	2	10	0	10	42	52
	3	14	2	12	38	52
	4 or more	20	1	19	32	52
Sex (Ref. male)	female	31	31	0	21	52
Size at birth (Ref. small)	average	37	37	0	14	51
	large	46	46	0	5	51

Note: Armenia and Senegal did not have the mother's weight variable and Columbia did not have the size at birth variable in the regressions.

Table 5. Summary of WAZ linear regression for 52 DHS surveys 2005-2014

Covariates	Category	Significant	Within significant coefficients: Positive coefficient	Within significant coefficients: Negative coefficient	Not significant	Total
Locality by wealth (Ref. rural poor)	rural non-poor	28	27	1	24	52
	urban poor	8	8	0	44	52
	urban non-poor	36	36	0	16	52
Education father (Ref. none/primary)	secondary+	17	17	0	35	52
Education mother (Ref. none/primary)	secondary+	29	29	0	23	52
Mother's work status (Ref. not working)	working	4	2	2	48	52
Mother's BMI (Ref. thin)	normal	42	42	0	9	51
	overweight/obese	47	47	0	4	51
Mother's age at birth (Ref. 18-34 years)	less than 18 years	21	0	21	31	52
	35 years and above	4	3	1	48	52
Child's birth order	2	12	0	12	40	52
	3	16	1	15	36	52
	4 or more	23	0	23	29	52
Sex (Ref. male)	female	26	25	1	26	52
Size at birth (Ref. small)	average	46	46	0	5	51
	large	49	49	0	2	51

Note: Armenia and Senegal did not have the mother's weight variable and Columbia did not have the size at birth variable in the regressions.

Table 6. Summary of WHZ linear regression for 52 DHS surveys 2005-2014

Covariates	Category	Significant	Within significant coefficients: Positive coefficient	Within significant coefficients: Negative coefficient	Not significant	Total
Locality by wealth (Ref. rural poor)	rural non-poor	10	7	3	42	52
	urban poor	4	2	2	48	52
	urban non-poor	11	10	1	41	52
Education father (Ref. none/primary)	secondary+	3	3	0	49	52
Education mother (Ref. none/primary)	secondary+	14	13	1	38	52
Mother's work status (Ref. not working)	working	10	6	4	42	52
Mother's BMI (Ref. thin)	normal	41	41	0	10	51
	overweight/obese	45	45	0	6	51
Mother's age at birth (Ref. 18-34 years)	less than 18 years	7	2	5	45	52
	35 years and above	3	1	2	49	52
Child's birth order	2	11	2	9	41	52
	3	13	0	13	39	52
	4 or more	20	0	20	32	52
Sex (Ref. male)	female	10	10	0	42	52
Size at birth (Ref. small)	average	33	33	0	18	51
	large	45	45	0	6	51

Note: Armenia and Senegal did not have the mother's weight variable and Columbia did not have the size at birth variable in the regressions.

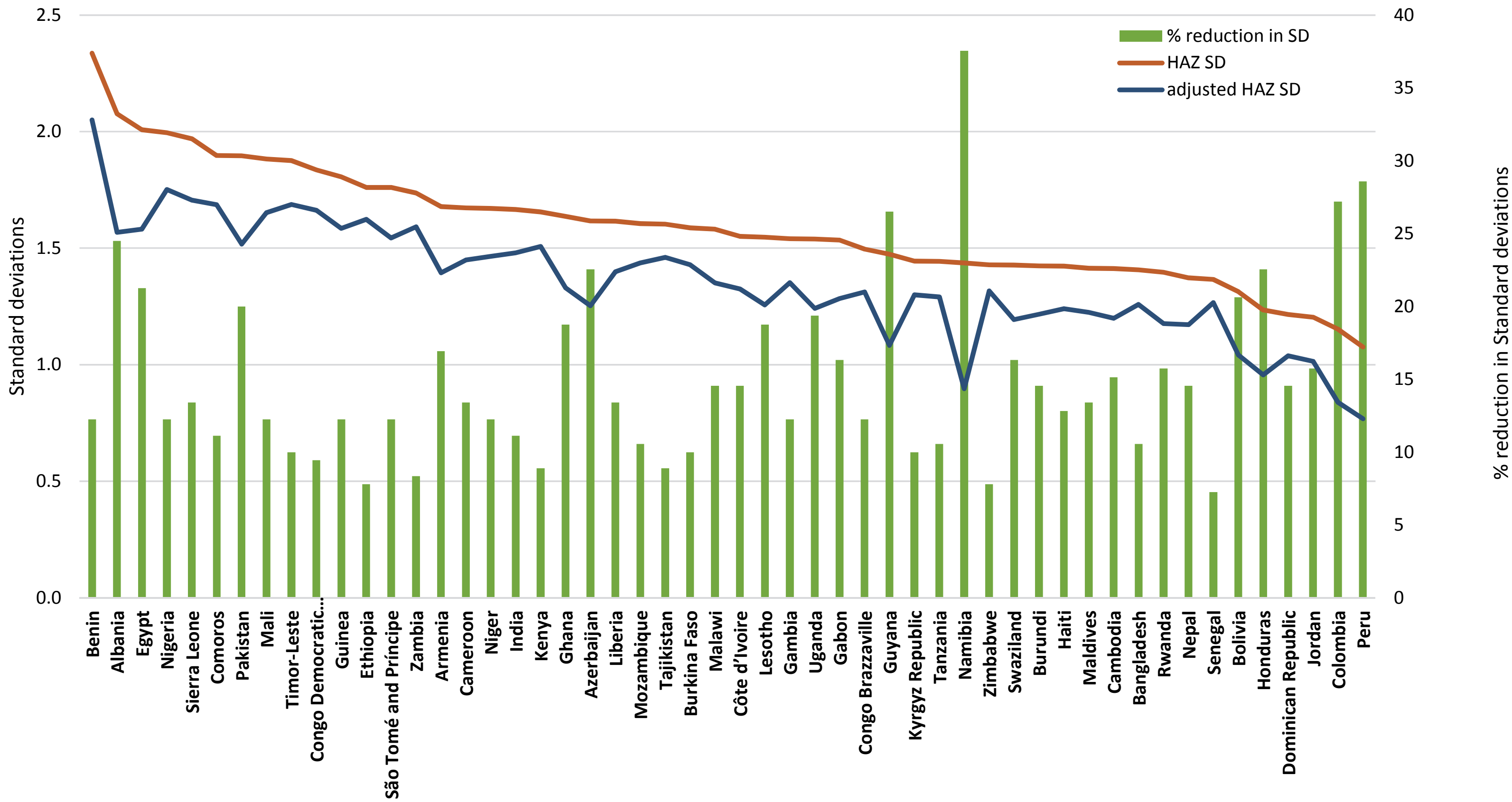
In addition to the regressions above, another regression model was estimated for each of the 52 countries for the HAZ z-score by adding the cluster as a fixed effect categorical covariate in addition to the other covariates in the first regression. In this model, the locality by wealth variable was removed and replaced with only the wealth index, because clusters are either all urban or all rural. The resulting R-squared values of these regressions can then be used to observe how much of the SD in the HAZ z-score can be explained by the heterogeneity of children between clusters. Table 7 shows that the R-squared value increased substantially for most countries after the addition of the cluster variable. For Namibia, for example, the R-squared value was 0.09 before adding the cluster variable and 0.61 after adding it. This adjusts the SD by a factor of 0.62 or the square root of one minus the R-squared value ($\sqrt{(1-R^2)}$). The adjusted HAZ SD for Namibia becomes 0.90 compared with the HAZ SD of 1.44 before taking into account the cluster heterogeneity; this translates into a 38% reduction in the SD, implying that much of the variability was explained by the cluster characteristics. For the countries with the highest HAZ SD, such as Benin, Albania, Egypt and Nigeria (all with HAZ SDs above 2), the adjustment factor ($\sqrt{(1-R^2)}$) was between 0.8 and 0.9. For Albania and Egypt the percent reduction in the SD after removing the cluster heterogeneity was between 21% and 25% and for Benin and Nigeria the percent reduction in the SD was approximately 12%, indicating that the high SDs for these countries is not due to heterogeneity across clusters but rather to either within-cluster heterogeneity or data quality issues. Table 7 and Figure 16 show that after Namibia, the second and third highest percent reduction in the SDs were found in Peru and Colombia (28% and 27%, respectively) indicating that in these countries there is also a high level of heterogeneity between clusters in terms of height-for-age for children under five. The lowest percent reductions in the SDs were found in Senegal, Ethiopia, and Zimbabwe, all of which were below 8%.

Table 7. R-squared values of the HAZ regressions before and after including the cluster variable with the adjusted HAZ SD, 52 DHS surveys 2005-2014

Country	HAZ SD	R^{2a}	R^{2b}	Sqrt (1-R^{2b})	Adjusted HAZ SD	% reduction in SD
Albania	2.08	0.05	0.43	0.75	1.57	24.50
Armenia	1.68	0.03	0.31	0.83	1.39	16.93
Azerbaijan	1.62	0.06	0.40	0.77	1.25	22.54
Bangladesh	1.41	0.08	0.20	0.89	1.26	10.56
Benin	2.34	0.01	0.23	0.88	2.05	12.25
Bolivia	1.31	0.18	0.37	0.79	1.04	20.63
Burkina Faso	1.59	0.04	0.19	0.90	1.43	10.00
Burundi	1.42	0.10	0.27	0.85	1.22	14.56
Cambodia	1.41	0.07	0.28	0.85	1.20	15.15
Cameroon	1.67	0.09	0.25	0.87	1.45	13.40
Colombia	1.15	0.05	0.47	0.73	0.84	27.20
Comoros	1.90	0.05	0.21	0.89	1.69	11.12
Congo Brazzaville	1.50	0.07	0.23	0.88	1.31	12.25
Congo Democratic Republic	1.84	0.06	0.18	0.91	1.66	9.45
Côte d'Ivoire	1.55	0.06	0.27	0.85	1.32	14.56
Dominican Republic	1.21	0.06	0.27	0.85	1.04	14.56
Egypt	2.01	0.01	0.38	0.79	1.58	21.26
Ethiopia	1.76	0.04	0.15	0.92	1.62	7.80
Gabon	1.53	0.11	0.30	0.84	1.28	16.33
Gambia	1.54	0.08	0.23	0.88	1.35	12.25
Ghana	1.64	0.06	0.34	0.81	1.33	18.76
Guinea	1.81	0.04	0.23	0.88	1.58	12.25
Guyana	1.47	0.16	0.46	0.73	1.08	26.52
Haiti	1.42	0.07	0.24	0.87	1.24	12.82
Honduras	1.23	0.22	0.40	0.77	0.96	22.54
India	1.67	0.07	0.21	0.89	1.48	11.12
Jordan	1.20	0.07	0.29	0.84	1.01	15.74
Kenya	1.66	0.05	0.17	0.91	1.51	8.90
Kyrgyz Republic	1.44	0.04	0.19	0.90	1.30	10.00
Lesotho	1.55	0.05	0.34	0.81	1.26	18.76
Liberia	1.62	0.08	0.25	0.87	1.40	13.40
Malawi	1.58	0.05	0.27	0.85	1.35	14.56
Maldives	1.41	0.06	0.25	0.87	1.22	13.40
Mali	1.88	0.05	0.23	0.88	1.65	12.25
Mozambique	1.61	0.05	0.20	0.89	1.44	10.56
Namibia	1.44	0.09	0.61	0.62	0.90	37.55
Nepal	1.37	0.10	0.27	0.85	1.17	14.56
Niger	1.67	0.03	0.23	0.88	1.47	12.25
Nigeria	2.00	0.09	0.23	0.88	1.75	12.25
Pakistan	1.90	0.11	0.36	0.80	1.52	20.00
Peru	1.08	0.28	0.49	0.71	0.77	28.59
Rwanda	1.40	0.10	0.29	0.84	1.18	15.74
São Tomé and Príncipe	1.76	0.09	0.23	0.88	1.54	12.25
Senegal	1.37	0.05	0.14	0.93	1.27	7.26
Sierra Leone	1.97	0.02	0.25	0.87	1.71	13.40
Swaziland	1.43	0.06	0.30	0.84	1.19	16.33
Tajikistan	1.60	0.03	0.17	0.91	1.46	8.90
Tanzania	1.44	0.06	0.20	0.89	1.29	10.56
Timor-Leste	1.88	0.02	0.19	0.90	1.69	10.00
Uganda	1.54	0.07	0.35	0.81	1.24	19.38
Zambia	1.74	0.03	0.16	0.92	1.59	8.35
Zimbabwe	1.43	0.03	0.15	0.92	1.32	7.80

R^{2a} = R-squared values for the regression omitting the cluster variable
R^{2b} = R-squared values for the regression including the cluster variable

Figure 16. Standard deviations of height-for-age (HAZ) z-scores before and after adjusting for cluster heterogeneity with percent reduction, 52 DHS surveys 2005-2014



4. Discussion

Because it is difficult to obtain accurate measurements of the height/length and weight of young children in the field, all surveys are subject to measurement errors. To minimize anthropometric measurement errors the DHS Program has implemented procedures to reduce the occurrence of these errors and strengthen and improve the data quality control systems used in DHS surveys. The current study analyzes estimates of 10 indicators of data quality that have been applied to anthropometric data from 52 DHS surveys conducted between 2005 and 2014.

The prevalence of undernutrition varies substantially across the 52 countries included in the report, which highlights the complexity of measuring nutritional status. The surveys differ widely according to the 10 data quality indicators used in this analysis. Several countries were identified (Columbia, Peru and Honduras) that consistently performed well across the data quality indicators, while other countries were identified (Benin and Albania) that consistently performed poorly. Although Benin has been included in this analysis, the nutrition data in the Benin DHS final report were suppressed because the country implementing organization decided that the data quality issues were too serious.

It is generally expected that the standard deviations of the weight-for-height z-scores (WHZ) and the weight-for-age (WAZ) will be smaller than the standard deviations of the height-for-age (HAZ) z-scores because the latter is associated with measurement error in age and height that tend to have higher error than measurements of weight. In this study, the HAZ showed the greatest dispersion, with an SD ranging from 1.08 to 2.33 compared to the standard deviations of the other two scores. The wide dispersion is partly due to heterogeneity but also reflects measurement error caused by the difficulty in measuring height/length of children under five years. Determining how much of the dispersion can be attributed to heterogeneity and how much to measurement error is an ongoing data quality issue. The only way to estimate the technical error of measurement (TEM) would be to measure children twice in the field. However, given the structure of DHS surveys, initiating a duplicate measurement procedure—particularly one involving independent measurements—would be difficult and impractical. The most that could reasonably be implemented would be re-measurement of a subset of children, but that would not give an accurate measure of the TEM for the entire survey.

It is also expected that all or almost all of the individual z-score values should fall within the WHO limits. WHO has suggested that the quality of anthropometry data is questionable if more than 1% of values fall outside these limits (World Health Organization 1995). In this analysis, 12 of the 52 countries had 5 percent or more of cases flagged according to the WHO limits. These cases were flagged because of extreme values on any combination of age, weight, and length/height. It is difficult to identify the reason the values are being flagged—that is, which of the three z-scores is/are out of range. In future analyses it would be useful to distinguish the source of the flag.

It is expected that the SDs of sub-populations will be more homogeneous than the SDs of the whole population. To test this we ran a few additional tables on selected countries to investigate mean z-scores and SDs of various subgroups. Seven countries identified as good, average, and poor in data quality were part of this investigation. Figures 13-15 and Appendix F indicate that countries that were labeled as having poor data quality (Albania and Benin) had SDs that fluctuated by age much more than countries with good data quality (Columbia and Peru). Further, except for age (and two other covariates for Albania only), no other background variables included in the analysis had a major impact on SD variation.

In the countries with poor and average data quality, the SDs of HAZ are largest for younger children and become tighter as the age of children increases. As suggested earlier, this pattern may be due to the difficulty of measuring the youngest children, who are lying down. Figures 8-9 and Appendix A support the inference that measurement of length of children is an issue in some DHS surveys. When z-scores are disaggregated for children under two years of age and children two years of age and over, a clear distinction in the SDs is seen across many countries. An alternative explanation for this pattern could be that a one-month error in the estimated age of a child will have a larger impact on the z-score for a 7-month-old child than for a child who is, say, 37 months of age.

In the quest to further identify the source of variations in z-scores, the cluster id code was introduced in a regression model in addition to selected background characteristics. It is evident from Figure 16 (Table 7) that for many countries a high percentage of the variability in scores is between or across clusters. The cluster variation is likely due primarily to heterogeneity of the clusters. However, different interviewing teams work in different clusters; so, cluster variation can, conceivably, also be due to variations in the quality of the measurements taken by the different teams. Even in Peru, identified as a country with very good quality data, a large portion of the variation was explained by the cluster variable, implying heterogeneity across clusters.

It is possible to simulate the effect of *random error and/or bias* in the measurements of age, height, and weight, and to estimate their impact on the means and SDs of the z-scores and on the estimates of the prevalence of stunting, underweight, overweight, and wasting. Obviously, random unbiased measurement error will tend to increase the SDs and the estimates of stunting, etc. Errors in the measurement of age will affect the HAZ and WAZ but not the WHZ; errors in the measurement of height will affect the HAZ and WHZ but not the WAZ; and errors in the measurement of weight will affect the WAZ and WHZ. We have carried out simulations of various potential patterns of measurement error but have not included them in this report.

5. Conclusion and Recommendations

The anthropometry data presented in the majority of DHS surveys appears to be of good quality. However, a substantial minority of the surveys have levels of flagged cases or dispersion that suggest measurement error. It has been suggested by some that surveys with high-quality anthropometric measurements should have HAZ, WAZ, and WHZ measurements that are normally distributed with a standard deviation of *one* at all levels of aggregation. However, most of the countries that conduct DHS surveys include sub-populations that are known to be malnourished, in which case genuine variability in nutritional status indicators may be confounded with measurement error. From the results presented in this report it is difficult to accept an assumption that the (true) z-scores in a population are normally distributed with a SD close to 1.0. Certainly, for higher levels of aggregation, moving from clusters to regions to an entire country, the level of heterogeneity in terms of factors that affect nutrition will tend to increase, with a tendency for the SDs to increase. Measurement error will also tend to increase the SDs, leading to potential over-estimates of the prevalence of malnutrition. The risk of over-estimating the level of malnutrition must be weighed against the risk of under-estimating the level of malnutrition, which could result from *over-editing* the data. As in most decision-making situations, there are two complementary types of potential errors, false positives and false negatives. The consequences of these two types of error are very different.

We have identified several DHS surveys with clear symptoms of measurement error. The Benin survey is the most egregious example and serves as a validation of the 10 selected indicators of misreporting. It must be emphasized that although this survey was included in our analysis, the nutrition data from the survey have not been released. Benin is the only country in which the anthropometric estimates on height/length and weight were not published in the final survey report because of data quality concerns. In the case of the Benin survey, the decision to suppress the nutrition results was made by the implementing agency in Benin, not by DHS or USAID. The policy of DHS is to make the data, including the computer files, publicly available so that users worldwide can carry out their own analyses, including adjustments, if they so choose. The Benin nutrition data are included in the publicly available DHS data sets.

The WHO 1995 expert committee report recommended the inclusion of the following information when presenting anthropometry data: general characteristics of the population; sample size; measurement methods; method of determining age; percentage of excluded data; prevalence based on fixed cutoff; confidence intervals of the prevalence estimates; mean z-scores with 95% confidence intervals; SD of z-scores; and frequency distribution plots against the reference distribution. In DHS surveys all the indicators are included in the main survey reports except SDs of the z-scores and frequency distribution plots. It should be recognized that this information is only a subset of the information that is needed to assess the overall quality of the data collected in a population-based survey. It is equally important to examine such factors as the quality of the sample design, whether a complete mapping and household listing operation is conducted, whether households are selected independently and not by the interviewing team, the implementation of a robust field monitoring plan at multiple levels, the extent and quality of secondary editing of the data, and the public availability of all the survey data and all the survey documentation.

Well-defined and internationally accepted criteria to assess anthropometry data quality are needed. A monitoring and evaluation reference group (MERG) for nutrition would be useful for developing criteria to assess all the platforms collecting population-level anthropometry data.

Regarding training in future surveys, an area where more emphasis and practice is desirable is the measurement of *length* in children under two years of age. DHS will continue to explore the possibility of using new types of equipment to measure the height/length of children, including digital and lightweight measuring boards. We also recommend that additional variables be created in the DHS recode data files to flag weight height/length and the three z-scores separately.

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Appendix A

Table A. Standard deviations of height-for-age z-scores (HAZ) for measured children under two years of age and measured children two years of age and over in 52 DHS surveys (2005-2014)

	HAZ SD < 2 years		HAZ SD ≥ 2 years		
Country	**mean**	**SD**	**mean**	**SD**	**difference**
Albania	-0.3	2.3	-0.4	1.9	0.5
Armenia	-0.6	1.7	-0.9	1.6	0.0
Azerbaijan	-0.6	1.6	-1.4	1.5	0.1
Bangladesh	-1.4	1.5	-1.8	1.3	0.2
Benin	-1.1	2.6	-2.0	2.1	0.5
Bolivia	-0.9	1.4	-1.5	1.2	0.3
Burkina Faso	-0.9	1.7	-1.7	1.4	0.3
Burundi	-1.9	1.5	-2.4	1.3	0.2
Cambodia	-1.2	1.5	-2.0	1.2	0.3
Cameroon	-0.8	1.8	-1.6	1.5	0.3
Colombia	-0.7	1.2	-0.9	1.0	0.2
Comoros	-0.9	2.1	-1.3	1.7	0.4
Congo Brazzaville	-0.8	1.6	-1.2	1.3	0.3
Congo Democratic Republic	-1.0	1.9	-2.0	1.7	0.2
Côte d’Ivoire	-0.8	1.7	-1.5	1.5	0.2
Dominican Republic	-0.3	1.4	-0.3	1.2	0.2
Egypt	-0.4	2.2	-0.7	1.9	0.4
Ethiopia	-1.0	1.8	-2.1	1.5	0.4
Gabon	-0.6	1.6	-0.8	1.4	0.2
Gambia	-0.7	1.7	-1.3	1.4	0.4
Ghana	-0.5	1.8	-1.4	1.4	0.4
Guinea	-0.5	1.9	-1.6	1.6	0.3
Guyana	-0.8	1.5	-0.9	1.4	0.2
Haiti	-0.6	1.5	-1.2	1.3	0.2
Honduras	-0.8	1.2	-1.3	1.2	0.1
India	-1.5	1.8	-2.1	1.5	0.2
Jordan	-0.2	1.3	-0.5	1.1	0.3
Kenya	-1.2	1.8	-1.6	1.5	0.3
Kyrgyz Republic	-0.4	1.6	-1.1	1.2	0.4
Lesotho	-1.2	1.8	-1.8	1.3	0.5
Liberia	-0.7	1.8	-1.6	1.5	0.3
Malawi	-1.5	1.8	-2.0	1.4	0.4
Maldives	-0.9	1.6	-0.9	1.3	0.3
Mali	-0.9	2.0	-1.8	1.7	0.3
Mozambique	-1.4	1.8	-1.9	1.5	0.3
Namibia	-0.6	1.6	-1.4	1.2	0.3
Nepal	-1.2	1.5	-2.0	1.3	0.2
Niger	-1.3	1.7	-2.0	1.6	0.1
Nigeria	-0.9	2.2	-1.7	1.8	0.3
Pakistan	-1.4	1.8	-2.0	1.6	0.2
Peru	-1.0	1.1	-1.1	1.1	0.0
Rwanda	-1.4	1.6	-2.0	1.2	0.3
São Tomé and Príncipe	-1.4	2.0	-1.1	1.5	0.5
Senegal	-0.7	1.4	-1.1	1.3	0.1
Sierra Leone	-1.0	2.1	-1.6	1.8	0.3
Swaziland	-0.9	1.7	-1.5	1.3	0.5
Tajikistan	-0.8	1.8	-1.4	1.4	0.4
Tanzania	-1.4	1.6	-1.9	1.3	0.3
Timor-Leste	-1.7	2.2	-2.4	1.5	0.6
Uganda	-1.1	1.7	-1.7	1.4	0.3
Zambia	-1.3	1.9	-1.9	1.5	0.5
Zimbabwe	-1.0	1.6	-1.7	1.2	0.3

Appendix B

Table B. Standard deviations of weight-for-height z-scores (WHZ) for measured children under two years of age and measured children two years of age and over in 52 DHS surveys (2005-2014)

	WHZ SD < 2 years		WHZ SD ≥ 2 years		
Country	**mean**	**SD**	**mean**	**SD**	**difference**
Albania	0.5	2.0	0.6	1.8	0.2
Armenia	0.6	1.5	0.7	1.5	0.0
Azerbaijan	0.0	1.6	0.5	1.4	0.1
Bangladesh	-0.8	1.4	-1.1	1.1	0.3
Benin	-0.1	2.0	0.1	2.0	0.0
Bolivia	0.5	1.2	0.7	1.0	0.2
Burkina Faso	-1.1	1.5	-0.4	1.2	0.2
Burundi	-0.4	1.3	-0.1	1.0	0.3
Cambodia	-0.7	1.2	-0.7	1.0	0.2
Cameroon	0.0	1.5	0.3	1.2	0.3
Colombia	0.3	1.0	0.3	1.0	0.1
Comoros	-0.2	1.7	-0.1	1.5	0.2
Congo Brazzaville	-0.3	1.3	-0.1	1.1	0.1
Congo Democratic Republic	-0.3	1.4	-0.1	1.2	0.2
Côte d'Ivoire	-0.4	1.4	0.0	1.1	0.3
Dominican Republic	0.4	1.3	0.2	1.1	0.1
Egypt	0.3	1.7	0.4	1.6	0.1
Ethiopia	-0.6	1.3	-0.4	1.1	0.2
Gabon	0.3	1.4	0.2	1.2	0.2
Gambia	-0.6	1.5	-0.6	1.1	0.4
Ghana	-0.6	1.5	0.0	1.2	0.3
Guinea	-0.6	1.5	-0.1	1.2	0.3
Guyana	0.0	1.4	0.0	1.2	0.2
Haiti	-0.2	1.3	-0.1	1.1	0.3
Honduras	0.3	1.1	0.3	1.0	0.1
India	-1.1	1.4	-1.0	1.2	0.3
Jordan	0.3	1.2	0.1	1.0	0.2
Kenya	0.0	1.4	-0.2	1.2	0.3
Kyrgyz Republic	0.5	1.3	0.4	1.1	0.2
Lesotho	0.2	1.5	0.2	1.1	0.4
Liberia	-0.5	1.3	0.0	1.1	0.3
Malawi	0.2	1.5	0.3	1.1	0.4
Maldives	-0.3	1.4	-0.6	1.4	0.1
Mali	-0.8	1.5	-0.4	1.3	0.2
Mozambique	0.0	1.6	0.3	1.2	0.4
Namibia	-0.5	1.3	0.0	1.1	0.2
Nepal	-0.8	1.3	-0.6	1.0	0.2
Niger	-1.0	1.6	-0.8	1.2	0.3
Nigeria	-0.9	1.6	-0.5	1.5	0.1
Pakistan	-0.7	1.4	-0.4	1.2	0.3
Peru	0.6	1.1	0.5	1.0	0.1
Rwanda	0.2	1.3	0.4	1.0	0.3
São Tomé and Príncipe	0.3	1.9	-0.2	1.5	0.4
Senegal	-0.4	1.2	-0.7	1.0	0.2
Sierra Leone	-0.1	1.7	0.1	1.4	0.2
Swaziland	0.6	1.4	0.6	1.1	0.3
Tajikistan	-0.4	1.6	0.0	1.3	0.3
Tanzania	0.0	1.4	0.0	1.1	0.4
Timor-Leste	-0.6	1.8	-0.9	1.4	0.4
Uganda	-0.2	1.3	0.1	1.0	0.3
Zambia	0.1	1.5	0.3	1.2	0.3
Zimbabwe	0.1	1.3	0.2	1.0	0.3

Appendix C

Table C. Heaping indices for height and weight measurements in 52 DHS surveys (2005-2014)

	Height			Weight		
Country	**Myers' Index**	**excess**	**ratio**	**Myers' Index**	**excess**	**ratio**
Albania	13.7	4.9	1.3	7.1	-0.2	1.0
Armenia	36.0	35.5	2.8	16.4	14.8	1.7
Azerbaijan	13.6	5.8	1.3	7.2	-0.8	1.0
Bangladesh	7.6	1.1	1.1	2.0	0.0	1.0
Benin	48.5	48.5	3.4	17.4	16.6	1.8
Bolivia	16.9	16.1	1.8	7.0	5.8	1.3
Burkina Faso	15.9	13.2	1.7	3.1	0.2	1.0
Burundi	27.9	27.6	2.4	6.6	3.9	1.2
Cambodia	20.0	17.3	1.9	3.6	2.3	1.1
Cameroon	8.4	-0.7	1.0	1.7	-0.9	1.0
Colombia	9.6	8.0	1.4	2.0	0.9	1.0
Comoros	23.4	20.2	2.0	8.7	1.1	1.1
Congo Brazzaville	12.2	7.9	1.4	2.8	0.8	1.0
Congo Democratic Republic	12.1	7.2	1.4	4.8	1.1	1.1
Côte d'Ivoire	18.7	17.7	1.9	3.7	1.7	1.1
Dominican Republic	11.8	7.1	1.4	1.7	-0.1	1.0
Egypt	19.7	6.8	1.3	9.1	3.1	1.2
Ethiopia	8.2	4.3	1.2	3.4	1.3	1.1
Gabon	14.6	12.5	1.6	4.0	1.1	1.1
Gambia	15.9	12.9	1.9	5.5	1.5	1.1
Ghana	13.8	12.0	1.6	2.9	-0.4	1.0
Guinea	2.3	0.1	1.0	2.3	0.1	1.0
Guyana	24.3	24.3	2.2	6.8	3.7	1.2
Haiti	13.7	10.1	1.5	3.3	0.8	1.0
Honduras	10.1	8.0	1.4	1.6	-0.6	1.0
India	15.6	12.2	1.6	2.4	1.1	1.1
Jordan	15.1	15.1	1.8	4.1	0.7	1.0
Kenya	14.3	14.3	1.7	2.2	0.2	1.0
Kyrgyz Republic	17.5	15.8	1.8	6.8	5.6	1.3
Lesotho	14.0	12.3	1.6	2.3	1.9	1.1
Liberia	14.0	6.3	1.3	3.9	2.6	1.1
Malawi	31.8	31.8	2.6	4.5	4.0	1.2
Maldives	31.9	31.9	2.6	3.1	2.0	1.1
Mali	15.6	13.6	1.7	4.5	4.2	1.2
Mozambique	22.2	21.2	2.1	3.5	0.8	1.0
Namibia	33.6	33.5	2.7	5.7	3.0	1.2
Nepal	10.0	7.7	1.4	2.6	-0.3	1.0
Niger	28.5	28.1	2.4	5.0	2.3	1.1
Nigeria	18.1	13.2	1.7	4.6	0.6	1.0
Pakistan	16.3	11.2	1.6	3.3	1.6	1.1
Peru	4.4	0.3	1.0	2.1	-0.5	1.0
Rwanda	20.7	19.6	2.0	3.0	0.4	1.0
São Tomé and Príncipe	78.7	74.0	4.7	73.5	72.7	4.6
Senegal	14.2	10.2	1.5	3.0	1.2	1.1
Sierra Leone	24.1	21.7	2.1	11.4	5.1	1.3
Swaziland	8.6	4.9	1.2	2.9	0.4	1.0
Tajikistan	25.8	24.6	2.2	6.1	3.7	1.2
Tanzania	20.3	19.7	2.0	2.1	1.5	1.1
Timor-Leste	22.6	18.9	1.9	5.3	2.9	1.1
Uganda	13.7	12.7	1.6	2.7	0.6	1.0
Zambia	25.6	24.8	2.2	3.1	1.7	1.1
Zimbabwe	11.6	9.2	1.5	1.2	0.9	1.0

Appendix D

Table D. Myers' heaping Index of age in 52 DHS surveys (2005-2014)

Country	Myers' Index
Albania	7.6
Armenia	5.2
Azerbaijan	4.8
Bangladesh	5.3
Benin	5.3
Bolivia	4.6
Burkina Faso	3.0
Burundi	3.2
Cambodia	5.1
Cameroon	4.5
Colombia	5.1
Comoros	7.4
Congo Brazzaville	6.0
Congo Democratic Republic	5.5
Côte d'Ivoire	5.1
Dominican Republic	8.3
Egypt	7.3
Ethiopia	3.6
Gabon	6.0
Gambia	3.7
Ghana	7.0
Guinea	11.7
Guyana	5.5
Haiti	4.8
Honduras	4.6
India	4.7
Jordan	5.5
Kenya	6.6
Kyrgyz Republic	4.2
Lesotho	5.6
Liberia	5.7
Malawi	6.5
Maldives	6.3
Mali	10.4
Mozambique	3.3
Namibia	3.7
Nepal	7.1
Niger	12.0
Nigeria	4.4
Pakistan	4.3
Peru	5.0
Rwanda	6.2
São Tomé and Príncipe	7.0
Senegal	3.0
Sierra Leone	9.0
Swaziland	4.5
Tajikistan	2.8
Tanzania	4.7
Timor-Leste	7.0
Uganda	4.0
Zambia	2.2
Zimbabwe	4.4

Appendix E

Table E. WHO flags and height out of plausible limits in 52 DHS surveys (2005-2014)

Country	Flagged cases	Height out of plausible limits
Albania	11.4%	2.7%
Armenia	5.0%	0.6%
Azerbaijan	6.2%	0.0%
Bangladesh	2.1%	0.5%
Benin	14.6%	3.1%
Bolivia	1.0%	0.1%
Burkina Faso	2.5%	0.5%
Burundi	1.0%	0.2%
Cambodia	2.2%	0.2%
Cameroon	2.2%	0.3%
Colombia	0.3%	0.0%
Comoros	9.0%	2.4%
Congo Brazzaville	1.0%	0.0%
Congo Democratic Republic	3.5%	0.5%
Côte d'Ivoire	2.3%	0.4%
Dominican Republic	1.3%	0.2%
Egypt	7.5%	1.8%
Ethiopia	1.9%	0.6%
Gabon	2.5%	0.7%
Gambia	4.6%	3.3%
Ghana	3.9%	2.1%
Guinea	3.3%	0.8%
Guyana	4.9%	2.7%
Haiti	1.0%	0.2%
Honduras	0.4%	0.0%
India	3.6%	0.8%
Jordan	0.7%	0.3%
Kenya	2.6%	1.0%
Kyrgyz Republic	1.3%	0.1%
Lesotho	2.3%	1.1%
Liberia	2.4%	0.5%
Malawi	3.9%	6.4%
Maldives	2.1%	0.5%
Mali	5.1%	1.8%
Mozambique	3.1%	0.6%
Namibia	2.3%	10.0%
Nepal	0.9%	2.8%
Niger	4.4%	0.8%
Nigeria	8.0%	1.4%
Pakistan	6.7%	2.2%
Peru	0.2%	3.0%
Rwanda	1.0%	0.1%
São Tomé and Príncipe	7.9%	1.4%
Senegal	2.4%	0.5%
Sierra Leone	8.1%	4.0%
Swaziland	2.3%	6.3%
Tajikistan	4.5%	0.6%
Tanzania	1.7%	0.4%
Timor-Leste	6.1%	0.8%
Uganda	1.3%	0.4%
Zambia	3.9%	0.8%
Zimbabwe	1.8%	0.5%
Average	**3.6%**	**1.4%**

Appendix F

Table F. Mean and standard deviations of the z-scores by background variables in 7 DHS countries (2005-2014)

Variable	Category	Benin						Albania						Sierra Leone					
		HAZ		WAZ		WHZ		HAZ		WAZ		WHZ		HAZ		WAZ		WHZ	
Variable	Category	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
Age of child in months	0-11	-0.60	2.51	-0.58	1.57	-0.13	2.13	-0.47	2.45	-0.25	1.44	0.25	2.31	-0.69	1.99	-0.57	1.55	-0.04	1.79
	12-23	-1.38	2.53	-0.77	1.52	-0.09	1.90	-0.26	2.22	0.37	1.41	0.68	1.69	-1.25	2.16	-0.81	1.47	-0.26	1.54
	24-35	-1.81	2.34	-0.93	1.56	0.06	1.96	-0.40	2.16	0.17	1.21	0.53	1.74	-1.67	2.10	-0.82	1.42	0.13	1.44
	36-47	-1.89	2.03	-1.05	1.40	0.08	1.94	-0.46	1.89	0.21	1.23	0.71	1.81	-1.63	1.69	-0.88	1.26	0.10	1.37
	48-59	-2.10	1.86	-1.16	1.32	0.20	2.12	-0.44	1.57	0.15	1.24	0.63	1.78	-1.64	1.52	-0.94	1.08	0.10	1.37
Sex of child	male	-1.67	2.32	-1.00	1.49	-0.06	2.03	-0.26	2.00	0.12	1.34	0.42	1.88	-1.41	1.97	-0.85	1.40	-0.06	1.55
	female	-1.45	2.33	-0.79	1.49	0.11	1.99	-0.56	2.03	0.18	1.27	0.74	1.81	-1.33	1.94	-0.75	1.36	0.06	1.49
Birth order of child	1	-1.57	2.32	-0.82	1.49	0.14	1.99	-0.18	1.98	0.20	1.38	0.46	1.81	-1.24	2.00	-0.71	1.43	0.04	1.52
	2	-1.51	2.34	-0.88	1.50	0.02	1.99	-0.52	2.13	0.25	1.24	0.83	1.84	-1.45	1.89	-0.82	1.32	0.04	1.51
	3	-1.48	2.40	-0.83	1.53	0.06	2.05	-0.47	1.91	0.10	1.21	0.55	1.79	-1.24	1.98	-0.80	1.38	-0.10	1.58
	4+	-1.62	2.29	-0.98	1.46	-0.05	2.01	-0.62	1.99	-0.15	1.36	0.30	2.04	-1.43	1.94	-0.83	1.38	0.01	1.50
Perceived size of child at birth	small	-1.67	2.27	-0.92	1.46	0.08	2.07	-0.51	2.26	-0.03	1.16	0.48	1.79	-1.63	1.93	-1.11	1.44	-0.22	1.53
	average	-1.59	2.37	-0.91	1.52	0.03	2.02	-0.51	1.96	0.12	1.28	0.60	1.82	-1.39	1.99	-0.76	1.37	0.08	1.49
	large	-1.38	2.20	-0.76	1.39	0.06	1.97	0.06	2.09	0.37	1.43	0.51	2.02	-1.26	1.92	-0.74	1.34	0.00	1.53
Locality	urban	-1.46	2.32	-0.81	1.49	0.07	1.99	-0.36	2.07	0.16	1.27	0.54	1.90	-0.99	2.02	-0.57	1.41	0.03	1.52
	rural	-1.62	2.33	-0.95	1.49	-0.01	2.02	-0.44	1.98	0.15	1.32	0.61	1.82	-1.48	1.92	-0.87	1.36	-0.01	1.52
Wealth	lowest	-1.76	2.41	-1.08	1.49	-0.08	2.03	-0.89	2.07	-0.02	1.41	0.78	1.85	-1.51	2.09	-0.82	1.42	0.10	1.53
	second	-1.72	2.30	-1.01	1.53	-0.01	2.10	-0.33	1.89	0.14	1.14	0.46	1.77	-1.55	1.84	-0.99	1.28	-0.12	1.50
	middle	-1.49	2.42	-0.84	1.52	0.05	2.03	-0.31	2.04	0.24	1.31	0.62	1.85	-1.41	1.86	-0.80	1.40	0.02	1.53
	fourth	-1.51	2.28	-0.90	1.45	-0.02	1.95	-0.47	1.89	0.10	1.24	0.53	1.82	-1.18	1.93	-0.71	1.43	-0.02	1.54
	highest	-1.33	2.22	-0.66	1.42	0.17	1.93	0.03	2.10	0.31	1.37	0.48	1.98	-0.94	2.01	-0.53	1.32	0.05	1.47
Education of mother	none/primary	-1.58	2.35	-0.93	1.49	0.00	2.02	-0.52	2.02	0.09	1.27	0.58	1.84	-1.41	1.96	-0.83	1.37	0.00	1.51
	secondary+	-1.44	2.21	-0.70	1.48	0.20	1.97	-0.20	2.01	0.27	1.36	0.58	1.87	-1.15	1.92	-0.65	1.40	0.03	1.55
Education of partner	none/primary	-1.64	2.37	-0.95	1.52	0.01	2.03	-0.59	2.01	0.08	1.29	0.62	1.81	-1.42	1.93	-0.82	1.39	0.00	1.52
	secondary+	-1.42	2.20	-0.76	1.42	0.10	1.93	-0.19	2.01	0.24	1.31	0.53	1.91	-1.30	1.96	-0.72	1.30	0.07	1.53
Mother's working status	not working	-1.68	2.46	-0.96	1.56	0.04	2.01	-0.48	2.02	0.12	1.32	0.59	1.87	-1.21	2.00	-0.72	1.50	0.00	1.64
	working	-1.51	2.28	-0.87	1.46	0.01	2.01	-0.13	2.00	0.27	1.26	0.54	1.80	-1.42	1.94	-0.82	1.34	0.00	1.48
Mother's BMI	thin	-1.96	2.22	-1.25	1.48	-0.19	1.90	-1.35	2.14	-0.13	0.96	0.97	1.86	-1.62	1.86	-1.11	1.36	-0.24	1.53
	normal	-1.61	2.35	-0.96	1.50	-0.02	2.01	-0.40	2.03	0.11	1.36	0.50	1.86	-1.36	1.98	-0.79	1.37	0.01	1.47
	overweight/ obese	-1.36	2.30	-0.69	1.43	0.17	2.02	-0.41	1.98	0.18	1.21	0.65	1.85	-1.29	1.88	-0.66	1.31	0.14	1.62
Age of mother at child's birth	<18	-2.03	2.15	-1.15	1.54	0.03	2.11	-0.75	1.92	-0.06	1.17	0.47	1.19	-1.65	1.87	-1.02	1.37	-0.08	1.52
	18-34	-1.52	2.34	-0.89	1.48	0.00	2.01	-0.39	2.04	0.18	1.30	0.60	1.82	-1.33	1.97	-0.78	1.37	0.00	1.53
	35+	-1.68	2.32	-0.90	1.55	0.13	2.00	-0.55	1.86	-0.07	1.32	0.36	2.22	-1.42	1.93	-0.82	1.42	0.03	1.47
Total		-1.56	2.33	-0.90	1.49	0.02	2.01	-0.41	2.02	0.15	1.30	0.58	1.85	-1.37	1.95	-0.80	1.38	0.00	1.52

Variable	Category	India						Rwanda						Colombia						Peru					
		HAZ		WAZ		WHZ		HAZ		WAZ		WHZ		HAZ		WAZ		WHZ		HAZ		WAZ		WHZ	
Variable	Category	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
Age of child in months	0-11	-0.90	1.74	-1.47	1.33	-1.16	1.58	-0.81	1.55	-0.43	1.23	0.21	1.50	-0.53	1.21	-0.14	1.06	0.32	1.11	-0.78	1.09	0.00	1.19	0.73	1.13
	12-23	-2.02	1.62	-1.78	1.27	-1.07	1.33	-1.88	1.40	-0.77	1.12	0.20	1.18	-0.93	1.17	-0.17	1.01	0.37	0.99	-1.19	1.09	-0.23	1.11	0.46	1.03
	24-35	-2.16	1.61	-1.87	1.23	-0.96	1.19	-2.05	1.32	-0.80	1.03	0.45	1.06	-0.95	1.10	-0.29	1.00	0.29	0.95	-1.07	1.09	-0.29	0.98	0.38	0.92
	36-47	-2.14	1.53	-1.89	1.16	-0.93	1.18	-2.03	1.13	-0.81	0.88	0.54	1.02	-0.87	1.04	-0.26	0.97	0.36	0.96	-1.06	1.06	-0.18	1.06	0.63	1.00
	48-59	-2.02	1.45	-1.87	1.11	-0.98	1.14	-1.93	1.15	-0.99	0.96	0.30	1.01	-0.84	1.02	-0.33	0.96	0.27	0.97	-1.04	1.06	-0.25	1.04	0.58	0.97
Sex of child	male	-1.88	1.65	-1.76	1.23	-1.03	1.30	-1.86	1.39	-0.82	1.06	0.34	1.19	-0.85	1.14	-0.24	1.02	0.34	1.02	-1.02	1.13	-0.17	1.12	0.58	1.07
	female	-1.85	1.66	-1.81	1.23	-1.01	1.27	-1.65	1.39	-0.71	1.06	0.35	1.15	-0.79	1.10	-0.24	0.99	0.30	0.98	-1.04	1.03	-0.22	1.03	0.52	0.96
Birth order of child	1	-1.64	1.58	-1.57	1.22	-0.91	1.30	-1.55	1.38	-0.59	0.98	0.42	1.17	-0.71	1.12	-0.13	1.00	0.39	1.00	-0.82	1.06	-0.03	1.12	0.62	1.08
	2	-1.75	1.60	-1.68	1.21	-0.97	1.30	-1.69	1.36	-0.68	1.07	0.40	1.16	-0.81	1.08	-0.22	0.99	0.33	1.02	-0.92	1.04	-0.10	1.04	0.59	0.99
	3	-1.96	1.66	-1.87	1.18	-1.06	1.28	-1.84	1.41	-0.84	1.05	0.31	1.18	-0.87	1.12	-0.30	0.96	0.26	0.95	-1.04	1.06	-0.22	1.05	0.53	1.01
	4+	-2.19	1.74	-2.08	1.22	-1.17	1.26	-1.88	1.39	-0.88	1.09	0.29	1.17	-1.10	1.15	-0.51	1.02	0.16	0.97	-1.51	1.06	-0.56	1.00	0.43	0.94
Perceived size of child at birth	small	-2.05	1.65	-2.06	1.20	-1.25	1.30	-2.06	1.36	-1.14	1.05	0.09	1.16	na	na	na	na	na	na	-1.52	1.07	-0.67	1.09	0.29	1.06
	average	-1.83	1.66	-1.73	1.21	-0.97	1.28	-1.74	1.40	-0.81	1.04	0.26	1.14	na	na	na	na	na	na	-1.01	1.01	-0.17	0.99	0.57	0.96
	large	-1.77	1.65	-1.66	1.24	-0.93	1.27	-1.67	1.38	-0.60	1.04	0.49	1.17	na	na	na	na	na	na	-0.67	1.09	0.15	1.09	0.75	1.04
Locality	urban	-1.56	1.66	-1.48	1.25	-0.85	1.35	-1.14	1.50	-0.43	1.09	0.30	1.25	-0.75	1.11	-0.18	1.00	0.34	1.00	-0.74	1.02	0.03	1.08	0.63	1.05
	rural	-1.97	1.64	-1.88	1.20	-1.07	1.26	-1.84	1.36	-0.81	1.05	0.35	1.16	-1.00	1.13	-0.38	1.00	0.27	0.99	-1.58	0.99	-0.62	0.94	0.41	0.93
Wealth	lowest	-2.29	1.69	-2.18	1.20	-1.23	1.29	-2.05	1.38	-0.93	1.09	0.36	1.20	-1.10	1.17	-0.45	1.00	0.24	0.96	-1.77	0.95	-0.75	0.92	0.38	0.95
	second	-2.07	1.64	-1.99	1.18	-1.13	1.25	-1.96	1.35	-0.93	1.03	0.28	1.22	-0.83	1.08	-0.26	0.99	0.29	1.01	-1.24	0.95	-0.42	0.94	0.40	0.93
	middle	-1.89	1.60	-1.78	1.16	-1.00	1.27	-1.84	1.30	-0.78	1.05	0.39	1.12	-0.77	1.10	-0.22	0.98	0.31	0.97	-0.83	0.95	-0.07	1.00	0.56	1.01
	fourth	-1.61	1.55	-1.54	1.15	-0.89	1.27	-1.67	1.29	-0.72	1.00	0.34	1.10	-0.68	1.08	-0.11	0.99	0.38	1.03	-0.56	0.94	0.23	1.05	0.75	1.07
	highest	-1.10	1.50	-1.08	1.16	-0.67	1.30	-1.08	1.47	-0.35	1.04	0.37	1.21	-0.52	1.07	0.05	1.00	0.49	1.03	-0.27	1.02	0.47	1.12	0.88	1.11
Education of mother	none/primary	-2.12	1.66	-2.01	1.20	-1.12	1.28	-1.83	1.35	-0.81	1.05	0.35	1.16	-1.08	1.12	-0.47	0.99	0.20	0.96	-1.62	1.01	-0.64	0.96	0.42	0.95
	secondary+	-1.43	1.55	-1.39	1.18	-0.83	1.28	-0.94	1.57	-0.29	1.08	0.35	1.24	-0.73	1.10	-0.15	0.99	0.37	1.01	-0.76	1.01	0.01	1.07	0.62	1.04
Education of partner	none/primary	-2.16	1.68	-2.04	1.21	-1.14	1.29	-1.84	1.35	-0.82	1.05	0.35	1.16	-1.01	1.14	-0.39	1.01	0.26	0.98	-1.58	1.01	-0.62	0.98	0.42	0.98
	secondary+	-1.64	1.60	-1.58	1.20	-0.92	1.28	-1.18	1.52	-0.41	1.08	0.36	1.19	-0.72	1.09	-0.17	0.99	0.35	1.00	-0.86	1.04	-0.06	1.06	0.60	1.01
Mother's working status	not working	-1.79	1.66	-1.71	1.23	-0.98	1.31	-1.69	1.42	-0.75	1.12	0.32	1.21	-0.84	1.11	-0.29	1.01	0.27	1.00	-1.00	1.06	-0.17	1.07	0.57	1.03
	working	-2.05	1.63	-1.95	1.20	-1.11	1.22	-1.78	1.38	-0.77	1.04	0.35	1.16	-0.80	1.13	-0.18	1.00	0.38	0.99	-1.05	1.11	-0.22	1.09	0.54	1.01
Mother's BMI	thin	-2.07	1.61	-2.06	1.16	-1.26	1.23	-1.94	1.31	-1.24	1.06	-0.20	1.25	-0.96	1.09	-0.67	0.98	-0.19	0.95	-1.15	1.23	-0.69	1.18	-0.07	1.12
	normal	-1.75	1.66	-1.64	1.21	-0.90	1.28	-1.83	1.38	-0.84	1.03	0.30	1.15	-0.87	1.10	-0.30	0.97	0.26	0.95	-1.17	1.09	-0.39	1.04	0.38	0.96
	overweight/ obese	-1.26	1.53	-1.06	1.18	-0.50	1.24	-1.39	1.43	-0.38	1.08	0.60	1.17	-0.75	1.12	-0.09	1.00	0.47	1.01	-0.93	1.07	-0.03	1.08	0.71	1.03
Age of mother at child's birth	<18	-2.18	1.56	-1.98	1.16	-1.02	1.30	-2.14	1.48	-0.81	0.98	0.59	1.02	-0.92	1.14	-0.30	0.98	0.31	0.99	-1.22	1.03	-0.28	1.01	0.57	1.01
	18-34	-1.83	1.66	-1.75	1.23	-1.01	1.29	-1.73	1.39	-0.74	1.05	0.37	1.17	-0.82	1.11	-0.23	1.00	0.32	1.00	-1.01	1.08	-0.19	1.08	0.55	1.02
	35+	-2.07	1.77	-2.01	1.31	-1.17	1.28	-1.84	1.38	-0.89	1.10	0.25	1.19	-0.78	1.15	-0.22	1.05	0.33	1.03	-1.04	1.13	-0.20	1.09	0.56	1.00
Total		-1.87	1.66	-1.78	1.23	-1.02	1.29	-1.76	1.39	-0.77	1.06	0.35	1.17	-0.82	1.12	-0.24	1.00	0.32	1.00	-1.03	1.09	-0.19	1.08	0.55	1.02

na = Information not available

Appendix G

Table G. HAZ linear regressions for 52 DHS surveys (2005-2014)

Variable	Category	Albania	Armenia	Azerbaijan	Bangladesh	Benin	Bolivia	Burkina Faso	Burundi	Cambodia	Cameroon	Colombia	Comoros	Congo Brazzaville	Congo Democratic Republic	Côte d'Ivoire	Dominican Republic	Egypt	Ethiopia
		coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient
Locality by wealth (ref. rural poor)	rural non-poor	0.27	-0.28	0.20	0.20***	0.06	0.34***	0.04	0.22***	0.21**	0.42***	0.01	0.24	0.24*	0.05	0.20	0.46**	0.26***	0.13*
	urban poor	-0.12	0.06	0.07	-0.07	0.07	0.30***	0.19	-0.28	-0.02	0.13	0.05	0.34	0.21*	-0.12	0.52***	0.02	0.13	0.49
	urban non-poor	-0.05	0.06	0.53***	0.33***	0.11	0.69***	0.35***	0.74***	0.42***	0.48***	0.18***	0.32	0.48***	0.38***	0.58***	0.27**	0.09	0.29*
Education of partner (ref. none/primary)	secondary+	0.32	-0.22	0.04	0.25***	0.12	0.16***	0.17	0.06	0.26***	0.19**	0.10**	-0.06	0.06	0.30***	-0.02	0.10	0.13*	0.32**
Education of mother (ref. none/primary)	secondary+	0.11	0.08	0.77	0.18***	0.01	0.28***	0.49***	0.67***	0.03	0.28***	0.18***	0.46**	0.26*	0.26**	0.29	0.12	0.14*	0.39**
Mother's working status (ref. not working)	working	0.31	-0.01	-0.03	-0.00	0.18*	-0.13***	0.16**	-0.04	-0.22***	-0.15*	-0.01	0.23	-0.18	-0.29***	-0.05	-0.08	-0.22**	-0.05
Mother's BMI (ref. thin)	normal	0.91	na	-0.35	0.21***	0.37*	0.11	0.33***	0.16	0.10	0.26	0.11	0.39	0.27*	-0.15	0.25	0.33**	-0.14	0.07
	overweight/ obese	0.89	na	-0.22	0.46***	0.59***	0.22	0.44***	0.39**	0.08	0.49**	0.28***	0.65	0.37*	0.14	0.38	0.35**	0.07	0.60***
Age of mother at child's birth (ref. 18-34)	<18	-0.27	-0.32	0.05	-0.23***	-0.41*	-0.05	-0.33**	0.06	-0.04	-0.43***	-0.23***	-0.68*	-0.15	-0.36*	-0.45*	-0.06	-0.40**	-0.37**
	35+	-0.12	-0.12	-0.21	-0.03	-0.19	0.07	0.24***	0.07	0.06	0.06	0.14**	-0.17	0.19	0.20	-0.07	0.04	0.13	0.14
Birth order of child (ref. 1)	2	-0.44*	-0.43***	0.07	-0.08	0.03	-0.15**	0.04	-0.10	0.03	-0.10	-0.15***	-0.03	0.04	-0.01	-0.17	-0.18*	-0.07	-0.00
	3	-0.35*	-0.26	0.07	-0.14**	0.00	-0.21***	0.10	-0.23*	-0.13	-0.20*	-0.16***	-0.08	0.05	-0.06	-0.20	-0.04	-0.03	-0.16
	4+	-0.54*	-0.61	-0.17	-0.19**	-0.12	-0.31***	-0.04	-0.21*	-0.23*	-0.17	-0.34***	-0.08	0.03	-0.07	-0.17	-0.25**	0.01	-0.07
Sex of child (ref. male)	female	-0.18	0.17	0.24*	-0.01	0.26***	0.11**	0.18***	0.28***	0.03	0.12	0.06*	0.25*	-0.04	0.25***	0.13	0.14*	0.15***	0.14*
Perceived size of child at birth (ref. small)	average	0.06	0.51**	0.56***	0.31***	0.02	0.29***	0.24**	0.40***	0.32**	0.09	na	0.03	0.30*	0.15	0.16	0.18*	0.26***	0.25***
	large	0.60	0.64**	0.58***	0.43***	0.21	0.75***	0.39***	0.53***	0.52***	0.38***	na	-0.23	0.48***	0.42***	0.37**	0.43***	0.29*	0.34***
Observations		1,211	1,225	1,429	7,027	5,814	6,406	5,573	2,736	3,210	3,880	12,757	1,862	3,270	6,064	2,215	2,608	11,980	8,129
R-squared		0.05	0.03	0.06	0.08	0.01	0.18	0.04	0.10	0.07	0.09	0.05	0.05	0.07	0.06	0.06	0.06	0.01	0.04

(Continued…)

Table G. − *Continued*

Variable	Category	Gabon	Gambia	Ghana	Guinea	Guyana	Guinea	Guyana	Haiti	Honduras	India	Jordan	Kenya	Kyrgyz Republic	Lesotho	Liberia	Malawi	Maldives	Mali	Mozam-bique
		coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient
Locality by wealth (ref. rural poor)	rural non-poor	0.38	0.02	0.11	0.01	0.59***	0.01	0.59***	0.29**	0.52***	0.25***	0.27***	0.13	0.13	0.14	0.17	0.04	0.23**	0.31***	0.28***
	urban poor	0.30**	0.35*	0.01	0.16	0.51**	0.16	0.51**	-0.11	0.28***	0.04	0.11	0.47	0.07	0.18	-0.14	-0.12	-0.06	0.68	-0.08
	urban non-poor	0.73***	0.37***	0.32*	0.58***	0.31	0.58***	0.31	0.34***	0.54***	0.36***	0.49***	0.21	0.14	0.16	0.16	0.10	0.35**	0.62***	0.44***
Education of partner (ref. none/primary)	secondary+	0.01	0.16	0.05	0.09	-0.00	0.09	-0.00	0.06	0.16***	0.10***	0.19*	0.28**	-0.96	0.26*	0.09	0.10	0.10	0.46***	0.16*
Education of mother (ref. none/primary)	secondary+	0.20*	0.39**	0.09	0.47*	0.40*	0.47*	0.40*	0.20*	0.27***	0.32***	0.16	0.14	-0.13	0.07	0.28*	0.15	-0.03	0.09	0.31***
Mother's working status (ref. not working)	working	0.02	-0.22**	-0.01	0.13	0.20	0.13	0.20	-0.12	-0.05	-0.08**	0.11	-0.01	0.03	-0.00	-0.18	-0.16*	0.11	-0.02	0.02
Mother's BMI (ref. thin)	normal	0.18	0.03	-0.10	0.30*	0.19	0.30*	0.19	0.33*	0.12	0.21***	0.27	0.20*	0.15	0.33	0.56*	0.17	0.17	0.16	0.29**
	Overweight/ obese	0.44*	0.07	0.38*	0.36*	0.52**	0.36*	0.52**	0.45**	0.30**	0.39***	0.29*	0.38***	0.16	0.55*	0.90***	0.51**	0.12	0.45**	0.58***
Age of mother at child's birth (ref. 18-34)	<18	-0.36	0.14	-0.84**	-0.18	-0.29	-0.18	-0.29	-0.46**	-0.18***	-0.36***	-0.13	-0.13	0.19	0.25	-0.49*	0.08	0.11	-0.39**	-0.24*
	35+	0.36*	-0.09	0.07	0.11	0.21	0.11	0.21	-0.02	0.03	0.06	0.05	0.05	0.20	-0.01	0.07	-0.02	0.12	-0.09	0.11
Birth order of child (ref. 1)	2	-0.00	0.23	0.05	-0.03	0.03	-0.03	0.03	-0.21**	-0.15***	-0.13***	-0.00	-0.04	-0.11	-0.08	-0.16	0.14	0.01	-0.14	0.10
	3	-0.03	0.34*	-0.17	0.05	0.08	0.05	0.08	-0.20*	-0.21***	-0.23***	-0.27**	-0.00	-0.08	0.04	-0.35	0.21	-0.11	-0.08	0.08
	4+	-0.33*	0.32*	0.08	0.05	-0.25	0.05	-0.25	-0.27**	-0.34***	-0.34***	-0.12	-0.17	-0.33***	-0.07	-0.27	0.20	-0.31*	-0.11	0.08
Sex of child (ref. male)	female	0.24*	0.18*	0.12	0.19*	0.05	0.19*	0.05	0.08	0.18***	0.04	0.05	0.11	0.16**	0.37***	0.31**	0.34***	0.10	0.08	0.19***
Perceived size of child at birth (ref. small)	average	0.40**	0.13	0.28*	0.24	0.34*	0.24	0.34*	0.11	0.47***	0.17***	0.46***	0.37***	0.51***	0.40***	0.05	0.44***	0.56***	0.05	0.24***
	large	0.57***	0.50***	0.41***	0.34*	0.63***	0.34*	0.63***	0.28***	0.84***	0.21***	0.60***	0.55***	0.84***	0.56***	0.47**	0.71***	0.82***	0.10	0.38***
Observations		1,900	2,491	1,910	2,519	1,054	2,519	1,054	3,324	8,598	35,933	5,443	4,127	3,519	1,482	2,371	3,810	1,832	3,535	6,841
R-squared		0.11	0.08	0.06	0.04	0.16	0.04	0.16	0.07	0.22	0.07	0.07	0.05	0.04	0.05	0.08	0.05	0.06	0.05	0.05

Variable	Category	Namibia	Nepal	Niger	Nigeria	Pakistan	Peru	Rwanda	São Tomé and Príncipe	Senegal	Sierra Leone	Swaziland	Tajikistan	Tanzania	Timor-Leste	Uganda	Zambia	Zimbabwe
		coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient
Locality by wealth (ref. rural poor)	rural non-poor	-0.12	0.37***	0.06	0.50***	0.49***	0.28*	0.29***	0.56**	0.34***	0.18	0.24*	0.16*	0.14*	0.04	-0.23*	0.06	0.05
	urban poor	-0.15	0.49*	-0.85	0.44***	0.25	0.33***	0.28	-0.18	0.29**	0.44**	0.43*	0.15	-0.08	-0.08	0.19	0.22	-0.25
	urban non-poor	0.30	0.61***	0.28**	0.56***	0.35**	0.76***	0.80***	0.31	0.33**	0.43**	0.44**	0.41***	0.39***	0.40***	0.23	0.19*	0.14*
Education of partner (ref. none/primary)	secondary+	0.32*	0.08	0.27*	0.20***	0.21*	0.14***	0.31***	0.20	0.14	-0.02	0.14	0.18	0.30**	0.07	0.32**	0.01	-0.05
Education of mother (ref. none/primary)	secondary+	-0.05	0.25*	0.37**	0.48***	0.56***	0.29***	0.37***	-0.01	0.23*	0.14	0.18	0.16	0.41***	0.07	0.20	0.30***	0.10
Mother's working status (ref. not working)	working	-0.07	0.02	-0.06	0.03	0.07	-0.02	0.00	0.07	-0.05	-0.10	0.12	-0.10	-0.08	-0.06	-0.04	-0.00	-0.08
Mother's BMI (ref. thin)	normal	0.25	0.10	0.20	0.24***	0.26	0.02	0.16	0.20	na	0.22	0.18	-0.04	0.25**	0.29***	-0.13	0.23*	0.21
	overweight/ obese	0.41	0.35*	0.43***	0.46***	0.44**	0.15	0.42***	0.37	na	0.15	0.27	0.03	0.44***	0.30**	0.24	0.44**	0.31**
Age of mother at child's birth (ref. 18-34)	<18	-0.62**	-0.47***	-0.34*	-0.46***	-0.36	-0.13*	-1.06***	0.01	-0.19	-0.56**	0.33	-0.48	-0.09	-0.05	-0.33	-0.28	-0.20
	35+	-0.04	0.02	0.03	0.11*	0.35*	0.19***	0.10	0.21	0.11	-0.04	-0.03	0.07	-0.13*	0.01	0.10	0.02	0.04
Birth order of child (ref. 1)	2	-0.07	-0.12	-0.09	-0.00	-0.05	-0.11**	-0.13	-0.23	-0.20*	-0.23	0.24	-0.06	-0.03	-0.06	0.12	-0.10	0.02
	3	-0.04	-0.10	-0.01	-0.11	-0.15	-0.17***	-0.24**	-0.28	-0.02	-0.02	0.36*	-0.04	0.04	0.00	0.07	-0.03	-0.05
	4+	-0.23	-0.41***	-0.02	-0.21***	-0.07	-0.40***	-0.31***	-0.37	-0.18*	-0.18	0.22	-0.19*	0.04	-0.07	0.15	0.14	-0.11
Sex of child (ref. male)	female	-0.02	0.11	0.21***	0.21***	0.18*	0.04	0.25***	0.07	0.15**	0.09	0.22*	-0.02	0.19***	0.18***	0.29***	0.28***	0.18***
Perceived size of child at birth (ref. small)	average	0.35**	0.24**	0.06	0.04	0.37**	0.36***	0.25***	0.62*	0.40***	0.24*	0.47***	0.29***	0.35***	0.01	0.30**	0.22*	0.27**
	large	0.53***	0.38**	0.23*	0.32***	0.70***	0.67***	0.40***	1.32***	0.32***	0.33**	0.67***	0.50***	0.57***	0.10	0.39***	0.32**	0.48***
Observations		760	2,130	3,736	19,471	2,522	8,074	3,353	1,170	4,410	3,234	1,162	3,626	5,341	6,445	1,602	3,958	3,552
R-squared		0.09	0.10	0.03	0.09	0.11	0.28	0.10	0.09	0.05	0.02	0.06	0.03	0.06	0.02	0.07	0.03	0.03

*** p<0.001, ** p<0.01, * p<0.05
na = Information not available

Appendix H

Table H. WAZ linear regressions for 52 DHS surveys (2005-2014)

Variable	Category	Albania	Armenia	Azerbaijan	Bangladesh	Benin	Bolivia	Burkina Faso	Burundi	Cambodia	Cameroon	Colombia	Comoros	Congo Brazzaville	Congo Democratic Republic	Côte d'Ivoire	Dominican Republic	Egypt	Ethiopia
		coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient
Locality by wealth (ref. rural poor)	rural non-poor	0.10	0.04	0.11	0.16***	0.10	0.24***	0.07	0.23***	0.06	0.51***	0.10	0.23*	0.06	0.07	0.19*	0.41***	0.08*	0.18***
	urban poor	-0.06	0.21	0.10	0.05	-0.01	0.17***	0.10	-0.26	-0.08	0.27***	0.00	0.13	0.16	-0.05	0.15	0.03	-0.04	-0.01
	urban non-poor	-0.07	0.13	0.50***	0.33***	0.09	0.42***	0.20**	0.40***	0.34***	0.49***	0.14***	0.17	0.21**	0.39***	0.30**	0.19*	-0.00	0.33**
Education of partner (ref. none/primary)	secondary+	0.14	-0.30	0.12	0.13***	0.05	0.16***	0.03	0.03	0.18***	0.15**	0.05	0.02	0.09	0.12*	0.03	0.05	0.02	0.30***
Education of mother (ref. none/primary)	secondary+	0.10	0.42	0.24	0.24***	0.06	0.08*	0.42***	0.44***	0.08	0.29***	0.16***	0.26**	0.18*	0.13*	0.16	0.09	0.13***	0.43***
Mother's working status (ref. not working)	working	0.17	-0.02	0.12	0.00	0.08	-0.03	0.09*	0.02	-0.10*	0.02	0.04	-0.04	-0.11	-0.08	0.05	0.01	0.03	0.03
Mother's BMI (Ref. thin)	normal	0.20	na	-0.06	0.29***	0.30**	0.36**	0.44***	0.39***	0.24***	0.58***	0.38***	0.45**	0.41***	0.23**	0.58***	0.40***	0.19	0.31***
	overweight/ obese	0.28	na	0.04	0.61***	0.52***	0.60***	0.75***	0.81***	0.38***	1.03***	0.63***	0.63***	0.61***	0.58***	0.87***	0.61***	0.43***	0.80***
Age of mother at child's birth (ref. 18-34)	<18	-0.15	-0.72	0.01	-0.23***	-0.32*	-0.07	-0.16	-0.02	-0.04	-0.31***	-0.17***	-0.40	-0.04	-0.24*	-0.18	-0.14	-0.20	-0.11
	35+	-0.14	-0.22	-0.08	-0.07	0.01	-0.01	0.09	0.00	-0.06	0.01	0.10**	-0.22*	0.11	0.03	-0.05	0.18	-0.01	0.05
Birth order of child (ref. 1)	2	0.01	-0.05	-0.16*	-0.11**	-0.11	-0.13***	-0.12	-0.06	0.00	-0.15*	-0.16***	-0.04	-0.10	0.04	-0.06	-0.18*	-0.07*	0.01
	3	-0.08	0.02	-0.11	-0.15**	-0.11	-0.20***	-0.02	-0.14	-0.04	-0.17*	-0.21***	-0.07	-0.05	0.06	-0.17	-0.08	-0.08*	-0.14*
	4+	-0.36*	-0.21	-0.36**	-0.20**	-0.25***	-0.26***	-0.09	-0.16*	-0.09	-0.24***	-0.39***	-0.04	-0.19	-0.08	-0.09	-0.36***	-0.14***	-0.06
Sex of child (ref. male)	female	0.10	-0.03	0.11	-0.06*	0.23***	0.12***	0.10**	0.17***	-0.01	0.08	0.00	0.13	-0.04	0.14**	0.09	0.06	0.10***	0.14**
Perceived size of child at birth (ref. small)	average	0.19	0.50**	0.46***	0.39***	0.01	0.29***	0.28***	0.32***	0.27***	0.21**	na	0.30**	0.11	0.19*	0.23*	0.27***	0.23***	0.36***
	large	0.41*	0.67***	0.51***	0.60***	0.14	0.69***	0.56***	0.55***	0.53***	0.71***	na	0.15	0.42***	0.50***	0.52***	0.62***	0.40***	0.51***
Observations		1,211	1,224	1,429	7,027	5,814	6,406	5,573	2,736	3,210	3,880	12,756	1,862	3,270	6,064	2,215	2,608	11,980	8,129
R-squared		0.03	0.05	0.10	0.14	0.02	0.16	0.08	0.11	0.09	0.25	0.06	0.06	0.09	0.09	0.08	0.10	0.02	0.10

(Continued…)

Table H. − *Continued*

Variable	Category	Gabon	Gambia	Ghana	Guinea	Guyana	Haiti	Honduras	India	Jordan	Kenya	Kyrgyz Republic	Lesotho	Liberia	Malawi	Maldives	Mali	Mozambique
		coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient
Locality by wealth (ref. rural poor)	rural non-poor	0.22	-0.12	0.06	0.04	0.31*	0.16*	0.32***	0.25***	0.18**	0.13*	0.09	0.15*	0.09	0.02	0.07	0.27***	0.32***
	urban poor	0.08	0.24*	-0.07	0.13	0.17	-0.14	0.21***	0.07	-0.01	0.19	0.16	0.16	-0.09	0.12	-0.15	0.37	0.01
	urban non-poor	0.40***	0.20*	0.26*	0.31***	0.09	0.16*	0.38***	0.34***	0.24***	0.20*	0.06	0.16	0.00	0.18	0.26*	0.33***	0.49***
Education of partner (ref. none/primary)	secondary+	0.01	0.05	0.06	0.11	0.05	0.03	0.13***	0.07***	0.17*	0.26***	-0.01	0.17	0.09	0.03	0.07	0.29**	0.04
Education of mother (ref. none/primary)	secondary+	0.23**	0.35***	0.08	0.28	0.19	0.17*	0.23***	0.25***	-0.04	0.21***	-0.16	0.14	0.15	0.18*	0.17	0.16	0.21***
Mother's working status (ref. not working)	working	-0.09	-0.08	0.01	0.16	0.15	-0.05	-0.01	-0.05**	0.16*	-0.02	0.02	0.00	-0.10	-0.04	-0.08	0.07	0.04
Mother's BMI (Ref. thin)	normal	0.35*	0.22*	0.12	0.43***	0.36*	0.60***	0.37***	0.33***	0.43**	0.48***	0.28**	0.30	0.59***	0.29**	0.41***	0.24**	0.52***
	overweight/ obese	0.75***	0.40***	0.49***	0.55***	0.81***	0.78***	0.62***	0.64***	0.61***	0.76***	0.42***	0.59***	0.93***	0.55***	0.52***	0.54***	0.87***
Age of mother at child's birth (ref. 18-34)	<18	-0.23	-0.00	-0.33	-0.07	-0.28	-0.26*	-0.12*	-0.21***	-0.20	-0.21*	0.07	0.05	-0.22	-0.13	-0.80**	-0.21*	-0.21*
	35+	0.11	-0.05	0.07	0.04	0.19	-0.02	-0.03	-0.00	0.03	0.09	0.01	-0.07	0.02	0.06	0.21	-0.08	0.07
Birth order of child (ref. 1)	2	0.01	0.14	-0.04	0.04	-0.05	-0.12	-0.14***	-0.12***	-0.10	0.01	-0.13*	-0.01	-0.08	-0.01	-0.09	0.00	-0.02
	3	-0.15	0.21*	-0.11	0.03	0.06	-0.24**	-0.19***	-0.20***	-0.24***	-0.09	-0.18**	0.03	-0.23	0.05	-0.23*	0.03	-0.08
	4+	-0.29*	0.10	-0.06	0.04	-0.23	-0.20*	-0.29***	-0.31***	-0.19*	-0.19*	-0.21***	-0.14	-0.15	0.02	-0.39**	-0.00	-0.08
Sex of child (ref. male)	female	0.08	0.10	0.09	0.04	0.12	0.04	0.13***	-0.03	0.01	0.10*	0.03	0.25***	0.18**	0.14**	0.03	0.02	0.17***
Perceived size of child at birth (ref. small)	average	0.26**	0.30***	0.25*	0.40***	0.53***	0.28***	0.43***	0.27***	0.45***	0.45***	0.30***	0.62***	0.19*	0.40***	0.50***	0.15	0.27***
	large	0.54***	0.51***	0.56***	0.58***	0.91***	0.56***	0.79***	0.32***	0.68***	0.72***	0.65***	0.92***	0.67***	0.60***	0.94***	0.25**	0.50***
Observations		1,900	2,491	1,910	2,519	1,054	3,324	8,598	35,933	5,443	4,127	3,519	1,482	2,371	3,810	1,832	3,535	6,841
R-squared		0.14	0.10	0.09	0.07	0.20	0.11	0.20	0.13	0.09	0.15	0.05	0.11	0.12	0.06	0.11	0.05	0.11

Variable	Category	Namibia	Nepal	Niger	Nigeria	Pakistan	Peru	Rwanda	São Tomé and Príncipe	Senegal	Sierra Leone	Swaziland	Tajikistan	Tanzania	Timor-Leste	Uganda	Zambia	Zimbabwe
		coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient
Locality by wealth (ref. rural poor)	rural non-poor	-0.06	0.19*	0.10	0.33***	0.38***	0.15	0.20***	0.02	0.26***	0.08	0.19*	0.20**	0.14**	-0.10*	-0.04	0.08	0.12*
	urban poor	0.02	0.12	-0.08	0.19*	0.09	0.20***	0.02	-0.16	0.21*	0.27*	0.42	0.10	-0.19	-0.10	0.01	0.07	-0.16
	urban non-poor	0.49**	0.33***	0.19*	0.19**	0.19	0.66***	0.40***	0.07	0.32***	0.21*	0.31**	0.21**	0.27***	0.22**	0.19	0.08	0.11
Education of partner (ref. none/primary)	secondary+	0.08	0.01	0.15	0.18***	0.18*	0.08*	0.19**	0.04	0.04	-0.01	0.10	0.37*	0.14	0.11**	0.13	-0.01	0.01
Education of mother (ref. none/primary)	secondary+	0.18	0.27**	0.20	0.31***	0.37***	0.19***	0.20**	0.02	0.28***	0.22**	0.14	0.25*	0.22*	0.07	0.11	0.20***	0.09
Mother's working status (ref. not working)	working	-0.03	0.02	0.02	-0.01	0.03	-0.04	0.06	0.09	-0.02	-0.01	0.06	0.01	0.12*	-0.18***	0.06	-0.03	-0.01
Mother's BMI (Ref. thin)	normal	0.29	0.34***	0.45***	0.32***	0.34**	0.22	0.43***	0.41*	na	0.31**	-0.34	0.25**	0.40***	0.35***	0.25*	0.38***	0.50***
	overweight/ obese	0.56**	0.73***	0.64***	0.64***	0.67***	0.51*	0.78***	0.56**	na	0.35**	-0.11	0.39***	0.65***	0.51***	0.64***	0.65***	0.73***
Age of mother at child's birth (ref. 18-34)	<18	-0.26	-0.20	-0.37***	-0.25***	-0.16	0.01	-0.39*	-0.40	-0.22*	-0.42**	-0.26	-0.15	0.08	-0.20*	-0.38*	-0.27*	-0.19*
	35+	-0.18	0.02	0.04	0.11**	0.16	0.12**	0.02	-0.21	0.12	-0.01	-0.03	0.00	-0.07	0.00	-0.03	0.01	-0.04
Birth order of child (ref. 1)	2	-0.20	-0.14*	-0.09	0.05	-0.12	-0.10*	-0.08	-0.11	-0.07	-0.17	-0.10	0.01	-0.04	0.05	-0.04	-0.09	-0.01
	3	-0.04	-0.22*	-0.12	-0.03	-0.26*	-0.18***	-0.26***	-0.07	-0.00	-0.15	0.05	-0.06	0.05	0.06	-0.16	-0.06	-0.10
	4+	-0.19	-0.43***	-0.20*	-0.19***	-0.09	-0.33***	-0.28***	-0.16	-0.08	-0.17	-0.17	-0.16*	-0.00	0.02	-0.08	-0.00	-0.11
Sex of child (ref. male)	female	0.04	0.09	0.13**	0.15***	0.11*	-0.01	0.14***	0.21*	0.10*	0.11*	0.10	-0.03	0.11***	0.09**	0.13*	0.17***	0.07*
Perceived size of child at birth (ref. small)	average	0.48***	0.34***	0.19***	0.13**	0.35***	0.37***	0.28***	0.65**	0.38***	0.34***	0.35**	0.37***	0.45***	0.07	0.45***	0.38***	0.39***
	large	0.62***	0.61***	0.45***	0.44***	0.62***	0.67***	0.53***	1.18***	0.48***	0.34***	0.62***	0.56***	0.67***	0.23***	0.55***	0.50***	0.66***
Observations		760	2,130	3,736	19,471	2,522	8,074	3,353	1,170	4,410	3,234	1,162	3,626	5,341	6,445	1,602	3,958	3,552
R-squared		0.18	0.16	0.06	0.11	0.15	0.22	0.11	0.09	0.07	0.03	0.09	0.05	0.07	0.05	0.09	0.06	0.09

*** p<0.001, ** p<0.01, * p<0.05
na = Information not available

Appendix I

Table I. WHZ linear regressions for 52 DHS surveys (2005-2014)

Variable	Category	Albania	Armenia	Azerbaijan	Bangla-desh	Benin	Bolivia	Burkina Faso	Burundi	Cambodia	Cameroon	Colombia	Comoros	Congo Brazzaville	Congo Democratic Republic	Côte d'Ivoire	Dominican Republic	Egypt	Ethiopia
		coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient
Locality by wealth (ref. rural poor)	rural non-poor	-0.08	0.34*	0.04	0.05	0.09	0.07	0.06	0.14*	-0.10	0.35***	0.16	0.14	-0.12	0.05	0.10	0.20	-0.09	0.14**
	urban poor	-0.03	0.25	0.08	0.11	-0.08	-0.01	-0.05	-0.09	-0.07	0.23**	-0.05	-0.05	0.03	0.01	-0.20	0.00	-0.15	-0.44
	urban non-poor	-0.08	0.14	0.30	0.19**	0.03	0.05	-0.02	-0.07	0.11	0.27***	0.04	-0.01	-0.10	0.22**	-0.07	0.06	-0.07	0.21*
Education of partner (ref. none/primary)	secondary+	-0.04	-0.25	0.15	-0.02	-0.04	0.08	-0.09	-0.02	0.06	0.06	-0.01	0.07	0.06	-0.08	0.08	-0.00	-0.08	0.19**
Education of mother (ref. none/primary)	secondary+	0.05	0.54*	-0.30	0.18***	0.08	-0.10**	0.23*	0.07	0.10	0.19**	0.08**	-0.03	0.05	-0.02	-0.00	0.03	0.08	0.25*
Mother's working status (ref. not working)	working	-0.01	-0.02	0.16	-0.00	-0.06	0.07	-0.01	0.06	0.01	0.13*	0.06**	-0.26*	-0.02	0.13	0.07	0.05	0.21***	0.08*
Mother's BMI (Ref. thin)	normal	-0.50	na	0.21	0.25***	0.18	0.47***	0.35***	0.43***	0.27***	0.59***	0.44***	0.35	0.36***	0.50***	0.66***	0.32**	0.42**	0.41***
	overweight/ obese	-0.33	na	0.25	0.52***	0.32*	0.74***	0.73***	0.79***	0.49***	1.05***	0.68***	0.42	0.56***	0.75***	0.97***	0.60***	0.58***	0.70***
Age of mother at child's birth (ref. 18-34)	<18	-0.05	-0.67	-0.02	-0.12*	-0.15	-0.06	0.05	-0.13	0.02	-0.12	-0.06	-0.07	0.05	-0.05	0.11	-0.15	0.07	0.14
	35+	-0.09	-0.23	0.10	-0.09	0.16	-0.06	-0.06	-0.06	-0.15*	-0.05	0.04	-0.18	0.00	-0.11	-0.02	0.24	-0.12	-0.04
Birth order of child (ref. 1)	2	0.40*	0.28*	-0.31**	-0.09*	-0.16	-0.08	-0.19*	-0.01	-0.01	-0.16*	-0.11***	-0.04	-0.18*	0.09	0.05	-0.14	-0.04	0.01
	3	0.19	0.24	-0.20	-0.09	-0.16	-0.13*	-0.09	-0.03	0.06	-0.09	-0.17***	-0.04	-0.13	0.15	-0.10	-0.11	-0.10*	-0.07
	4+	-0.09	0.22	-0.41*	-0.11	-0.27**	-0.12*	-0.08	-0.06	0.08	-0.21*	-0.28***	0.04	-0.29**	-0.04	0.02	-0.34**	-0.22***	-0.03
Sex of child (ref. male)	female	0.29*	-0.18	-0.05	-0.00	0.17**	0.08**	0.05	0.07	0.01	0.05	-0.04	0.03	0.00	0.04	0.06	-0.02	0.02	0.16***
Perceived size of child at birth (ref. small)	average	0.12	0.27	0.21	0.29***	0.01	0.18***	0.21**	0.13	0.12	0.22**	na	0.38**	-0.09	0.11	0.14	0.23**	0.10	0.31***
	large	0.00	0.44	0.25	0.49***	0.02	0.38***	0.47***	0.33***	0.31**	0.68***	na	0.35**	0.19	0.33***	0.39***	0.52***	0.31**	0.45***
Observations		1,211	1,224	1,429	7,027	5,814	6,406	5,573	2,736	3,210	3,880	12,750	1,862	3,270	6,064	2,215	2,608	11,980	8,129
R-squared		0.02	0.04	0.03	0.06	0.01	0.04	0.03	0.04	0.04	0.17	0.04	0.02	0.04	0.05	0.05	0.07	0.01	0.08

(Continued…)

Table I. − *Continued*

Variable	Category	Gabon	Gambia	Ghana	Guinea	Guyana	Haiti	Honduras	India	Jordan	Kenya	Kyrgyz Republic	Lesotho	Liberia	Malawi	Maldives	Mali	Mozam-bique
		coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient
Locality by wealth (ref. rural poor)	rural non-poor	0.03	-0.20**	-0.04	0.03	-0.02	-0.03	0.02	0.14***	0.03	0.08	0.02	0.11	-0.03	-0.01	-0.09	0.10	0.21***
	urban poor	-0.16	0.05	-0.16	0.02	-0.20	-0.11	0.05	0.07	-0.12*	-0.13	0.14	0.02	-0.02	0.25*	-0.10	-0.16	0.07
	urban non-poor	-0.03	-0.04	0.06	-0.03	-0.12	-0.06	0.09*	0.16***	-0.05	0.12	-0.00	0.07	-0.17	0.15	0.08	-0.05	0.31***
Education of partner (ref. none/primary)	secondary+	0.02	-0.06	0.04	0.09	0.11	0.01	0.06	0.01	0.10	0.11	0.64*	0.00	0.06	-0.05	0.06	0.05	-0.09
Education of mother (ref. none/primary)	secondary+	0.17	0.19	0.05	0.03	-0.11	0.07	0.10*	0.09***	-0.18	0.20**	-0.35	0.15	-0.01	0.13	0.26**	0.20	0.04
Mother's working status (ref. not working)	working	-0.16*	0.05	0.01	0.13	0.04	0.01	0.04	-0.03	0.14*	-0.02	-0.02	-0.03	0.01	0.07	-0.24**	0.10	0.04
Mother's BMI (Ref. thin)	normal	0.33*	0.27*	0.24	0.36***	0.37*	0.59***	0.42***	0.32***	0.43*	0.54***	0.29*	0.20	0.38**	0.29*	0.46***	0.23**	0.49***
	overweight/ obese	0.68***	0.51***	0.41*	0.50***	0.75***	0.75***	0.64***	0.61***	0.68**	0.79***	0.49***	0.45	0.61***	0.42**	0.66***	0.44***	0.76***
Age of mother at child's birth (ref. 18-34)	<18	-0.04	-0.12	0.28	0.05	-0.15	0.04	-0.01	0.03	-0.17	-0.18	0.06	-0.16	0.07	-0.23	-1.15***	0.04	-0.06
	35+	-0.11	0.03	0.05	-0.03	0.10	-0.04	-0.07	-0.05	0.00	0.09	-0.14	-0.10	-0.02	0.09	0.20	-0.04	0.03
Birth order of child (ref. 1)	2	0.03	-0.02	-0.12	0.10	-0.09	0.02	-0.09*	-0.06**	-0.15*	0.03	-0.09	0.06	-0.03	-0.13	-0.15	0.13	-0.10
	3	-0.17	0.01	-0.01	0.03	0.02	-0.17	-0.11*	-0.08**	-0.14	-0.11	-0.19**	0.01	-0.11	-0.11	-0.27*	0.12	-0.15*
	4+	-0.13	-0.17	-0.15	0.03	-0.13	-0.04	-0.14**	-0.15***	-0.19**	-0.13	-0.05	-0.13	-0.04	-0.14	-0.33*	0.09	-0.18*
Sex of child (ref. male)	female	-0.06	0.04	0.05	-0.07	0.13	0.00	0.05	0.04*	-0.03	0.08	-0.08	0.08	0.04	-0.05	-0.01	0.03	0.09*
Perceived size of child at birth (ref. small)	average	0.07	0.32**	0.13	0.36***	0.50***	0.27***	0.19***	0.24***	0.26***	0.35***	0.02	0.48***	0.21*	0.21**	0.24*	0.14	0.17*
	large	0.32**	0.33***	0.48***	0.54***	0.82***	0.54***	0.42***	0.28***	0.48***	0.58***	0.24*	0.79***	0.55***	0.26**	0.63***	0.25**	0.36***
Observations		1,900	2,491	1,910	2,519	1,054	3,324	8,598	35,933	5,443	4,127	3,519	1,482	2,371	3,810	1,832	3,535	6,841
R-squared		0.06	0.04	0.04	0.03	0.10	0.07	0.06	0.05	0.05	0.09	0.02	0.06	0.05	0.02	0.07	0.02	0.04

Variable	Category	Namibia	Nepal	Niger	Nigeria	Pakistan	Peru	Rwanda	São Tomé and Príncipe	Senegal	Sierra Leone	Swaziland	Tajikistan	Tanzania	Timor-Leste	Uganda	Zambia	Zimbabwe
		coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient	coefficient
Locality by wealth (ref. rural poor)	rural non-poor	0.01	-0.07	0.09	0.05	0.10	-0.01	0.04	-0.43*	0.07	-0.03	0.10	0.13	0.06	-0.18**	0.13	0.05	0.11*
	urban poor	0.19	-0.28*	0.62	-0.10	-0.08	0.01	-0.22	-0.07	0.06	0.03	0.31	-0.00	-0.16	-0.09	-0.13	-0.08	-0.03
	urban non-poor	0.46**	-0.08	0.01	-0.21**	-0.07	0.32***	-0.12	-0.14	0.16**	-0.05	0.10	-0.04	0.05	-0.02	0.11	-0.05	0.04
Education of partner (ref. none/primary)	secondary+	-0.13	-0.07	-0.00	0.11**	0.08	-0.00	0.01	-0.07	-0.04	0.03	0.04	0.41	-0.04	0.09	-0.11	-0.02	0.06
Education of mother (ref. none/primary)	secondary+	0.27*	0.20*	-0.02	0.04	0.04	0.00	-0.02	-0.01	0.23**	0.15	0.03	0.22	-0.04	0.00	-0.04	0.02	0.02
Mother's working status (ref. not working)	working	0.01	-0.04	0.07	-0.04	-0.04	-0.05	0.08	0.01	-0.01	0.06	-0.01	0.08	0.21***	-0.22***	0.13	-0.05	0.03
Mother's BMI (Ref. thin)	normal	0.21	0.41***	0.52***	0.27***	0.30**	0.32	0.48***	0.50**	na	0.26*	-0.63	0.42***	0.39***	0.28***	0.49***	0.34***	0.56***
	overweight/ obese	0.49**	0.77***	0.59***	0.53***	0.65***	0.64***	0.78***	0.57*	na	0.37*	-0.37	0.57***	0.60***	0.48***	0.77***	0.56***	0.81***
Age of mother at child's birth (ref. 18-34)	<18	0.20	0.14	-0.24*	0.02	0.12	0.11	0.40**	-0.59	-0.15	-0.15	-0.58**	0.26	0.21*	-0.28	-0.30*	-0.13	-0.13
	35+	-0.20	0.06	0.05	0.09*	-0.05	0.01	-0.05	-0.49**	0.09	0.03	-0.02	-0.02	0.01	-0.01	-0.17	-0.02	-0.10
Birth order of child (ref. 1)	2	-0.23	-0.12	-0.04	0.09	-0.08	-0.07	0.00	0.01	0.06	-0.07	-0.33*	0.07	-0.03	0.12	-0.14	-0.04	-0.05
	3	0.00	-0.24*	-0.16	0.05	-0.22*	-0.14**	-0.14*	0.12	-0.00	-0.21	-0.20	-0.04	0.02	0.08	-0.27*	-0.04	-0.11
	4+	-0.11	-0.29**	-0.28**	-0.11*	-0.09	-0.16**	-0.12*	0.11	0.02	-0.11	-0.39**	-0.10	-0.04	0.06	-0.22*	-0.10	-0.05
Sex of child (ref. male)	female	0.12	0.09	0.08	0.10***	0.09	-0.05	0.01	0.28*	0.06	0.14*	-0.02	-0.00	0.01	0.10*	-0.03	0.05	-0.02
Perceived size of child at birth (ref. small)	average	0.39**	0.28***	0.19***	0.14**	0.14	0.23***	0.17**	0.25	0.21***	0.31**	0.11	0.27**	0.32***	0.05	0.37***	0.35***	0.31***
	large	0.43**	0.52***	0.42***	0.35***	0.26*	0.39***	0.40***	0.49	0.41***	0.23*	0.32**	0.38***	0.44***	0.22**	0.42***	0.46***	0.52***
Observations		760	2,130	3,736	19,471	2,522	8,074	3,353	1,170	4,410	3,234	1,162	3,626	5,341	6,445	1,602	3,958	3,552
R-squared		0.11	0.09	0.04	0.02	0.04	0.08	0.04	0.04	0.03	0.01	0.04	0.03	0.03	0.02	0.06	0.02	0.06

*** p<0.001, ** p<0.01, * p<0.05
na = Information not available