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Evaluation of Indicators to Monitor Quality of Anthropometry Data during Fieldwork

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2019 No. 162

DEMOGRAPHIC AND HEALTH SURVEYS

September 2019

This document was produced for review by the United States Agency for International Development.

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September 2019

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Acknowledgments: The authors acknowledge the contribution of Mianmian Yu for providing the raw DHS dataset files used for the analyses in this paper. The authors also wish to thank Ashley Aimone, Diego Bassani, Nandita Perumal, Huma Qamar, and Daniel Roth for the development of the anthropometry data quality score that was modified for use in this paper and the UNICEF-WHO Anthropometry Data Quality Working Group for their work developing global indicators of anthropometry data quality. Thanks also to Lindsay Mallick for consideration of the methodology and PCA interpretation. We are grateful for Wenjuan Wang's thorough and thoughtful review and insightful comments. The authors also acknowledge Erin Milner and Jeniece Alvey from USAID for their support of our work and input on anthropometry data quality.

Editor: Diane Stoy and Cathy Johnson
Document Production: Chris Gramer and Joan Wardell

This study was implemented with support provided by the United States Agency for International Development (USAID) through The DHS Program (#720-OAA-18C-00083). The views expressed are those of the authors and do not necessarily reflect the views of USAID or the United States Government.

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Recommended citation:

Allen, Courtney K., Trevor N. Croft, Thomas W. Pullum, and Sorrel M. L. Namaste. *Evaluation of Indicators to Monitor Quality of Anthropometry Data during Fieldwork*. DHS Working Paper No. 162. Rockville, Maryland, USA: ICF.

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ACRONYMS AND ABBREVIATIONS

CAPI	computer-assisted personal interviewing
DHS	Demographic Health Survey
HAZ	height-for-age z-score
MICS	Multiple Indicator Cluster Survey
PCA	principal component factor analysis
SDG	Sustainable Development Goal
WAZ	weight-for-age z-score
WHO	World Health Organization
WHZ	weight-for-height z-score

ABSTRACT

Background: High-quality data on stunting (height-for-age (HAZ) < -2SD) and wasting (weight-for-height (WHZ) < -2SD) are critical to inform country and global decision-making on nutrition policy and programming. Yet, anthropometry assessment in field settings remains a challenge, and tools are needed to improve data collection. We sought to evaluate the capability of anthropometric data quality indicators to assess survey teams' performance during fieldwork.

Methods: A total of 26 data quality indicators were identified for height, weight, and date of birth data. Two target levels for each indicator were established by taking the lowest 25th and median of 147 Demographic and Health Survey (DHS) surveys. We applied the indicators to six recent DHS surveys. Data quality indicators were summarized, and Pearson's correlation coefficients were calculated between teams using cumulative data across the survey period. Patterns of performance over time were examined by calculating the quarterly HAZ implausible values and standard deviations by team. Principal component factor analysis (PCA) was used to generate a composite anthropometry data quality score in order to rank each team's performance.

Results: Thirteen of the 26 data quality indicators were retained, with those related to HAZ and WHZ z-scores being particularly useful. There was a wide range in the teams' implausible HAZ and WHZ anthropometry z-scores (HAZ: range 0-17%, WHZ: 0-19%) and standard deviations (HAZ: range 0.97-2.54, WHZ: 0.94-2.35) across surveys. These indicators also tended to contribute the greatest to the PCA factor loading for the PCA using height and weight indicators in the four lowest-performing surveys (ranging from 0.28 to 0.49 for HAZ implausible, 0.35 to 0.47 for WHZ implausible, 0.25 to 0.43 for HAZ SD, and 0.13 to 0.37 for WHZ SD). The HAZ interval, used to capture date of birth quality, showed some teams achieving the expected near-zero HAZ z-score, but reached as high as a z-score of 1.86. There were inconsistent factor loadings across surveys for the PCA that used date of birth indicators. The targets we constructed based on the median performance of 147 surveys were 0.7% for HAZ implausible, 1.6%, for WHZ implausible, 1.59 for HAZ SD, 1.30 for WHZ SD, and 0.25 for HAZ interval. There was no clear pattern in improvements or degeneration as fieldwork progressed based on HAZ implausible values and HAZ SD.

Conclusion: In the present study, we found anthropometry data quality indicators can be used to detect poorly performing teams during fieldwork. Further research should link data quality indicators to the outcomes of interest (stunting and wasting) to enhance monitoring practices.

Key words: anthropometry, data quality, demographic and health surveys, evaluation, monitoring, population-based surveys, real-time data collection

1 INTRODUCTION

Anthropometric data provides the magnitude and distribution of malnutrition in a country. The data are also used to track global targets such as Sustainable Development Goal (SDG) 2, which calls for ending all forms of malnutrition by 2030. Anthropometry data are typically obtained through population-based household surveys. The Demographic and Health Surveys (DHS) Program is one of the most long-standing entities collecting anthropometry data in low- and middle-income countries. As of late 2019, The DHS Program has collected height and weight data in 238 surveys in 77 countries from children and adults since 1985 (ICF 2012). The data collection methods have continuously been aligned with global standards to allow for comparability over time and across countries.

Obtaining high-quality anthropometric data for children in field settings is difficult. Children grow quickly and small errors can result in the misclassification of a child's nutritional status. Further, several inputs (height, weight, sex, and date of birth) are required to calculate anthropometry z-scores, which means the measurement error contributed by each component is compounded compared to that in a single measure. Careful monitoring of anthropometry data collection during fieldwork is vital. Use of electronic data collection provides an opportunity for real-time data quality assessment during fieldwork, rather than waiting for large amounts of data to accumulate before detecting problems. Because nationally representative surveys implemented under The DHS Program or similar survey programs such as UNICEF's Multiple Indicator Cluster Surveys (MICS) are large and include many topics, the length of data collection for a survey ranges from 4 to 6 months or more. This makes use of monitoring technologies particularly useful.

In The DHS Program, the primary monitoring tool used during data collection are field check tables. These field check tables include summary outputs of recently collected data that reflect team performance by various measures of data quality. A total of 41 standard DHS field check tables have been developed that describe data across the variety of topics in a DHS Survey including anthropometry data (Arnold and Khan 2018). The tables are generated periodically and often weekly, and are reviewed by staff from The DHS Program and the host country. The host country provides feedback about any data quality issues to the teams through the team supervisor. Similar tools are used by other surveys programs, such as in the MICS.

In a recent report on the enhancement of nutrition data collected in The DHS Program, key informants identified field check tables as crucial for facilitating data quality during the survey process, and also acknowledged a need for improvement (Namaste, Benedict, and Henry 2018). Informants found receiving information by team allowed for the identification of patterns and performance issues while the teams are still in the field. The informants reported that use of the field check tables mitigates the challenges of being unable to be on the ground in all areas of fieldwork at one time, and also provides insight into data collection procedures in remote and insecure environments. However, the existing field check tables used by The DHS Program can be unwieldy and difficult to interpret. To be effective, field check tables should be manageable and capable of providing insightful information.

Previous work has assessed the quality of the anthropometric data post-survey (Assaf, Kothari, and Pullum 2016; Corsi, Perkins, and Subramanian 2017; Grellety and Golden 2016). This work supports the interpretation and use of malnutrition estimates. However, there has been little research that evaluates the quality of data during data collection in order to increase the accuracy of malnutrition estimates. Research is needed to advance the content and interpretation of field check tables in The DHS Program, with potential relevance for other major survey platforms collecting anthropometry data.

Using de-identified, un-recoded field data of completed DHS surveys, we mimic the processes used to monitor data during fieldwork to answer five questions:

1) What indicators can be used to assess anthropometry data quality during fieldwork?

2) Are any anthropometry data quality indicators redundant in the assessment of anthropometry data quality and team performance during fieldwork?

3) What are meaningful thresholds for each anthropometry data quality indicator that can be used as a target for teams during fieldwork?

4) Can we detect poorly performing teams using data quality indicators during fieldwork?

5) Is the level of data quality consistent over time during fieldwork?

Improving monitoring tools for anthropometry data collection will create a more sensitive lens to capture data quality issues early and to improve the quality of the data used to monitor child growth and malnutrition.

2 DATA AND METHODS

2.1 Data

The study included the most recent DHS survey in six countries (Chad, Egypt, Ethiopia, Guatemala, Nepal, and Nigeria) conducted in DHS phase 7 (2013-18, n=40 surveys) (see Table 1). The survey selection was driven by the goal of including countries with varying degrees of data quality. A previously developed stunting data quality composite score was used to characterize the quality of anthropometry data of DHS surveys (Perumal et al. Under-review). This score ranked 145 DHS surveys conducted from 2000 to 2018, and then categorized the surveys that occurred between 2013 and 2018 into high- and low-performing surveys. From these groups, we selected two high-performing and four low-performing surveys. This selection allowed for insights on the performance of the field check table indicators in surveys of varying quality while also emphasizing the countries that may benefit the most from the detection of data quality issues during field operations. In addition, geographic region was considered in the selection of surveys to allow for the inclusion of several world regions in both Anglophone and Francophone countries.

Table 1 Summary of DHS surveys included in analysis

	Guatemala	Nepal	Ethiopia	Chad	Egypt	Nigeria
Year	2015	2016	2016	2015	2014	2013
Mode of survey[1]	CAPI	CAPI	CAPI	CAPI	CAPI	Paper
Sample size[2]	12,567	2,428	10,552	10,854	13,601	26,190
Sample all or subsample[3]	all	sub	all	sub	all	all
PCA ranking (out of 145 surveys)[4]	4	8	98	107	122	130
SECA model used for weighing children[5]	874	878U	878	878	878	874
Number of interviewing teams[6]	17	16	33	26	14	37
Days of fieldwork[7]	265	226	153	177	78	157
Prevalence of stunting (%)[8]	47%	36%	39%	41%	24%	39%
Prevalence of wasting (%)[8]	0.8%	10%	9%	13%	9%	18%
Prevalence of underweight (%)[8]	12%	27%	24%	30%	7%	31%

[1] Collection method for household and women's questionnaire; anthropometry data is recorded using a paper-based biomarker questionnaire in all surveys. Computer-assisted personal interviewing (CAPI).
[2] Number of children that were measured.
[3] Data collected on children in all households selected in cluster or in a subsample of households in the cluster.
[4] Principal-Component Analysis (PCA) score is based on previous ranking of 145 DHS surveys from 2000-2018 (Perumal et al. Under-review).
[5] Type of scale that was used during data collection to collect a child's weight.
[6] Teams were identified by the supervisor number recorded for each case.
[7] Days of fieldwork are a count of total days from first interview recorded to last interview recorded.
[8] Prevalence is a weighted estimate.

Data from The DHS Program is produced in both a raw and recode format. Raw data files include data as they were collected, without structural changes and variable recoding. The recode data, which are easier to use with a standardized format across countries, are more generally used by the public. The survey data from the six countries designated for this study will be in their raw form—a relatively un-recoded form of collected information that would be representative of what appears in field check tables during data collection. In addition to our goal of imitating the field check tables during the survey process, the raw data allow for examination of an un-recoded format of the data. This is particularly useful when examining weight data. The scales used in country record weight in kilograms including either a hundredth decimal place restricted to the digits 0 or 5 (scale model 874 SECA), which are rounded in the recode format or a hundredth decimal place restricted to the digit 0 (scale model 878 SECA). Using raw data, we can estimate the prevalence of incorrect weight digits outside of the expected 0 or 0 and 5, which would be impossible values for weight using these scales.

Additionally, we used recoded DHS survey datasets to perform a step in our analysis that centers on creating standard thresholds for the data quality indicators. We selected DHS surveys between 2000 and the public release of data as of August 2019 that include anthropometry data for children age 0-59 months, and where the sample design included all children in the surveyed households eligible for anthropometric assessment. Surveys were included if the anthropometry data was excluded from the final report for data quality reasons but retained in the publicly available dataset (Benin 2012; Jordan 2007). A total of 147 DHS surveys were included, with the majority from sub-Saharan Africa (n=84), followed by Latin America and the Caribbean (n=21), South Asia (n=13), Middle East and North Africa (n=11), Europe and Central Asia (n=10), and East Asia and Pacific (n=8).

2.2 Methods

2.2.1 Data Quality Indicators

We identified 26 potential indicators that could measure anthropometry data quality during fieldwork. This selection was based on common DHS practices and the existing literature on survey quality assessment (see Table 2) (Arnold and Khan 2018; WHO/UNICEF 2019). These indicators that capture data quality related to the components of the anthropometry indicators can broadly be broken into two groups—measures of height and weight and measures of date of birth. All indicators were calculated for the six selected surveys and were restricted to children under age 60 months. Both de jure and de facto children were included in our calculations because there is no filtering of children out of the field check tables. Table 2 contains the 26 data quality indicators, their definitions, and denominators.

2.2.2 Height and Weight Measures

Implausible values and distribution of nutritional indices

For the major nutritional indices—height-for-age (HAZ), weight-for-age (WAZ), and weight-for-height (WHZ)—the WHO igrowup Stata macro was used to construct indicators based on the WHO 2006 growth standards (WHO 2011). Adjustments were made if the incorrect method of height measurement was used. If a child was between age 9 and 24 months and was reportedly measured standing, 0.7 cm was added to their height. Additionally, if a child over age 2 was reportedly measured lying down, 0.7 cm was subtracted from their recorded height. Height adjustments deviated slightly from the standard WHO igrowup Stata macro when a child under 9 months of age was reportedly measured standing and no height adjustment was made under the assumption that a child at that age was likely to be measured lying down (WHO/UNICEF 2019).

Implausible values are defined as anthropometry data that are flagged using the 2006 WHO recommended flagging system that assesses data quality (WHO/UNICEF 2019). Flagged cases are values considered to be biologically incompatible with life for a child given their age and sex, and, are almost certainly a measurement error. Flagged values were calculated using the WHO igrowup Stata macro. Some values that the WHO igrowup Stata macro excludes before calculating z-scores were included in our denominator of the percentage of implausible values using the previously mentioned height adjustments (WHO/UNICEF

2019). These included children whose height or length was outside the ranges of 45-110 cm for children younger than 24 months and 65-120 cm for children 24 months and older.

After z-scores were obtained for the nutritional indices, and flagged values removed, three further indicators were constructed to describe the distribution of these indices: standard deviation, skew, and kurtosis. Standard deviation was used to describe the variation of HAZ, WAZ, and WHZ. Standard deviation, a measure that quantifies the observed variance, has greater values with the greater spread of HAZ, WAZ, WHZ values, and the more likely measurement error is contributing to this variance (WHO/UNICEF 2019). Skew and kurtosis were used to capture the symmetry and shape of HAZ, WAZ, and WHZ. Skew is the degree and direction of asymmetry in reference to a normal distribution. A skew of zero is symmetrical, and generally acceptable values of skew are between negative 0.5 and 0.5. These values represent data that are skewed compared to a normal distribution. Right-skewed data have a positive skew value and describe data that have more extreme cases in the right rather than the left tail of the distribution. Left-skewed data have a negative skew value with more extreme cases in the left tail. Kurtosis is the tailedness of the distribution. A kurtosis of 3 represents a normal distribution, while greater values represent a distribution with heavier, longer tails. Values less than 3 describe data with light tails, which is an absence of outliers. Generally acceptable values are between 2 and 4.

Digit preference and accuracy of measurement recording

Digit preference was measured using an index of dissimilarity, which is calculated as one-half of the sum of absolute differences between the observed and expected percentage as seen in Equation 1 (WHO/UNICEF 2019). The index of dissimilarity was calculated for the final digit of height (digits 0-9) and is referred to hereafter as the height index. If all digits occurred in a uniform distribution, each digit would be expected to occur 10% of the time. An index of dissimilarity was also calculated for the tenths digit of weight (hereafter weight index). This was the second to final digit, because the final digit of weight is restricted to 0 or 5 by the scale used in fieldwork. In addition, a heaping indicator was constructed examining recorded height measurements with the final digit 0 or 5. During fieldwork, a measurer reads the value from a ruler and may have the tendency to round up or down, as opposed to weight which is read directly from the scale and may have digit preference on any number. Since 0 and 5 are two of ten digits that could occur, the expected percentage of occurrence is 20%. An index of dissimilarity is characterized by a percent, which can be interpreted as the percent of values that would need to be redistributed in order to achieve uniform distribution. Digit preference indicators are useful because they can indicate lack of precision or data fabrication.

Equation 1:

$$Index\ of\ dissimilarity = \sum abs\ (actual\ percentage - expected\ percentage)/2$$

Lastly, the prevalence of incorrect weight digits was examined by calculating the percentage of incorrect values in the final digit (the hundredths place) of weight. With the SECA model 874, there should always be a 0 or 5 in the final digit because the specification of the scale is a graduation of 50 grams. For the SECA model 878, there should always be a 0 for the final digit because the graduation is 100 g. The prevalence of incorrect weight digits may indicate carelessness or data fabrication.

Measurement procedure and incompleteness

Height should be measured when a child is lying down and not standing if the child is younger than age 2. An indicator was constructed for the prevalence of incorrect method of measurement—a child measured lying or standing when the opposite was appropriate.

There were three indicators constructed to measure data incompleteness. The two indicators that reflect a height measurement without weight or weight measurement without height can identify interviewing teams that experience a high occurrence of incomplete interviewing or refusals. Finally, measurement incompleteness was estimated for any child who should have a height and weight measurement but had only one or neither of these measurements recorded.

2.2.4 Date of birth measures

Date preference

Digit preference for date of birth indicators was constructed also using an index of dissimilarity. This index was created for the spread of numbers reported for day of birth and month of birth characterized by the percentage of cases that would need to be redistributed to achieve a uniform distribution (see Equation 1) (WHO/UNICEF 2019).

The day of birth index only examined days 1-30, with each day having an expected occurrence of 3.33%. Days that go beyond 30 have fewer births in the population and would exclude relatively few cases. Since Nepal and Ethiopia do not follow Gregorian calendars, only examining days 1-30 excludes no cases in Ethiopia (the first 12 months in Ethiopia's year have 30 days each) and few in Nepal (months in Nepal have 31 or 32 days). The month of birth index only examined months 1-12, which excludes no months in Nepal and only one month in Ethiopia. Pagumiene, the 13th month in Ethiopia, consists of only 5 or 6 days, and excluding this month should exclude relatively few cases.

The difference in the mean HAZ or mean WAZ between children who were born in December and those born in January was examined to highlight misreporting of the month of birth. Children who are born early in the year and are assigned later birth months, or children born later in the year who are assigned earlier birth months, are likely to appear too tall or short for their age. Random month of birth misreporting can have nonrandom effects on nutritional indices, which is known as the calendar-year artifact. This is characterized by increasing values of HAZ or WAZ by birth month throughout the year with a large gap between December and January. A random or quasi-random relationship between month of birth, HAZ, and WAZ would be expected if there are no peaks in specific months, thus surveys with a larger range of HAZ or WAZ may be indicative of poor date of birth information (Larsen, Headey, and Masters 2019) . This gap would be expected between the first and last month of the year, regardless of the calendar system. Although the two indicators, the HAZ and WAZ interval, refer to a December-January gap, this is the twelfth and the first month in a country's calendar system (the Nehasa-Meskerem gap in Ethiopia and Chaitra-Baisakh gap in Nepal).

Date incompleteness

The incompleteness of date of birth reporting was captured for cases with a complete day, month, and year of birth, and for cases with just the month and year of birth (WHO/UNICEF 2019). Although day of birth can be imputed when calculating HAZ and WAZ, a missing day of birth can reflect the overall data of birth quality. Thus, we included both completeness indicators (WHO 2019).

Table 2 Summary of anthropometry data quality indicators

Indicators	Definition	Population (children <60 months)
Height and Weight Indicators		
Implausible HAZ, WAZ, WHZ values	Percent of flagged anthropometry values that are implausible according to WHO flagging conventions: – HAZ < -6 or > 6 – WAZ < -6 or > 5 – WHZ < -5 or > 5	Children with complete month and year of birth and have height and weight measurements.
Standard Deviation of HAZ, WAZ, WHZ	Amount of variation in HAZ, WAZ, WHZ.	Children with complete month and year of birth and have height and weight measurements. Excluded WHO flagged anthropometry values.
Skewness of HAZ, WAZ, WHZ	Symmetry of the HAZ, WAZ, WHZ in reference to a normal distribution.	Children with complete month and year of birth and have height and weight measurements. Excluded WHO flagged anthropometry values.
Kurtosis of HAZ, WAZ, WHZ	Extent of the tails of the distribution of HAZ, WAZ, and WHZ in reference to a normal distribution.	Children with complete month and year of birth and have height and weight measurements. Excluded WHO flagged anthropometry values.
Height index	Nonuniform distribution of the final digit (0-9) of the recorded height measurement.	Children with a recorded height.
Height heaping	Unexpected percentage of cases with a final digit for height that is 0 or 5 that would need to be redistributed to achieve the expected percentage.	Children with a recorded height.
Weight index	Nonuniform distribution of the digit (0-9) to the digit right of the decimal place of recorded weight measurement.	Children with a recorded weight.
Incorrect weight digit	Final digit not 0 or 5 (SECA model 874) or not 0 (SECA model 878) of the recorded weight measurement.	Children with a recorded weight.
Only height measured	Percent of children whose height was measured and no weight was measured.	All children eligible to be measured.
Only weight measured	Percent of children whose weight was measured and no height was measured.	All children eligible to be measured.
Measured incorrectly	Percent of children measured lying when the child should have been standing or measured standing when should have been lying; age calculated in days.	All children eligible to be measured.
Measured incompleteness	Percent of children whose height and weight were not recorded.	All children eligible to be measured.
Date of Birth Indicators		
Day of birth index	Nonuniform distribution of the reported day of birth (0-30). Birthdates that occur on the 31st day of the month or excluded as these will not occur uniformly.	Children with recorded day of birth if born on days 1-30 of the month.
Month of birth index[1]	Nonuniform distribution of the reported month (1-12) of birth.	Children with recorded month of birth if born in months 1-12 of the year.
HAZ interval[1]	Difference in the mean HAZ between children born in January and December (or the 1st and 12th month of the country's calendar system).	Children born in the first or twelfth month and have recorded height and age. Excluded WHO flagged anthropometry values.
WAZ interval[1]	Difference in the mean WAZ between children born in January and December (or the 1st and 12th month of the country's calendar system).	Children born in the first or twelfth month and have recorded height and weight. Excluded WHO flagged anthropometry values.
DMY of birth incompleteness	Percent of children without a reported day, month, and year recorded.	All children.
MY of birth incompleteness	Percent of children without a reported month and year recorded.	All children.

Note: Abbreviations include SD, standard deviation; HAZ, height-for-age; WAZ, weight-for-age; WHZ, weight-for-height; DMY, day month year; MY, month year.

[1]Days and months are recorded in the Nepali and Ethiopian calendar in those countries.

3 ANALYSIS

Stata version 15.0 was used for all statistical analyses. Complex survey design was not considered when calculating data quality indicators to allow each case to have an equal weight. The Taylor linearization method was used for estimating the prevalence of stunting, wasting, and underweight.

3.1 Individual Indicators and Indicator Redundancy

To understand the indicators and their variance among countries with differing quality of data, each indicator was calculated by team and the median, min, and max among teams were assessed. Teams are constructed using the supervisor number recorded for each case during fieldwork. Team values were not shown if any team did not have at least 25 cases.

Redundancy was assessed in order to refine field check tables so that they consist of useful and telling indicators. To explore redundancy of the data quality indicators among teams, we assessed the strength of association by using Pearson's correlation coefficients to assess the indicators among teams in the six study countries. We used a commonly used threshold coefficient of |0.7| to indicate meaningful correlations.

3.2 Indicator Targets

Targets are needed for any indicator monitored during fieldwork. Ideally, global standards would be used to set thresholds. However, global standards were only available for the percentage of implausible anthropometry z-scores (HAZ, WAZ, WHZ) (WHO/UNICEF 2019). In such cases where global standards are not available, we relied on external data from DHS surveys to set the standard of performance. We used 147 DHS surveys that collected anthropometry data from 2000-19 to create two targets, Targets A and B, which reflect the indicator as performed in the top 25th percentile (Target A) and the 50th percentile (Target B). Because the 26 indicators are characterized by high values reflecting worse quality than low values, the 25th percentile of surveys had higher quality values than the 75 percent of the surveys. Given the lack of global values, the two targets allowed for two tiers of quality standards, which offered a less severe approach.

3.3 Quality Summary Measures

Field check tables may become cumbersome with too many indicators, which make it difficult to monitor quality. To understand if there are advantageous ways of summarizing indicators in a way that demonstrates the overall data quality, we used a similar approach to a previously developed composite score of anthropometric data quality (Perumal et al. Under-review). In this previous work, PCA was used to rank the quality of anthropometry data across surveys. Instead of ranking surveys, we used PCA to rank teams using data quality indicators as performance measures. The use of PCA reduced our data without losing variance. This approach has the potential to provide an assessment of a team's overall anthropometry performance in the field check tables. Two PCAs were carried out on team level data to first analyze the height and weight indicators, and then the date of birth indicators. After estimating component coefficients based on real team data for each survey, scores were predicted for all teams with the addition of two mock teams, whose data were simulated: the Target Team and the Perfect Team. The Target Team had data points equal to the minimum targets set by Target A or Target B, while the Perfect Team had maximally perfect scores. The two mock teams allowed us to observe where real teams are ranked against a team with minimally acceptable values and a team with perfect values, making relative team rankings more interpretable. Because there are two Target Teams (Target A Team, Target B Team), scores were predicted for either the Target A Team or Target B Team based on whether they were binned as high or low data quality score (refer to Table 1 summary of study countries).

3.4 Team Performance

We also present team performance among all indicators. By assessing the 20 height and weight measures in each country, we display which teams did not meet Target A or Target B for each indicator. We compare these team performances with the rankings from the PCA to understand which teams the PCA ranked above and below the mock target teams. This is also done for the six date of birth indicators.

Finally, we describe two select indicators—the standard deviation and implausible values of HAZ—by performance throughout the progression of the survey. Ideally, indicators should be examined weekly, because field check tables can be produced weekly. However, a lack of sufficient cases may prevent this kind of examination. The pace and sample size of every survey is different, and some surveys may have few cases on a weekly basis. This creates unstable, unreliable estimates of the data quality indicators by team. Therefore, each survey was split into quarters by days of fieldwork. All quartiles do not have the same number of cases, and cases were kept in the same quartile if they were recorded on the same day. By examining these indicators in each quarter, we describe how many quarters each team met targets and the percent of teams whose cumulative indicator values met the targets.

4 RESULTS

4.1 Individual Indicators

The 26 indicators were calculated by survey teams. These teams' values in each country are summarized in Table 3. The percent of implausible values for HAZ, WAZ, and WHZ showed little or no variation in Guatemala, with median values at 1% or less, and to a lesser extent in Nepal as well. The WAZ implausible was low in all surveys, ranging from 0-2.2%. The range of values was widest for the percent of implausible values for HAZ and WHZ in Egypt (HAZ: 0.2-9.6%, WHZ: 0.6-27.2%) and Nigeria (HAZ: 0.9-17.3%, WHZ: 0.9-19.1%), though the range of implausible values was still notable for Ethiopia (HAZ: 0-4.6%, WHZ: 0-4.3%) and Chad (HAZ: 0.3-7%, WHZ: 0.6-6.4%).

The median standard deviation of HAZ was greater than the standard deviation for WAZ or WHZ in every country. The ranges of standard deviation of HAZ varied greatly. For example, Guatemala's range of values did not overlap the range of values in Chad, Egypt, and Nigeria (median ranged from 1.19 in Guatemala to 1.94 in Egypt). Compared to HAZ, the range of values for the standard deviation of WAZ is narrower in Guatemala, Nepal, Ethiopia, and Nigeria, although similar or wider in Chad and Egypt. The minimum and maximum values of the standard deviation of WAZ were always lower than those for HAZ, except for Guatemala. The median, minimum, and maximum values for the standard deviation of WHZ were lower than the corresponding values of HAZ in every country (WHZ median ranged from 1.00 in Guatemala to 1.64 in Egypt). There was a consistent pattern of wider standard deviations for the anthropometry z-scores with higher percentages of implausible anthropometry z-score values.

The values for the skewness of the data are expected to range from -0.5 to 0.5 for symmetrical data. The median values for the skewness of HAZ, WAZ, and WHZ were within this range for every country, though the minimum values show left skewness in the values of WHZ in Chad and Nigeria. However, most of the maximum values of skewness are above 0.5, showing right skewness was commonly found for HAZ, WAZ and WHZ. Similarly, values for kurtosis—a numerical measure of shape which indicates the tailedness of the distribution of the data—are acceptable within the values of 2 and 4. The median values for kurtosis of HAZ, WAZ, and WHZ were all within this acceptable range, except that of the median WAZ value in Egypt and Guatemala (4.18 and 4.08 respectively). Though the minimum values of kurtosis of HAZ, WAZ, and WHZ never fell below 2 in any country, the maximum values exceeded 4 for all three indicators in every country, meaning a higher proportion of data is in the tails.

Height digit preference, described by the height index of dissimilarity, would have a value of 0% if all possible last digits of height, digits 0 through 9, occurred uniformly. Any greater value indicates the percentage of digits that would have to be redistributed to achieve a uniform distribution among the last digits, the maximum value possible being 90%. The median values of digit preference for the last digit of height ranges from 7% in Guatemala to 22% in Egypt. Though the minimum values of digit preference in any country varied little (5% in Guatemala and 13% in Egypt), the maximum values of digit preference varied widely from 13% in Guatemala to 43% in Egypt, the latter meaning that 43% of the values would need to be redistributed in order to achieve a uniform distribution of reported last digits of height.

The heaping of the last digit of height on digits 0 and 5 is calculated similarly using an index of dissimilarity and would have a value of 0% if there were the expected percentage of cases ending in 0 and 5. Because 0 and 5 are two digits of 10 possible final digits, the expected percentage of cases ending in 0 and 5 is 20%. The median, minimum, and maximum values of heaping on digits 0 and 5 were always less than that of the height index.

The weight index is based on the tenths place value of weight and had median values that ranged from 4% in Guatemala to 11% in Egypt. Though the minimum values of the weight index had a small range from 2% in Guatemala to 9% in Egypt, the maximum values had a wide range of 9% in Chad to 24% in Nigeria.

The prevalence of incorrect weight digit among any team was relatively rare in most countries, as shown by the median values, though one team in Nigeria reached a maximum value of 29%. It was rare that a team only measured height or only measured weight, never exceeding 3% of cases among a team. Incorrectly measuring the height or length of a child, though rare in Guatemala and Nepal, was rather apparent in the other countries. Of note are Chad and Nigeria where the teams with the highest percentage of incorrectly measuring the child lying down or standing up reported at 27% and 21%, respectively. Finally, the incompleteness of measurement data was only apparent in Ethiopia and Chad, where teams ranged from 1% to 20% and 1% to 18%, respectively.

The day of birth index is calculated with the assumption that children's reported day of birth are evenly distributed throughout the month on days 1-30, each occurring 3.3% of the time. Because births occurring in the 31st or even the 32nd day in Nepal are relatively less common, they are not included in this indicator. The maximum percentage possible for the day of birth index would be 96.7%. The median day of birth index ranged from 8% in Guatemala to 21% in Chad. The highest day of birth index was among a team in Chad who would have needed nearly half of all their values to be shifted in order to get a uniform distribution. The month of birth index of dissimilarity has a maximum possible value of 91.7% if all reported months of births were evenly distributed and each month occurred 8.3% of the time. This index ranged among teams in the countries with a median of 5% in Guatemala and 11% in Nepal, the lowest index occurring in Ethiopia (4%) and the highest also in Ethiopia (24%).

The difference for the mean HAZ between children born in December and those born in January (hereafter the HAZ interval), had median values ranging from 0.20 (Guatemala) to 0.63 (Chad). Nepal, Ethiopia, and Nigeria had maximum values over one. The median WAZ interval was lower than or the same as the median HAZ interval in every country (ranged from 0.20 in Guatemala to 0.36 in Egypt) with the median being 0.36 or less in all countries.

Finally, the percentage of incomplete date of birth data was universally absent when only requiring month and year of birth. When day, month, and year were required, the median was 2% or less in nearly every country; however, Chad's median for incomplete date was 11%, and had an alarmingly maximum value of 87% incomplete in one team.

Table 3 Summary of teams' cumulative performance in each data quality indicator in the six study countries

	Guatemala			Nepal			Ethiopia			Chad			Egypt			Nigeria		
Indicators	**Median**	**Min**	**Max**	**Median**	**Min**	**Max**	**Median**	**Min**	**Max**	**Median**	**Min**	**Max**	**Median**	**Min**	**Max**	**Median**	**Min**	**Max**
HAZ implausible, %	0.1%	0.0%	0.4%	0.0%	0.0%	1.8%	1.0%	0.0%	4.6%	2.0%	0.3%	6.8%	3.7%	0.2%	9.6%	3.0%	0.9%	17.3%
WAZ implausible, %	0.0%	0.0%	0.2%	0.0%	0.0%	0.8%	0.0%	0.0%	0.7%	0.3%	0.0%	1.0%	0.4%	0.1%	1.8%	0.7%	0.0%	2.2%
WHZ implausible, %	0.2%	0.0%	0.6%	0.5%	0.0%	2.0%	1.3%	0.0%	4.3%	1.5%	0.6%	6.4%	5.5%	0.6%	27.2%	3.4%	0.9%	19.1%
HAZ SD	1.19	0.97	1.25	1.33	1.15	1.56	1.70	1.15	2.09	1.92	1.68	2.43	1.94	1.37	2.47	1.88	1.52	2.54
WAZ SD	1.08	1.01	1.13	1.04	0.98	1.22	1.29	0.97	1.47	1.40	1.22	1.98	1.24	1.00	2.25	1.35	1.13	1.82
WHZ SD	1.00	0.94	1.16	1.08	0.97	1.43	1.26	0.96	1.47	1.30	1.12	1.73	1.64	1.17	2.35	1.46	1.14	2.28
HAZ skewness	0.02	-0.17	0.31	0.16	-0.14	1.04	0.33	-0.40	0.87	0.33	0.07	0.85	0.27	-0.26	0.85	0.34	-0.14	0.91
WAZ skewness	0.28	-0.14	0.53	0.04	-0.18	0.48	0.08	-0.48	0.47	0.12	-0.29	0.60	-0.06	-0.45	0.55	0.04	-0.32	0.79
WHZ skewness	0.32	-0.05	0.96	0.00	-0.38	0.65	0.03	-0.41	0.69	-0.11	-0.55	0.54	-0.16	-0.46	0.56	-0.05	-0.55	0.57
HAZ kurtosis	3.13	2.69	4.04	3.66	2.81	8.52	3.33	2.77	5.63	3.35	2.61	4.23	3.71	2.50	5.98	3.55	2.46	4.21
WAZ kurtosis	4.08	3.56	4.79	3.31	2.68	4.05	3.50	2.63	4.62	3.44	2.95	4.94	4.18	2.32	5.17	3.86	2.82	5.13
WHZ kurtosis	3.97	3.38	4.47	3.40	2.64	5.51	3.99	3.16	5.02	3.77	2.97	4.99	3.42	2.41	4.64	3.56	2.16	4.61
Height index, %	7%	5%	13%	15%	10%	26%	18%	7%	36%	14%	8%	38%	22%	13%	43%	19%	8%	36%
Height heaping, %	2%	0%	3%	3%	1%	9%	6%	0%	16%	4%	1%	18%	5%	1%	15%	6%	2%	17%
Weight index, %	4%	2%	12%	9%	5%	17%	8%	3%	14%	7%	4%	9%	11%	9%	23%	7%	3%	24%
Incorrect weight digit, %	1%	0%	3%	0%	0%	0%	<1%	0%	2%	2%	0%	8%	<1%	<1%	4%	3%	0%	29%
Only height measured, %	0%	0%	0%	0%	0%	0%	0%	0%	<1%	0%	0%	<1%	0%	0%	<1%	<1%	0%	1%
Only weight measured, %	0%	0%	<1%	0%	0%	1%	<1%	0%	3%	<1%	0%	2%	0%	0%	<1%	1%	0%	3%
Incorrectly measured, %	2%	0%	5%	<1%	0%	2%	3%	1%	8%	10%	3%	27%	3%	1%	9%	7%	2%	21%
Measured incomplete, %	0%	0%	<1%	4%	0%	9%	7%	1%	20%	5%	1%	18%	1%	<1%	4%	2%	1%	9%
Day of birth index, %	8%	5%	22%	18%	12%	24%	15%	10%	21%	21%	11%	47%	15%	11%	22%	13%	7%	31%
Month of birth index, %	5%	4%	16%	11%	8%	15%	10%	4%	24%	9%	5%	17%	6%	5%	9%	8%	5%	19%
HAZ interval, z-score	0.20	0.03	0.83	0.48	0.02	1.86	0.55	<.01	1.32	0.63	0.01	0.96	0.50	0.08	0.95	0.38	0.01	1.58
WAZ interval, z-score	0.20	0.03	0.53	0.30	<.01	1.03	0.35	0.01	1.04	0.30	0.07	1.16	0.36	<.01	0.87	0.26	<.01	1.29
DMY of birth incomplete, %	<1%	0%	1%	0%	0%	0%	1%	0%	29%	11%	<1%	87%	2%	<1%	14%	2%	0%	6%
MY of birth incomplete, %	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	<1%	0%	0%	0%	0%	0%	<1%

Note: Countries presented from highest to lowest ranked data quality. Abbreviations include SD, standard deviation; HAZ, height-for-age; WAZ, weight-for-age; WHZ, weight-for-height; DMY, day month year; MY, month year.

4.2 Indicator Redundancy

Using a Pearson's correlation coefficient threshold of |0.7| to consider any two indicators as meaningfully correlated, we examined the correlation of indicators by teams. Table 4 shows the minimum and maximum Pearson's correlation coefficient from the six study countries' correlation matrices. Only a few indicators were correlated in any country. No indicators were correlated among all six study surveys (see Appendix Table A1-A6 for each survey's correlation matrix).

Though there are no consistently correlated indicators in all the surveys, correlations among the standard deviation and implausible values of HAZ, WAZ, and WHZ are evident in the low data quality surveys. In Egypt, all six of these indicators are correlated above the correlation coefficient threshold, often with a coefficient of 0.9 or greater. In Nigeria the correlation between implausible HAZ and WHZ is 0.83, between WAZ and both WHZ and HAZ the correlation is 0.67, and between standard deviation indicators are 0.85 or greater. In Ethiopia and Chad, the indicators are also correlated but to a lesser extent, whereas in Guatemala and Nepal, these correlations are absent. In Egypt, the kurtosis is inversely correlated with all the implausible values and standard deviation indicators.

Other notable correlations include height heaping with the height index in which the correlation was high in three of the six countries (Nigeria 0.80, Chad 0.93, and Ethiopia 0.95). However, height heaping and height index were low to moderately correlated with anthropometry implausible z-scores and standard deviation indicators. The strength and direction of the relationship between the weight index and incorrect weight recording indicators varied (ranged from -0.23 in Ethiopia to 0.76 in Nigeria). The weight index is correlated with the standard deviations and implausible values of HAZ and WHZ in Nigeria.

Among the indicators that are used to capture the quality date of birth reporting, the HAZ and WAZ interval are highly correlated in four countries and in the remaining two countries remain moderately correlated (Chad 0.59 and Nepal 0.63). However, the relationship between the HAZ and WAZ interval with anthropometry implausible z-scores and standard deviations varied across countries from no relationship to a moderate relationship in both the positive and negative direction. There was a wide variation in the strength and the direction of the correlation between day of birth and month of birth preference (ranging from -0.01 in Egypt to 0.90 in Guatemala). In most countries there was not enough variation in the month and year completeness indicator to calculate correlations with other indicators.

Table 4 **Heatmap of the min and max Pearson's correlation coefficients from the correlation matrices across countries**

		HAZ implausible	WAZ implausible	WHZ implausible	HAZ sd	WAZ sd	WHZ sd	HAZ skewness	WAZ skewness	WHZ skewness	HAZ kurtosis	WAZ kurtosis	WHZ kurtosis	Height index	Height heaping	Weight index	Incorrect weight digit	Only height measured	Only weight measured	Incorrectly measured	Measured incomplete	Day of birth index	Month of birth index	HAZ Jan-Dec interval	WAZ Jan-Dec interval	DMY of birth incomplete	MY of birth incomplete
HAZ Implausibe	Min	1.00	-0.16	0.27	0.12	-0.15	-0.38	-0.59	-0.40	-0.19	-0.81	-0.56	-0.75	-0.12	-0.11	-0.24	-0.33	0.04	0.05	-0.42	-0.38	-0.21	-0.13	-0.37	-0.28	-0.09	-0.12
	Max	1.00	0.70	0.83	0.88	0.84	0.88	0.44	0.58	0.68	0.29	0.27	0.33	0.54	0.69	0.78	0.57	0.27	0.45	0.69	0.32	0.42	0.52	0.41	0.57	0.25	-0.08
WAZ Implausibe	Min	-0.16	1.00	0.07	0.27	0.33	0.07	-0.64	-0.35	-0.17	-0.64	-0.74	-0.65	-0.16	-0.11	-0.17	-0.14	-0.12	-0.31	-0.21	-0.28	-0.13	-0.02	-0.38	-0.10	-0.22	-0.10
	Max	0.70	1.00	0.94	0.77	0.92	0.86	0.30	0.49	0.64	0.08	0.10	0.34	0.55	0.36	0.68	0.70	0.20	0.38	0.45	0.54	0.29	0.27	0.51	0.72	0.28	0.19
WHZ Implausibe	Min	0.27	0.07	1.00	0.23	0.02	-0.24	-0.67	-0.09	-0.42	-0.72	-0.73	-0.77	-0.20	-0.14	-0.15	-0.11	-0.05	-0.16	-0.34	-0.37	-0.35	-0.21	-0.28	-0.16	-0.16	-0.11
	Max	0.83	0.94	1.00	0.81	0.98	0.91	0.25	0.52	0.76	0.24	0.36	0.23	0.41	0.07	0.87	0.80	0.28	0.31	0.43	0.30	0.48	0.22	0.41	0.68	0.45	0.05
HAZ sd	Min	0.12	0.27	0.23	1.00	0.45	-0.58	-0.58	-0.43	-0.52	-0.89	-0.38	-0.81	-0.06	0.16	-0.70	-0.04	0.00	-0.23	-0.38	-0.42	-0.83	-0.75	-0.74	-0.55	-0.14	-0.16
	Max	0.88	0.77	0.81	1.00	0.90	0.91	0.55	0.59	0.50	0.02	0.08	0.20	0.57	0.39	0.71	0.64	0.25	0.26	0.49	0.44	0.48	0.37	0.40	0.46	0.60	-0.02
WAZ sd	Min	-0.15	0.33	0.02	0.45	1.00	0.15	-0.69	-0.02	0.04	-0.73	-0.74	-0.74	-0.05	-0.08	-0.06	-0.10	-0.06	-0.21	-0.53	-0.40	-0.15	-0.10	-0.52	-0.09	-0.17	-0.15
	Max	0.84	0.92	0.98	0.90	1.00	0.90	0.51	0.64	0.76	-0.06	0.32	0.16	0.39	0.34	0.68	0.56	0.37	0.12	0.58	0.35	0.50	0.46	0.50	0.65	0.48	-0.04
WHZ sd	Min	-0.38	0.07	-0.24	-0.58	0.15	1.00	-0.68	-0.05	0.10	-0.83	-0.52	-0.83	0.10	-0.25	-0.16	-0.25	0.04	-0.25	-0.43	-0.56	-0.10	-0.14	-0.31	-0.07	-0.21	-0.17
	Max	0.88	0.86	0.91	0.91	0.90	1.00	0.46	0.56	0.67	0.21	0.30	0.56	0.54	0.26	0.79	0.63	0.24	0.22	0.46	0.13	0.77	0.73	0.66	0.52	0.34	0.04
HAZ skew	Min	-0.59	-0.64	-0.67	-0.58	-0.69	-0.68	1.00	-0.04	-0.72	0.23	-0.31	-0.53	-0.52	-0.33	-0.60	-0.06	-0.20	-0.20	-0.28	-0.14	-0.28	-0.49	-0.50	-0.69	-0.10	-0.33
	Max	0.44	0.30	0.25	0.55	0.51	0.46	1.00	0.62	0.38	0.84	0.52	0.72	0.41	0.26	0.25	0.44	0.17	0.34	0.37	0.19	0.51	0.47	0.07	0.13	0.22	0.09
WAZ skew	Min	-0.40	-0.35	-0.09	-0.43	-0.02	-0.05	-0.04	1.00	-0.19	-0.24	-0.22	-0.32	-0.51	-0.51	-0.58	-0.15	-0.09	-0.23	-0.34	-0.24	-0.26	-0.28	-0.22	-0.30	-0.13	-0.21
	Max	0.58	0.49	0.52	0.59	0.64	0.56	0.62	1.00	0.62	0.23	0.60	0.37	0.22	0.21	0.64	0.39	0.18	0.02	0.60	-0.09	0.55	0.44	0.50	0.45	0.02	0.09
WHZ skew	Min	-0.19	-0.17	-0.42	-0.52	0.04	0.10	-0.72	-0.19	1.00	-0.52	-0.49	-0.73	-0.13	-0.22	-0.15	-0.11	-0.03	-0.27	-0.15	-0.54	-0.13	0.13	-0.20	0.03	-0.23	-0.23
	Max	0.68	0.64	0.76	0.50	0.76	0.67	0.38	0.62	1.00	0.15	0.36	0.32	0.45	0.15	0.76	0.35	0.31	0.16	0.29	0.03	0.77	0.71	0.57	0.55	0.14	-0.08
HAZ kurtosis	Min	-0.81	-0.64	-0.72	-0.89	-0.73	-0.83	0.23	-0.24	-0.52	1.00	0.00	0.00	-0.52	-0.35	-0.57	-0.33	-0.32	-0.35	-0.49	-0.28	-0.13	-0.30	-0.35	-0.48	-0.36	-0.17
	Max	0.29	0.08	0.24	0.02	-0.06	0.21	0.84	0.23	0.15	1.00	0.47	0.89	0.21	0.17	0.24	0.32	0.00	0.52	0.15	0.04	-0.05	-0.05	0.31	0.35	0.14	0.29
WAZ kurtosis	Min	-0.56	-0.74	-0.73	-0.38	-0.74	-0.52	-0.31	-0.22	-0.49	0.00	1.00	0.02	-0.32	-0.40	-0.24	-0.21	-0.14	-0.41	-0.49	-0.29	-0.50	-0.25	-0.48	-0.73	-0.29	-0.06
	Max	0.27	0.10	0.36	0.08	0.32	0.30	0.52	0.60	0.36	0.47	1.00	0.44	0.21	0.19	0.48	0.18	-0.01	0.49	0.53	-0.01	0.33	0.20	0.67	0.46	-0.02	0.15
WHZ kurtosis	Min	-0.75	-0.65	-0.77	-0.81	-0.74	-0.83	-0.53	-0.32	-0.73	0.00	0.02	1.00	-0.56	-0.27	-0.60	-0.44	-0.13	-0.24	-0.37	-0.67	-0.54	-0.34	-0.15	-0.38	-0.30	-0.18
	Max	0.33	0.34	0.23	0.20	0.16	0.56	0.72	0.37	0.32	0.89	0.44	1.00	0.18	0.23	0.32	0.04	-0.09	0.16	0.48	0.33	0.39	0.55	0.45	0.59	0.16	-0.01
Height index	Min	-0.12	-0.16	-0.20	-0.06	-0.05	0.10	-0.52	-0.51	-0.13	-0.52	-0.32	-0.56	1.00	0.32	0.06	-0.04	-0.05	-0.16	-0.15	-0.33	0.06	0.15	-0.12	-0.05	-0.19	-0.18
	Max	0.54	0.55	0.41	0.57	0.39	0.54	0.41	0.22	0.45	0.21	0.21	0.18	1.00	0.95	0.83	0.33	0.44	0.41	0.43	0.52	0.45	0.50	0.30	0.33	0.31	0.07
Height heaping	Min	-0.11	-0.11	-0.14	0.16	-0.08	-0.25	-0.33	-0.51	-0.22	-0.35	-0.40	-0.27	0.32	1.00	-0.32	-0.28	-0.20	-0.02	-0.23	0.01	-0.22	-0.23	-0.18	-0.31	-0.22	-0.18
	Max	0.69	0.36	0.07	0.39	0.34	0.26	0.26	0.21	0.15	0.17	0.19	0.23	0.95	1.00	0.31	0.33	0.33	0.45	0.57	0.55	0.44	0.46	0.42	0.32	0.38	-0.08
Weight index	Min	-0.24	-0.17	-0.15	-0.70	-0.06	-0.16	-0.60	-0.58	-0.15	-0.57	-0.24	-0.60	0.06	-0.32	1.00	-0.23	-0.15	-0.30	-0.32	-0.41	0.00	-0.06	-0.07	0.02	-0.22	-0.03
	Max	0.78	0.68	0.87	0.71	0.68	0.79	0.25	0.64	0.76	0.24	0.48	0.32	0.83	0.31	1.00	0.76	0.39	0.41	0.55	0.53	0.91	0.81	0.74	0.62	0.31	0.19
Unexpected weight digit	Min	-0.33	-0.14	-0.11	-0.04	-0.10	-0.25	-0.06	-0.15	-0.11	-0.33	-0.21	-0.44	-0.04	-0.28	-0.23	1.00	0.01	-0.22	-0.25	-0.22	-0.18	-0.46	-0.31	-0.22	-0.14	0.05
	Max	0.57	0.70	0.80	0.64	0.56	0.63	0.44	0.39	0.35	0.32	0.18	0.04	0.33	0.33	0.76	1.00	0.96	0.39	0.37	0.50	0.65	0.14	0.27	0.20	0.87	0.40
Only height measured	Min	0.04	-0.12	-0.05	0.00	-0.06	0.04	-0.20	-0.09	-0.03	-0.32	-0.14	-0.13	-0.05	-0.20	-0.15	0.01	1.00	-0.36	-0.14	0.00	0.00	-0.06	-0.39	-0.25	0.02	-0.16
	Max	0.27	0.20	0.28	0.25	0.37	0.24	0.17	0.18	0.31	0.00	-0.01	-0.09	0.44	0.33	0.39	0.96	1.00	0.46	0.36	0.56	0.54	0.48	0.03	-0.04	0.91	0.21
Only weight measured	Min	0.05	-0.31	-0.16	-0.23	-0.21	-0.25	-0.20	-0.23	-0.27	-0.35	-0.41	-0.24	-0.16	-0.02	-0.30	-0.22	-0.36	1.00	-0.32	0.03	-0.12	-0.14	-0.31	-0.48	-0.16	-0.19
	Max	0.45	0.38	0.31	0.26	0.12	0.22	0.34	0.02	0.16	0.52	0.49	0.16	0.41	0.45	0.41	0.39	0.46	1.00	0.58	1.00	0.20	0.36	0.22	0.45	0.46	-0.19
Incorrectly measured	Min	-0.42	-0.21	-0.34	-0.38	-0.53	-0.43	-0.28	-0.34	-0.15	-0.49	-0.49	-0.37	-0.15	-0.23	-0.32	-0.25	-0.14	-0.32	1.00	-0.24	-0.06	-0.40	-0.20	-0.21	-0.22	-0.16
	Max	0.69	0.45	0.43	0.49	0.58	0.46	0.37	0.60	0.29	0.15	0.53	0.48	0.43	0.57	0.55	0.37	0.36	0.58	1.00	0.58	0.26	0.42	0.46	0.51	0.21	0.14
Measured incomplete	Min	-0.38	-0.28	-0.37	-0.42	-0.40	-0.56	-0.14	-0.24	-0.54	-0.28	-0.29	-0.67	-0.33	0.01	-0.41	-0.22	0.00	0.03	-0.24	1.00	-0.19	-0.59	-0.35	-0.38	0.23	-0.17
	Max	0.32	0.54	0.30	0.44	0.35	0.13	0.19	-0.09	0.03	0.04	-0.01	0.33	0.52	0.55	0.53	0.50	0.56	1.00	0.58	1.00	0.36	0.31	0.24	0.28	0.69	-0.13
Day of birth index	Min	-0.21	-0.13	-0.35	-0.83	-0.15	-0.10	-0.28	-0.26	-0.13	-0.13	-0.50	-0.54	0.06	-0.22	0.00	-0.18	0.00	-0.12	-0.06	-0.19	1.00	-0.01	-0.09	-0.01	-0.37	-0.12
	Max	0.42	0.29	0.48	0.48	0.50	0.77	0.51	0.55	0.77	-0.05	0.33	0.39	0.45	0.44	0.91	0.65	0.54	0.20	0.26	0.36	1.00	0.90	0.79	0.64	0.51	-0.05
Month of birth index	Min	-0.13	-0.02	-0.21	-0.75	-0.10	-0.14	-0.49	-0.28	0.13	-0.30	-0.25	-0.34	0.15	-0.23	-0.06	-0.46	-0.06	-0.14	-0.40	-0.59	-0.01	1.00	-0.34	-0.24	-0.31	-0.13
	Max	0.52	0.27	0.22	0.37	0.46	0.73	0.47	0.44	0.71	-0.05	0.20	0.55	0.50	0.46	0.81	0.14	0.48	0.36	0.42	0.31	0.90	1.00	0.67	0.54	0.44	-0.11
HAZ Dec-Jan interval	Min	-0.37	-0.38	-0.28	-0.74	-0.52	-0.31	-0.50	-0.22	-0.20	-0.35	-0.48	-0.15	-0.12	-0.18	-0.07	-0.31	-0.39	-0.31	-0.20	-0.35	-0.09	-0.34	1.00	0.59	-0.45	0.08
	Max	0.41	0.51	0.41	0.40	0.50	0.66	0.07	0.50	0.57	0.31	0.67	0.45	0.30	0.42	0.74	0.27	0.03	0.22	0.46	0.24	0.79	0.67	1.00	0.82	0.02	0.15
WAZ Dec-Jan interval	Min	-0.28	-0.10	-0.16	-0.55	-0.09	-0.07	-0.69	-0.30	0.03	-0.48	-0.73	-0.38	-0.05	-0.31	0.02	-0.22	-0.25	-0.48	-0.21	-0.38	-0.01	-0.24	0.59	1.00	-0.38	0.00
	Max	0.57	0.72	0.68	0.46	0.65	0.52	0.13	0.45	0.55	0.35	0.46	0.59	0.33	0.32	0.62	0.20	-0.04	0.45	0.51	0.28	0.64	0.54	0.82	1.00	0.18	0.06
DMY of birth incomplete	Min	-0.09	-0.22	-0.16	-0.14	-0.17	-0.21	-0.10	-0.13	-0.23	-0.36	-0.29	-0.30	-0.19	-0.22	-0.22	-0.14	0.02	-0.16	-0.22	0.23	-0.37	-0.31	-0.45	-0.38	1.00	-0.06
	Max	0.25	0.28	0.45	0.60	0.48	0.34	0.22	0.02	0.14	0.14	-0.02	0.16	0.31	0.38	0.31	0.87	0.91	0.46	0.21	0.69	0.51	0.44	0.02	0.18	1.00	-0.02
MY of birth incomplete	Min	-0.12	-0.10	-0.11	-0.16	-0.15	-0.17	-0.33	-0.21	-0.23	-0.17	-0.06	-0.18	-0.18	-0.18	-0.03	0.05	-0.16	-0.19	-0.16	-0.17	-0.12	-0.13	0.08	0.00	-0.06	1.00
	Max	-0.08	0.19	0.05	-0.02	-0.04	0.04	0.09	0.09	-0.08	0.29	0.15	-0.01	0.07	-0.08	0.19	0.40	0.21	-0.19	0.14	-0.13	-0.05	-0.11	0.15	0.06	-0.02	1.00

Legend
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1.0

Note: Abbreviations include SD, standard deviation; HAZ, height-for-age; WAZ, weight-for-age; WHZ, weight-for-height; DMY, day month year; MY, month year.

4.3 Indicator Targets

Using 147 DHS surveys that collected anthropometry data from 2000-2018, Targets A and B were constructed after binning the data quality indicators into quartiles (Table 5). Target A is based on the value that marks the 25th percentile of the data quality indicators among these surveys, and Target B marks the median data quality value. Wherever possible, global thresholds are used as an absolute target, instead of a Target A or Target B.

Though Targets A and B reflect the varying indicators of many DHS surveys over the years, you may notice some of the indicators have very similar values for Target A and Target B. For example, month of birth preference is 3% for Target A and 4% for Target B, and the two targets are within 0.2% of each other for the percent of implausible WAZ values as well. Interestingly, several indicators have such low prevalence that the two targets have extremely low values, such as the indicator that captures when only height is measured and has target values of less than a tenth of a percent. No thresholds can be made for the indicator that estimates incorrect weight digits. This is because the 147 DHS survey datasets are recoded, providing only the first decimal, and incorrect weight digits can thus only be estimated using raw data.

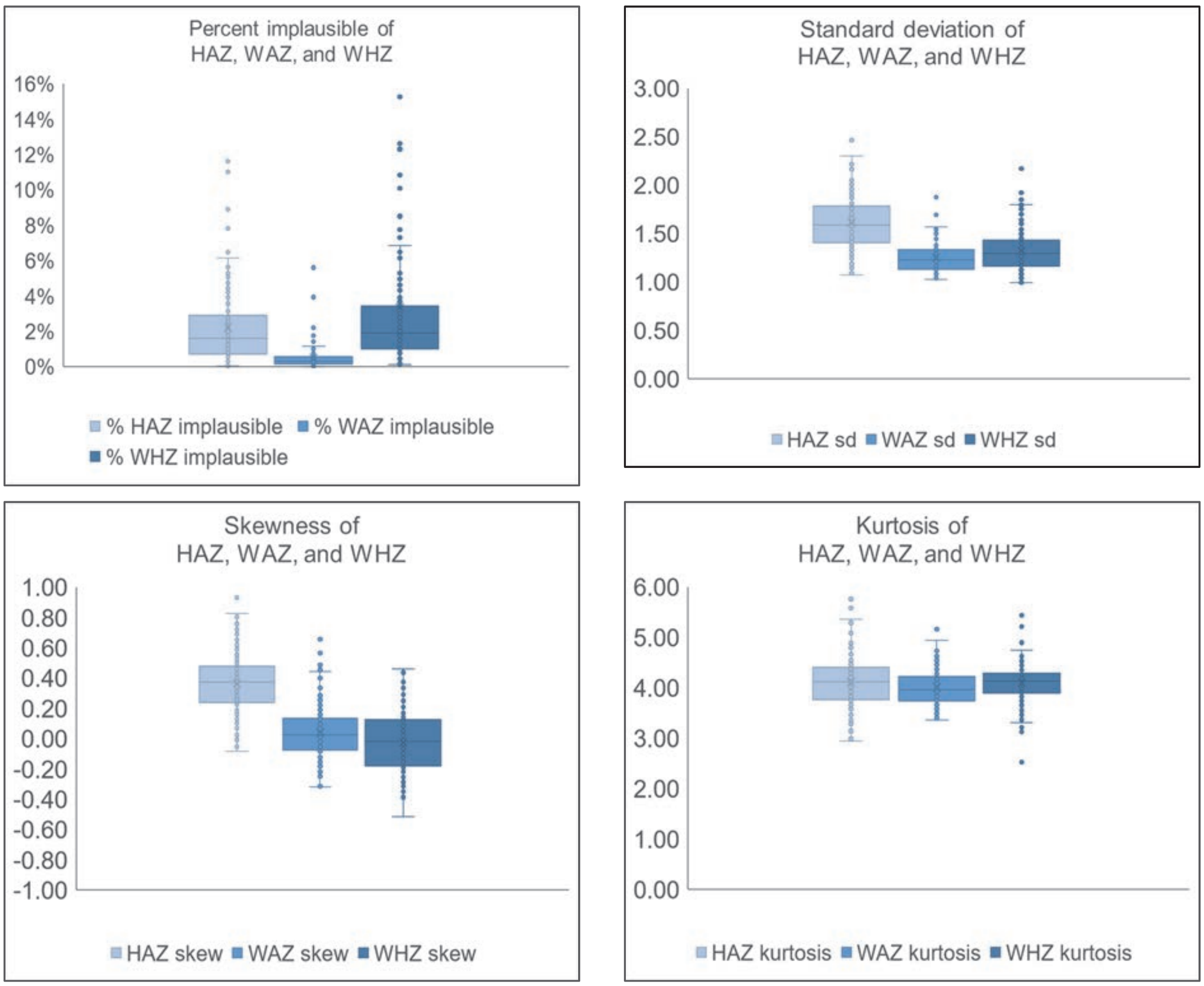
Table 5 Thresholds for data quality indicators based on 147 DHS surveys with anthropometric data

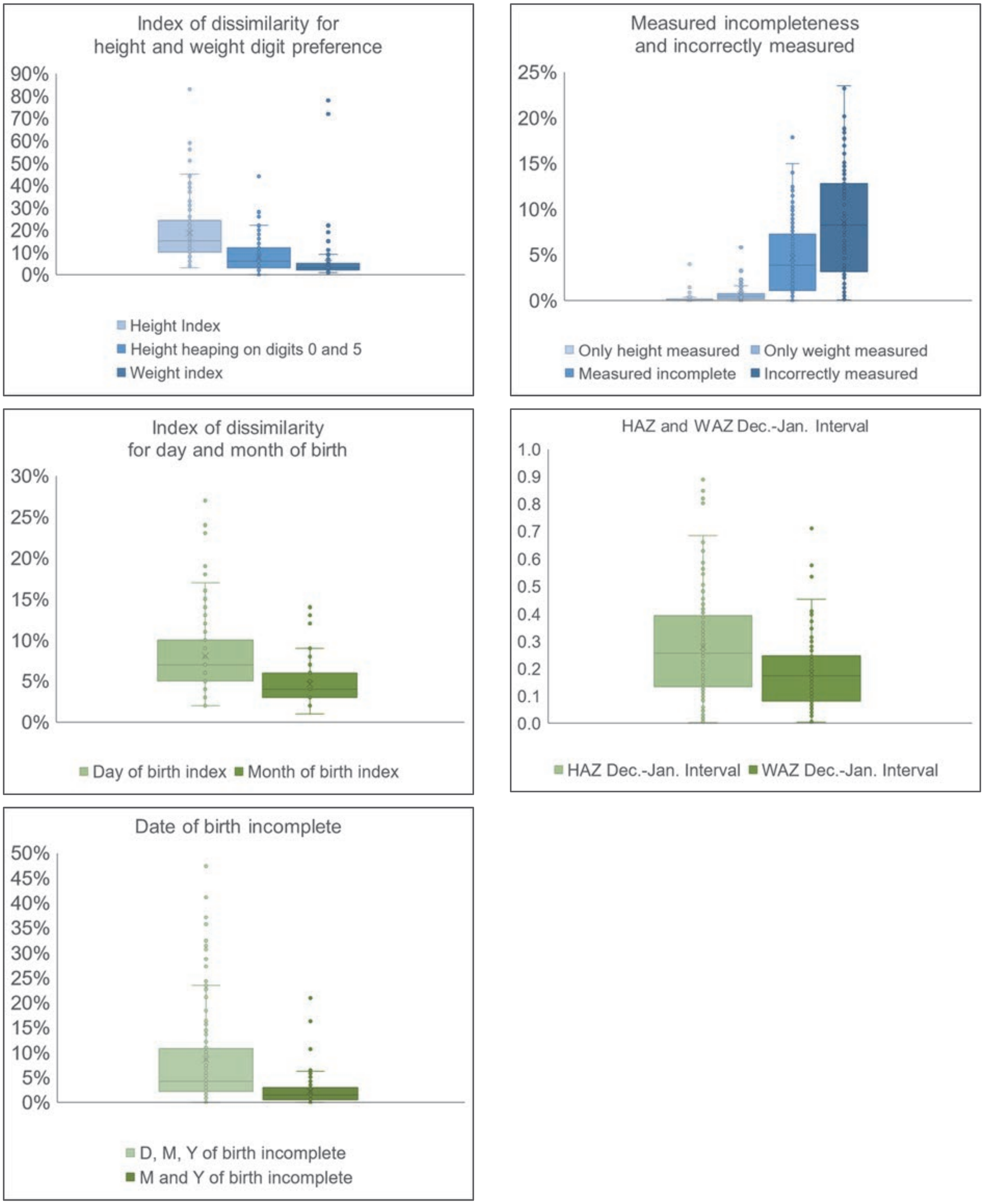
	Target A[1]	Target B[2]
Height and Weight Indicators		
HAZ implausible, %[3]	0.7%	1.6%
WAZ implausible, %[3]	0.1%	0.3%
WHZ implausible, %[3]	1.0%	2.0%
HAZ SD	1.41	1.59
WAZ SD	1.13	1.23
WHZ SD	1.17	1.30
HAZ skew—absolute deviation [4]	0.24	0.37
WAZ skew—absolute deviation[4]	0.05	0.10
WHZ skew—absolute deviation[4]	0.07	0.14
HAZ kurtosis—absolute deviation[5]	0.77	1.13
WAZ kurtosis—absolute deviation[5]	0.75	0.96
WHZ kurtosis—absolute deviation[5]	0.89	1.12
Height index, %	10.0%	15.0%
Height heaping on digits 0 and 5, %	3.0%	6.0%
Weight index, %	2.0%	3.0%
Incorrect weight digit, %	NA	NA
Only height measured, %	0.01%	0.05%
Only weight measured, %	0.2%	0.4%
Incorrectly measured, %	3.1%	8.2%
Measured incomplete, %	1.1%	3.9%
Date of birth indicators		
Day of birth index, %	5.0%	7.0%
Month of birth index, %	3.0%	4.0%
HAZ interval, z-score	0.13	0.25
WAZ interval, z-score	0.08	0.17
DMY of birth incomplete, %	2.2%	4.3%
MY of birth incomplete, %	0.6%	1.5%

Note: Abbreviations include SD, standard deviation; HAZ, height-for-age; WAZ, weight-for-age; WHZ, weight-for-height; DMY, day month year; MY, month year.
[1] 25^{th} percentile for the 147 DHS surveys.
[2] Median for the 147 DHS surveys.
[3] Global UNICEF-WHO threshold is 1% (WHO/UNICEF 2019).
[4] Threshold based on the absolute deviation of skew from 0.
[5] Threshold based on the absolute deviation of kurtosis from 3.

Figures 1a-i show the quartile boxplots of the data quality indicators in the 147 surveys. The prevalence of some indicators is noticeably low including implausible values of WAZ, only height or weight measured, and month and year of birth incomplete. The percent of implausible values shows wide variation, namely among HAZ and WHZ values. The standard deviation of HAZ has a wider range of values than the standard deviation of WAZ or WHZ and the skewness of HAZ is nearly always positive, while WAZ and the WHZ skew is distributed more evenly above and below zero. The HAZ interval indicator shows more variance across the 147 surveys compared to the WAZ interval.

Figures 1a-i Boxplots of data quality indicators using 147 DHS surveys that included anthropometry from 2000-2018





Note: Abbreviations include SD, standard deviation; HAZ, height-for-age; WAZ, weight-for-age; WHZ, weight-for-height; DMY, day month year; MY, month year.

4.4 Summary Measures

Table 6 shows the results of the PCA using the height and weight indicators. The percent of total variance explained by the first component ranged from 15% in Ethiopia to 31% in Nigeria. The lowest-quality countries had the highest percent of total variance explained. No indicator had the highest factor loading in every country. In the countries with higher data quality—Guatemala and Nepal—implausible HAZ and WHZ values were negatively correlated with the latent factor. Although implausible WAZ values contributed very little to the overall variance found in the component in Guatemala, they were a moderate contributor in Nepal. For all other countries, implausible values of HAZ and WHZ were some of the highest contributing indicators to the first component, and implausible values of WAZ had high factor loadings in Egypt and Nigeria. The standard deviation of HAZ and WAZ had high loadings in each country except Guatemala, while the standard deviation of WHZ had high loadings in every country except Nepal and Ethiopia.

In nearly all countries, all indicators beyond the standard deviation and implausible values indicators had either negative or negligible loadings, with a few exceptions. The WAZ skewness in Nepal and the WHZ skewness in Guatemala had high loadings. Although the height index contributed only in Nepal, the weight index had more noticeable loadings in half of the countries. Ethiopia was the only country where incompleteness of measurements or having only weight measured contributed to the component.

Table 6 Factor loadings of a principal component analysis using height and weight data quality indicators, eigenvalues, and percent of total variance in Guatemala, Nepal, Ethiopia, Chad, Egypt, and Nigeria

	Guatemala	Nepal	Ethiopia	Chad	Egypt	Nigeria
Height and Weight Indicators						
% HAZ Implausible	-0.16	-0.07	0.49	0.40	0.28	0.29
% WAZ Implausible	0.06	0.27	-0.05	0.15	0.40	0.38
% WHZ Implausible	-0.19	-0.08	0.47	0.35	0.41	0.40
HAZ SD	-0.41	0.28	0.41	0.43	0.32	0.25
WAZ SD	-0.01	0.55	0.28	0.47	0.40	0.25
WHZ SD	0.46	-0.02	0.13	0.34	0.37	0.27
HAZ skewness	0.02	0.04	0.08	-0.03	0.01	-0.03
WAZ skewness	0.25	0.38	-0.02	0.25	0.07	0.09
WHZ skewness	0.42	0.01	0.13	0.01	0.32	0.10
HAZ kurtosis	-0.07	-0.09	-0.06	-0.20	-0.18	0.00
WAZ kurtosis	0.03	0.12	0.01	0.07	-0.09	-0.02
WHZ kurtosis	0.19	-0.07	0.17	0.04	-0.07	-0.08
Height index	0.10	0.29	0.00	-0.06	0.04	-0.03
Height heaping	-0.16	0.01	-0.04	0.04	-0.12	-0.08
Weight index	0.42	0.32	0.04	0.07	0.01	0.37
Incorrect weight digit[1]	-0.23	NA	0.03	0.09	-0.01	0.42
Only height measured[1]	NA	NA	0.10	0.19	0.00	0.09
Only weight measured	0.00	-0.16	0.23	-0.07	0.00	0.06
Incorrectly measured	0.06	-0.30	0.07	0.01	-0.01	0.23
Measured Incomplete	0.00	-0.23	0.38	0.06	-0.13	-0.04
Eigenvalue	4.07	3.25	3.05	4.44	5.81	6.17
Percent of total variance[2]	21%	18%	15%	22%	29%	31%

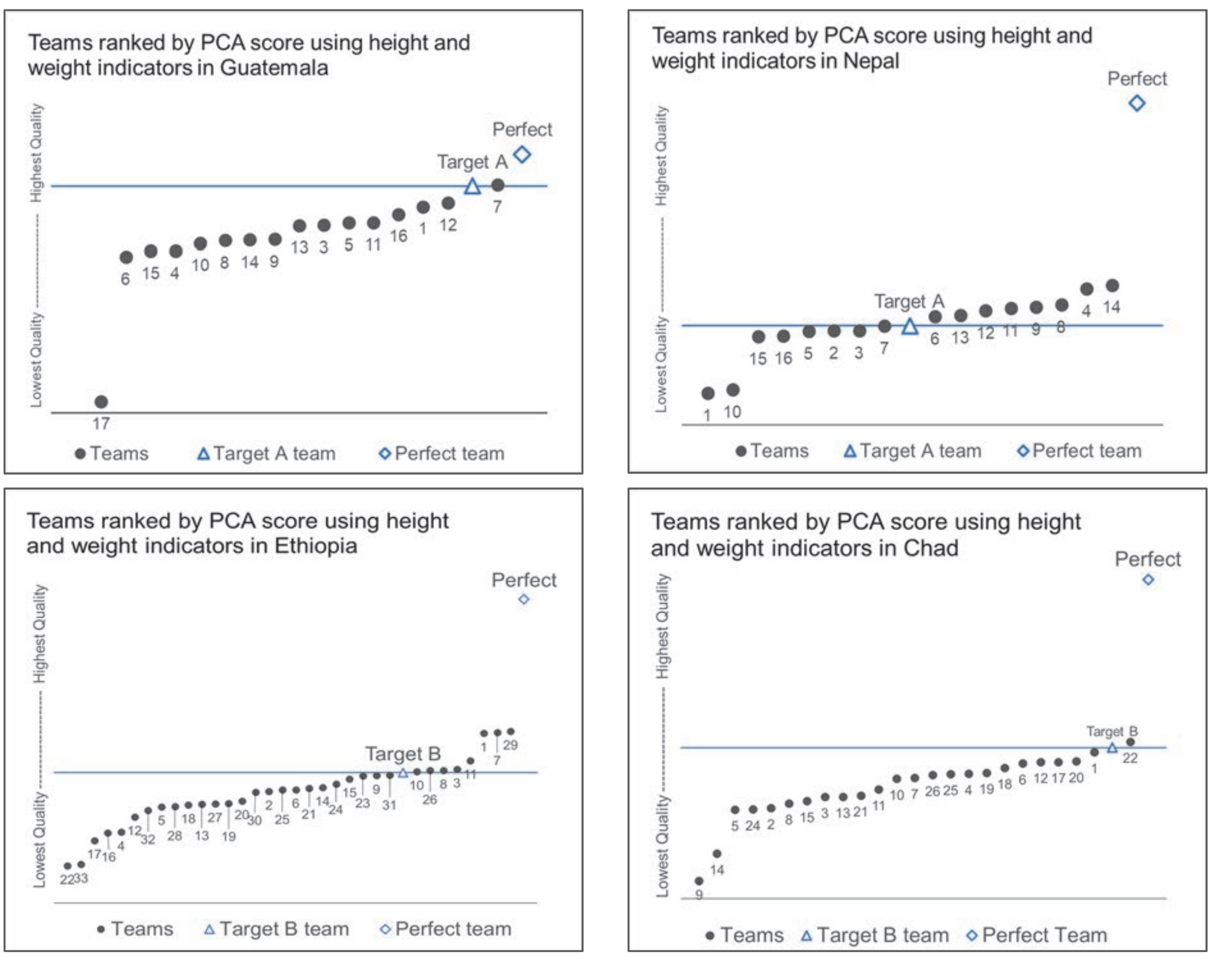
Note: Countries presented from highest to lowest ranked data quality. Abbreviations include SD, standard deviation; HAZ, height-for-age; WAZ, weight-for-age; WHZ, weight-for-height; DMY, day month year; MY, month year.
[1] Indicators with no variance in the survey not included in the PCA. These are marked as NA.
[2] Percent of total variance explained by first component.

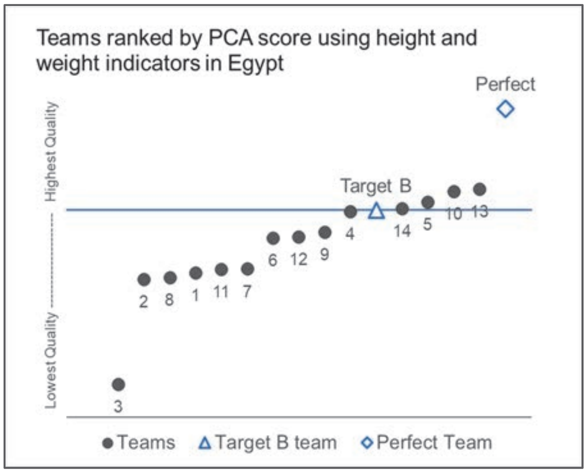
After the PCA was run using the teams' overall values for the height and weight indicators, scores were predicted for all teams including two additional teams, the Perfect Team and the Target Team. Scores were predicted for either the Target A Team or Target B Team based on whether they were categorized as a high or low data quality score (refer to Table 1 summary of study countries). Because Guatemala and Nepal had higher data quality, scores were predicted for a Target A Team, while the other four countries had scores predicted for a Target B Team.

The predicted scores varied in range, with the lowest score correlated to the highest quality because all indicators are characterized by a lower value being more desirable. The predicted scores would ideally set the perfect team as the most extreme score, which in this case was the most negative score. The rankings of the teams based on their PCA scores are shown below in Figures 2a-f with the y-axis reversed, showing the lowest scores (highest quality) near the top of the figure.

Among the two countries that were ranked using Target A thresholds, unexpectedly only one of sixteen teams surpassed this threshold in Guatemala, and eight of sixteen teams in Nepal (Figures 2a and 2b). Among the four countries that were ranked using Target B thresholds, only one team performed above the Target B team in Chad, while a quarter of teams in Egypt and Ethiopia were ranked above the Target B Team. In each country there are one or two teams that rank very low and appear to have performed substantially poorer than the rest. As expected, the Perfect Teams always ranked first.

Figures 2a-f **Teams ranked by PCA score using height and weight indicators in Guatemala, Nepal, Ethiopia, Chad, Egypt, and Nigeria.**





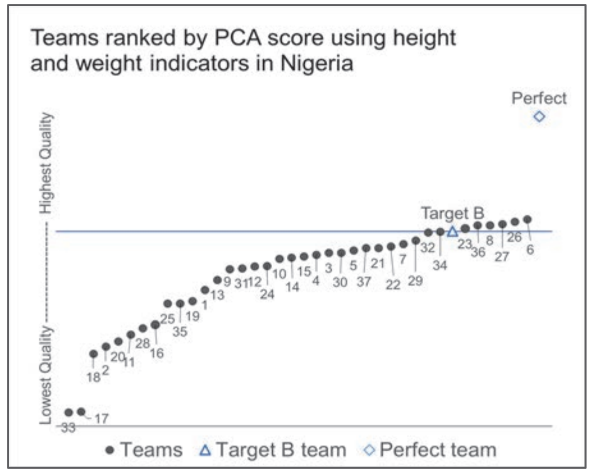


Table 7 shows the results of the PCA using the date of birth indicators. The percent of total variance explained by the first component ranged from 27%-68%. The highest-quality country, Guatemala, had the highest percent of total variance, while the other countries ranged from 27%-43%. No indicator had the highest factor loading in every country. Apart from Nigeria, the HAZ interval and WAZ interval had high loadings in every country with ranges 0.49-0.71 and 0.46-0.68, respectively. In Nigeria, these two indicators contributed little to the variance. The day of birth index and month of birth index had high loadings in Nigeria and Guatemala, but had small loadings or negative loadings in every other country. Day, month, and year incompleteness contributed to the component in Nigeria, while month and year incompleteness contributed in Chad. However, those two indicators contributed nowhere else or were unavailable due to no variance.

Table 7 **Factor loadings of a principal component analysis using date of birth quality indicators, eigenvalues, and percent of total variance in Guatemala, Nepal, Ethiopia, Chad, Egypt, and Nigeria.**

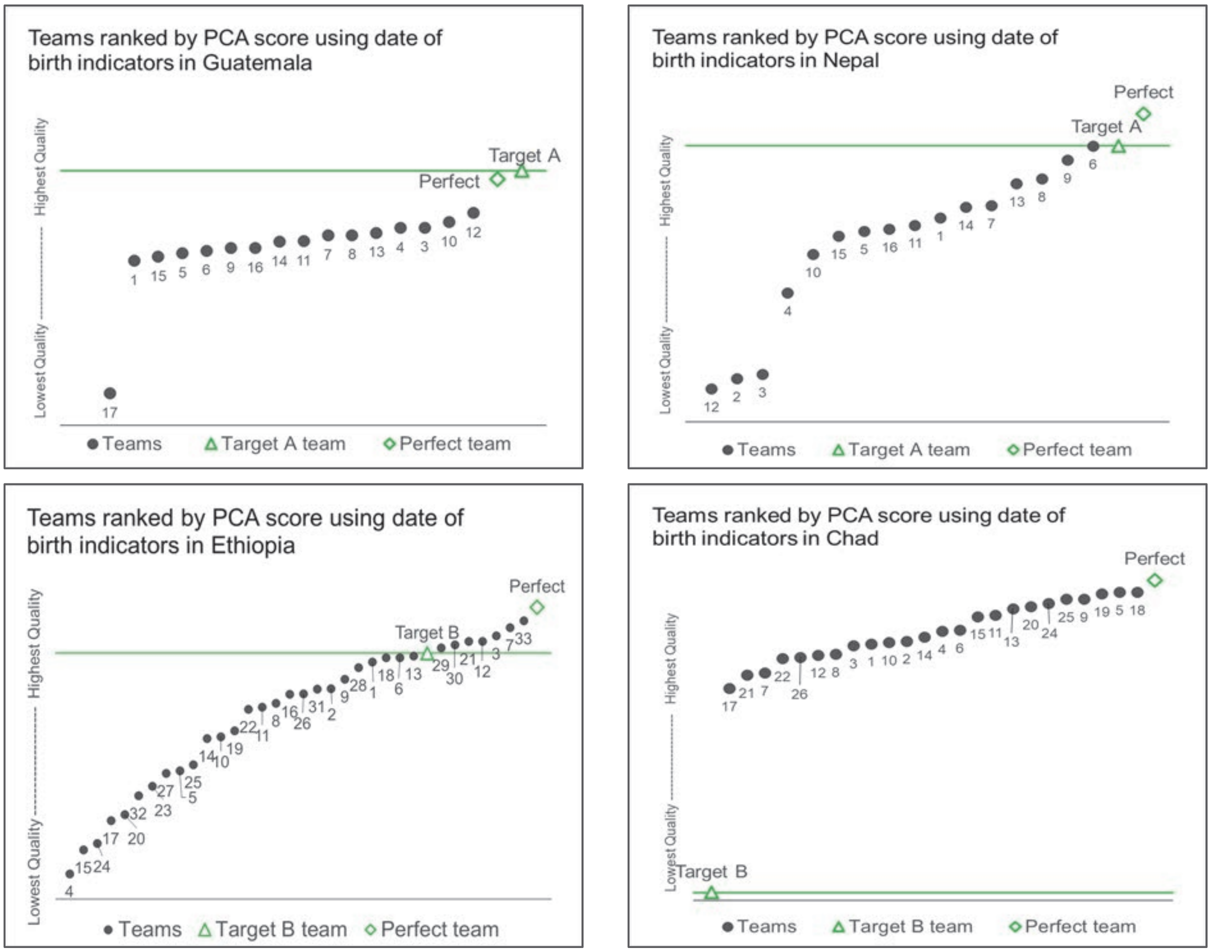
	Guatemala	Nepal	Ethiopia	Chad	Egypt	Nigeria
Date of Birth Indicators						
Day of birth index	0.51	0.18	-0.02	0.19	0.17	0.64
Month of birth index	0.47	-0.05	0.24	-0.09	-0.36	0.64
HAZ interval	0.49	0.71	0.71	0.71	0.64	-0.02
WAZ interval	0.46	0.68	0.65	0.57	0.61	0.06
D, M, Y of birth incomplete	-0.28	NA	-0.14	0.00	-0.24	0.37
M or Y of birth incomplete[1]	NA	NA	NA	0.36	NA	-0.21
Eigenvalue	3.38	1.66	1.87	1.64	2.14	1.86
Percent of total variance[2]	68%	42%	37%	27%	43%	31%

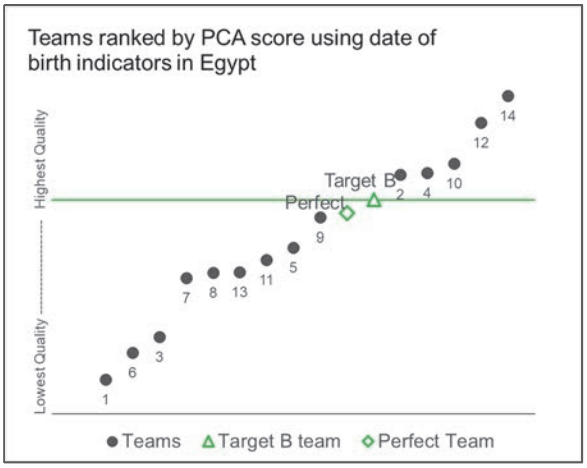
Note: Countries presented from highest to lowest ranked data quality. Abbreviations include SD standard deviation; HAZ, height-for-age; WAZ, weight-for-age; WHZ, weight-for-height; DMY, day month year; MY, month year.
[1] Indicators with no variance in the survey not included in the PCA. These are marked as NA.
[2] Percent of total variance explained by first component.

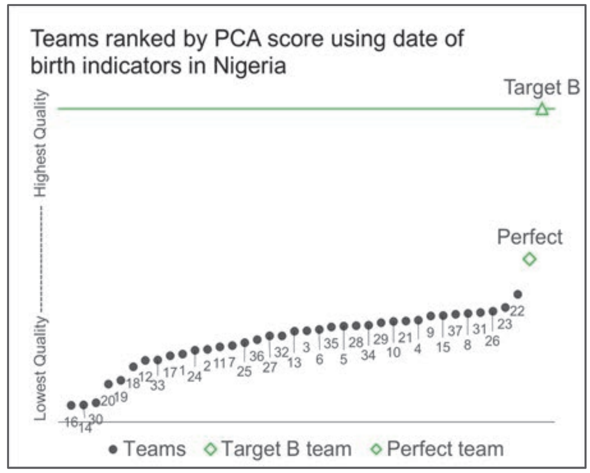
As with the height and weight indicators, scores were predicted for all teams including two additional teams, the Perfect Team and the Target Team. The ranking of the teams based on their PCA scores is shown in Figures 3a-f, with the y-axis reversed, and the lowest scores (highest quality) near the top of the figure.

Among the two countries that were ranked using Target A thresholds, no teams were ranked above the Target Teams, and unexpectedly in Guatemala, the Target Team ranked above the Perfect Team (Figures 3a and 3b). Similarly, the Target Team ranked above the Perfect Team in Egypt and Nigeria (Figures 3e and 3f). In Ethiopia, 7 of 32 teams were ranked higher than the Target B Team, while all teams were ranked above the Target B Team in Chad.

Figures 3a-f Teams ranked by PCA score using date of birth indicators in Guatemala, Nepal, Ethiopia, Chad, Egypt, and Nigeria.







4.5 Team Cumulative Performance during a Survey

To examine cumulative team performance, we show the 20 height and weight data quality indicators in three countries that offer a range of data quality: Guatemala (high quality), Ethiopia (medium quality), and Egypt (low quality) (see Appendix to see tables for Nepal, Chad, and Nigeria). Table 8 shows Guatemala's team performance for these indicators at the end of the survey. Each indicator, calculated by team, is highlighted if any team did not meet Target A for that indicator. In Guatemala, most teams met the indicator targets at the end of the survey, although the WAZ and WHZ skewness and kurtosis indicators did not meet targets despite other WAZ and WHZ indicators falling within the Target A thresholds. The target for weight index was rarely met, although most values for this indicator are low. Some indicators, such as only weight measured, had very low targets. For example, a team had less than 1% only weight measured yet did not perform within the target set for that indicator. This highlights the extreme standards set by some of these targets. The survey total for the weight index met Target A, although only one team was able to meet the target.

The only team that was ranked above Target A was Team 7, which was the only team to not meet the targets for only two indicators, while all other teams failed to meet Target A for at least four or more indicators.

Table 8 Height and weight indicator totals by team and team rankings using PCA scores in Guatemala

Team No.	% Invalid HAZ[1]	% Invalid WAZ[1]	% Invalid WHZ[1]	HAZ SD[2]	WAZ SD[2]	WHZ SD[2]	HAZ skew[2,3]	WAZ skew[2,3]	WHZ skew[2,3]	HAZ kurtosis[2,4]	WAZ kurtosis[2,4]	WHZ kurtosis[2,4]	Height index[2]	Height heaping[2]	Weight index[2]	Incorrect weight digit[5]	Only height measured[2]	Only weight measured[2]	Incorrectly measured[2]	Measured incomplete[2]	Relative team ranking using PCA scores[6]
1	0.3%	0.0%	0.6%	1.21	1.12	1.01	-0.12	0.22	0.08	3.12	4.76	3.95	6%	2%	5%	1%	0%	0%	2%	0%	3
3	0.0%	0.1%	0.3%	1.21	1.08	1.03	-0.17	0.21	0.04	3.17	4.02	4.03	10%	3%	4%	<1%	0%	0%	1%	0%	7
4	0.0%	0.0%	0.0%	1.18	1.08	1.00	-0.03	0.28	0.54	2.69	3.66	4.30	8%	2%	6%	3%	0%	0%	2%	0%	13
5	0.4%	0.0%	0.0%	1.17	1.01	0.94	0.14	0.17	0.58	3.28	3.61	3.92	9%	3%	4%	0%	0%	0%	0%	0%	6
6	0.0%	0.1%	0.1%	1.21	1.12	1.02	0.15	0.45	0.45	3.20	4.14	4.43	5%	2%	3%	1%	0%	0%	5%	0%	15
7	0.2%	0.0%	0.3%	1.18	1.02	0.94	0.03	-0.14	-0.05	3.34	3.56	3.76	8%	3%	2%	<1%	0%	0%	2%	0%	1
8	0.0%	0.0%	0.1%	1.19	1.06	1.01	-0.02	0.29	0.27	3.03	4.37	3.74	6%	1%	4%	<1%	0%	0%	1%	0%	11
9	0.1%	0.0%	0.0%	1.24	1.08	0.98	0.01	0.34	0.37	3.06	4.79	4.16	13%	3%	6%	2%	0%	0%	4%	0%	9
10	0.2%	0.0%	0.1%	1.19	1.09	1.02	0.31	0.28	0.38	4.04	4.56	4.30	7%	1%	5%	2%	0%	0%	2%	0%	12
11	0.2%	0.2%	0.1%	1.22	1.11	1.02	-0.07	0.19	0.20	3.60	3.58	3.97	6%	1%	4%	1%	0%	0%	2%	0%	5
12	0.3%	0.1%	0.3%	1.25	1.06	1.00	0.11	0.14	0.14	3.10	3.58	3.73	7%	2%	4%	<1%	0%	<1%	1%	<1%	2
13	0.1%	0.0%	0.2%	1.13	1.02	0.99	0.09	0.29	-0.04	3.41	3.85	4.47	7%	2%	4%	2%	0%	0%	2%	0%	8
14	0.0%	0.2%	0.4%	1.25	1.13	1.02	0.02	0.28	0.50	2.98	3.63	3.67	11%	3%	6%	1%	0%	0%	2%	0%	10
15	0.3%	0.0%	0.6%	1.16	1.08	0.97	-0.07	0.42	0.45	2.87	4.48	3.96	8%	0%	6%	<1%	0%	0%	2%	0%	14
16	0.0%	0.0%	0.4%	1.17	1.04	0.94	0.19	0.41	0.22	3.06	4.31	3.38	6%	1%	5%	3%	0%	0%	2%	0%	4
17	0.0%	0.0%	0.0%	0.97	1.05	1.16	-0.15	0.53	0.96	3.14	4.68	4.47	10%	1%	12%	0%	0%	0%	3%	0%	16
Survey Total	**0.1%**	**<1%**	**0.2%**	**1.20**	**1.07**	**1.00**	**0.03**	**0.25**	**0.24**	**3.21**	**4.12**	**4.02**	**4%**	**1%**	**1%**	**1%**	**0%**	**<1%**	**2%**	**<1%**	

Note: Teams are not shown if they did not have at least 25 cases by the end of the survey. Abbreviations include SD, standard deviation; HAZ, height-for-age; WAZ, weight-for-age; WHZ, weight-for-height; DMY, day month year; MY, month year.

[1] The percent of implausible values for HAZ, WAZ, and WHZ have a global standard of 1.0% used here instead of Target A.

[2] Target A for HAZ SD = 1.41; WAZ SD = 1.13; WHZ SD = 1.17; HAZ skew = 0.24; WAZ skew = 0.05; WHZ skew = 0.07; HAZ kurtosis = 0.77; WAZ kurtosis = 0.75; WHZ kurtosis = 0.89; Height index = 10%; Height heaping 3%; Weight index 2%; Only height measured = 0.01%; Only weight measured 0.2%; Incorrectly measured 3.1%; Measured incomplete 1.1%;

[3] Skewness highlighted based on the absolute deviation target using their absolute deviation from 0.

[4] Kurtosis highlighted based on the absolute deviation target using their absolute deviation from 3.

[5] There is no target for Incorrect weight digit.

[6] The number 1 indicates the best ranked team, cells are highlighted if teams ranked below the target team using the PCA scores.

Ethiopia's team performance in height and weight indicators, shown in Table 9, is highlighted where teams did not meet Target B. In contrast to Guatemala, many teams in Ethiopia were below Target B despite being held to the lower quality target. The percent of implausible values for HAZ and WHZ seemed difficult targets to reach, although all teams reached the percent of implausible values for WAZ. Nearly two out of three teams were unable to meet Target B for the standard deviations for HAZ and WAZ. Although about half of the teams did not meet Target B for the standard deviation of WHZ, the survey total for this indicator met the target. Many teams were unable to meet Target B for the skew and kurtosis indicators, although the survey total met the target for all of these indicators, except for the HAZ skewness. Targets for height digit preference (both height index and height heaping) were also often missed by teams. The height index was more often missed than the heaping indicator. Incompleteness of data was an issue for nearly every team.

Eight of the 33 teams were ranked above Target B. Many teams did not meet indicator targets, but teams that met most of the implausible values, the standard deviation indicators, and at least one of the weight completeness indicators ranked above Target B.

Table 9 Height and weight indicator totals by team and team rankings using PCA scores in Ethiopia

Team No.	% Invalid HAZ[1]	% Invalid WAZ[1]	% Invalid WHZ[1]	HAZ SD[2]	WAZ SD[2]	WHZ SD[2]	HAZ skew[2,3]	WAZ skew[2,3]	WHZ skew[2,3]	HAZ kurtosis[2,4]	WAZ kurtosis[2,4]	WHZ kurtosis[2,4]	Height index[2]	Height heaping[2]	Weight index[2]	Incorrect weight digit[5]	Only height measured[2]	Only weight measured[2]	Incorrectly measured[2]	Measured incomplete[2]	Relative team ranking using PCA scores[6]
1	0.0%	0.0%	0.0%	1.30	1.04	1.16	0.47	0.25	-0.06	3.48	3.51	4.38	22%	9%	6%	0%	0%	0%	2%	4%	3
2	1.7%	0.0%	2.3%	1.59	1.11	1.16	0.87	0.08	-0.19	5.63	3.82	3.61	21%	4%	9%	0%	0%	<1%	6%	9%	18
3	1.0%	0.0%	1.4%	1.55	1.10	1.31	0.80	0.28	-0.01	5.52	3.06	4.15	12%	3%	9%	<1%	0%	0%	4%	4%	5
4	3.6%	0.7%	1.8%	1.89	1.47	1.39	0.70	0.22	0.45	3.88	3.58	5.02	14%	3%	8%	0%	0%	0%	1%	5%	29
5	2.2%	0.0%	1.9%	1.83	1.41	1.25	0.24	0.36	0.05	2.82	4.15	3.53	32%	16%	11%	<1%	0%	0%	2%	9%	26
6	0.6%	0.0%	0.3%	1.70	1.21	1.24	0.24	-0.23	0.01	2.82	3.58	4.55	14%	6%	7%	0%	0%	3%	2%	13%	16
7	0.0%	0.0%	0.7%	1.27	1.05	1.08	0.30	-0.27	-0.21	3.13	3.40	3.16	7%	0%	8%	0%	0%	0%	2%	2%	2
8	0.8%	0.0%	0.8%	1.57	1.21	1.19	0.30	0.26	-0.31	3.27	3.55	4.26	16%	5%	6%	<1%	0%	1%	3%	4%	6
9	0.4%	0.0%	1.4%	1.52	1.17	1.24	0.82	0.38	0.69	4.79	4.02	4.76	20%	7%	9%	<1%	0%	0%	4%	1%	10
10	1.0%	0.0%	0.5%	1.55	1.21	1.04	0.23	0.11	-0.02	3.42	3.08	3.69	14%	5%	8%	<1%	0%	3%	5%	4%	8
11	0.6%	0.3%	0.6%	1.67	1.20	1.33	0.41	0.16	-0.12	4.40	3.50	3.47	18%	6%	8%	<1%	0%	0%	4%	3%	4
12	2.1%	0.3%	2.9%	1.88	1.28	1.34	0.43	-0.10	0.41	3.64	3.34	4.42	13%	4%	4%	<1%	0%	0%	3%	4%	28
13	2.6%	0.0%	1.2%	1.87	1.27	1.37	0.32	0.01	0.06	3.17	2.98	3.80	10%	1%	10%	<1%	0%	<1%	2%	7%	23
14	1.2%	0.3%	0.9%	1.67	1.31	1.47	0.34	-0.27	0.06	3.27	3.85	4.54	31%	15%	5%	2%	0%	0%	4%	6%	14
15	0.8%	0.0%	0.4%	1.69	1.32	1.21	0.31	0.08	0.08	3.72	3.10	3.38	33%	16%	5%	1%	0%	2%	2%	11%	12
16	1.9%	0.3%	2.5%	1.98	1.39	1.29	0.40	0.38	0.16	2.97	3.18	4.22	25%	12%	5%	2%	0%	1%	2%	15%	30
17	2.6%	0.0%	2.6%	2.09	1.38	1.27	0.39	0.15	0.06	3.44	3.91	3.82	26%	9%	10%	1%	0%	<1%	1%	17%	31
18	1.3%	0.3%	1.9%	1.76	1.36	1.31	0.24	-0.10	0.15	3.58	3.19	4.87	14%	2%	7%	<1%	0%	0%	1%	11%	24
19	0.6%	0.0%	0.6%	1.84	1.37	1.16	0.28	-0.13	0.03	3.33	3.19	3.73	11%	3%	9%	0%	0%	2%	4%	17%	21
20	1.7%	0.3%	0.7%	1.93	1.32	1.33	0.58	0.36	-0.24	3.33	3.42	4.09	16%	4%	12%	1%	0%	1%	2%	5%	20
21	1.0%	0.3%	0.7%	1.84	1.33	1.32	0.48	-0.04	-0.17	3.69	2.68	3.90	18%	8%	8%	0%	<1%	0%	4%	5%	15
22	4.6%	0.0%	4.3%	1.98	1.35	1.36	0.34	0.27	-0.20	3.33	3.60	4.32	16%	4%	3%	1%	<1%	1%	4%	7%	33
23	0.9%	0.3%	1.2%	1.75	1.31	1.09	0.15	-0.09	0.07	3.01	3.81	3.99	11%	3%	6%	<1%	0%	0%	5%	3%	11
24	0.4%	0.0%	1.3%	1.66	1.36	1.26	0.24	0.18	0.03	3.31	4.62	4.39	21%	10%	9%	0%	0%	0%	3%	8%	13
25	0.0%	0.0%	2.0%	1.58	1.27	1.18	0.15	-0.13	0.29	3.32	3.75	3.50	20%	7%	9%	1%	<1%	0%	2%	12%	17
26	0.9%	0.4%	1.8%	1.50	1.18	1.11	0.10	-0.48	-0.11	3.94	3.89	3.92	20%	9%	13%	<1%	0%	0%	4%	8%	7
27	1.3%	0.0%	1.7%	1.70	1.23	1.15	0.33	-0.07	-0.06	3.28	2.63	3.21	27%	13%	14%	0%	0%	2%	4%	18%	22
28	0.4%	0.0%	1.7%	1.77	1.27	1.40	0.56	-0.02	-0.11	3.94	3.40	3.49	36%	15%	11%	0%	0%	1%	3%	20%	25
29	0.0%	0.0%	0.0%	1.15	0.97	0.96	0.10	0.09	0.23	2.77	2.95	4.19	15%	1%	8%	0%	0%	1%	8%	4%	1
30	1.4%	0.0%	1.8%	1.63	1.35	1.28	-0.40	0.04	0.17	3.06	3.06	3.60	27%	12%	7%	0%	0%	1%	2%	5%	19
31	0.0%	0.0%	0.9%	1.53	1.37	1.31	0.10	0.18	0.35	2.92	3.67	3.36	23%	9%	8%	1%	0%	1%	4%	7%	9
32	1.2%	0.0%	1.2%	1.93	1.37	1.29	0.40	0.47	0.18	2.99	4.44	4.90	24%	9%	9%	<1%	0%	0%	4%	12%	27
33	3.9%	0.0%	2.6%	1.80	1.29	1.25	0.44	-0.13	-0.41	3.21	3.17	4.75	16%	5%	9%	<1%	0%	3%	6%	19%	32
Survey Total	**1.4%**	**0.1%**	**1.4%**	**1.77**	**1.30**	**1.28**	**0.39**	**0.07**	**0.04**	**3.57**	**3.56**	**4.11**	**15%**	**6%**	**2%**	**<1%**	**<1%**	**1%**	**3%**	**9%**	

Note: Teams are not shown if they did not have at least 25 cases by the end of the survey. Abbreviations include SD, standard deviation; HAZ, height-for-age; WAZ, weight-for-age; WHZ, weight-for-height; DMY, day month year; MY, month year.

[1] The percent of implausible values for HAZ, WAZ, and WHZ have a global standard of 1.0% used here instead of Target B.

[2] Target B for HAZ SD = 1.59; WAZ SD = 1.23; WHZ SD = 1.30; HAZ skew = 0.37; WAZ skew = 0.10; WHZ skew = 0.14; HAZ kurtosis = 1.13; WAZ kurtosis = 0.96; WHZ kurtosis = 1.12; Height index = 15%; Height heaping 6%; Weight index 3%; Only height measured = 0.05%; Only weight measured 0.4%; Incorrectly measured 8.2%; Measured incomplete 3.9%.

[3] Skewness highlighted based on the absolute deviation target using their absolute deviation from 0.

[4] Kurtosis highlighted based on the absolute deviation target using their absolute deviation from 3.

[5] There is no target for Incorrect weight digit.

[6] The number 1 indicates the best-ranked team, cells are highlighted if teams ranked below the target team using the PCA scores.

Egypt, like Ethiopia, was also considered using Target B values, and like Ethiopia nearly all teams were able to meet the target for implausible values for WAZ, but not the target for implausible values for HAZ and WHZ (Table 10). Many teams were unable to meet targets for the standard deviation indicators, although 3 of the 14 teams (numbers 5, 10, and 13) successfully performed within the targets for these indicators. The target for WHZ kurtosis was met by nearly every team, and unlike Ethiopia, incompleteness of data was not an issue among these teams.

Of the four teams ranked above the Target B Team using the PCA scores, three of the teams met four of the six indicators for implausible values and standard deviation. The team that did not meet four of the six targets had the lowest values for implausible and standard deviation of WHZ of any team that also ranked below the Target B Team. Other indicators showed no apparent pattern with these four teams.

Table 10 Height and weight indicator totals by team and team rankings using PCA scores in Egypt

Team No.	% Invalid HAZ[1]	% Invalid WAZ[1]	% Invalid WHZ[1]	HAZ SD[2]	WAZ SD[2]	WHZ SD[2]	HAZ skew[2,3]	WAZ skew[2,3]	WHZ skew[2,3]	HAZ kurtosis[2,4]	WAZ kurtosis[2,4]	WHZ kurtosis[2,4]	Height index[2]	Height heaping[2]	Weight index[2]	Incorrect weight digit[5]	Only height measured[2]	Only weight measured[2]	Incorrectly measured[2]	Measured incomplete[2]	Relative team ranking using PCA scores[6]
1	7.0%	0.8%	10.8%	2.12	1.44	1.61	0.04	-0.14	-0.15	3.10	3.33	3.17	20%	10%	18%	<1%	0%	0%	5%	2%	11
2	5.0%	0.8%	10.6%	2.19	1.47	1.93	0.00	-0.45	-0.08	2.52	4.15	2.74	43%	5%	20%	<1%	0%	0%	3%	1%	13
3	9.3%	1.9%	27.2%	2.47	2.25	2.35	-0.26	0.13	0.56	2.50	2.32	2.41	31%	5%	14%	<1%	0%	0%	3%	1%	14
4	1.4%	0.3%	2.1%	1.70	1.20	1.56	0.26	0.15	-0.05	4.24	4.22	3.44	26%	12%	11%	<1%	0%	0%	1%	1%	5
5	1.3%	0.3%	1.6%	1.49	1.00	1.29	0.84	0.16	-0.46	5.98	4.22	4.64	20%	4%	10%	<1%	0%	0%	1%	2%	3
6	2.3%	0.6%	3.5%	1.90	1.22	1.56	-0.08	-0.39	-0.19	3.87	4.31	4.03	24%	5%	14%	1%	0%	0%	3%	1%	8
7	5.8%	0.5%	7.5%	2.03	1.51	1.72	0.17	-0.10	-0.32	2.97	3.84	3.54	22%	11%	10%	<1%	0%	<1%	5%	<1%	9
8	4.1%	0.8%	7.0%	2.32	1.29	1.72	0.58	0.55	-0.35	3.16	4.35	3.14	16%	5%	9%	<1%	0%	0%	1%	1%	12
9	2.8%	0.2%	5.4%	1.96	1.20	1.67	0.38	0.11	-0.17	3.72	5.17	3.40	13%	3%	10%	<1%	0%	0%	4%	1%	6
10	1.3%	0.1%	0.9%	1.55	1.11	1.22	0.41	-0.15	0.04	4.72	5.01	3.74	16%	1%	10%	1%	0%	0%	1%	1%	2
11	9.6%	0.5%	9.8%	2.35	1.38	1.85	-0.05	-0.23	0.15	2.59	4.15	2.67	41%	15%	23%	<1%	0%	<1%	9%	3%	10
12	4.5%	0.3%	5.6%	1.93	1.26	1.66	0.29	-0.06	-0.14	3.69	4.04	3.25	36%	4%	20%	4%	<1%	<1%	3%	4%	7
13	0.2%	0.1%	0.6%	1.37	1.04	1.17	0.28	-0.05	-0.23	4.41	3.58	3.71	20%	9%	9%	<1%	0%	0%	2%	2%	1
14	3.3%	0.1%	1.1%	1.73	1.11	1.32	0.85	0.11	-0.35	4.40	4.32	4.21	22%	6%	9%	<1%	0%	0%	5%	3%	4
Survey Total	**4.2%**	**0.5%**	**6.8%**	**2.16**	**1.39**	**1.80**	**0.33**	**-0.14**	**-0.30**	**3.29**	**4.21**	**3.31**	**21%**	**4%**	**10%**	**1%**	**<1%**	**<1%**	**3%**	**1%**	

Note: Teams are not shown if they did not have at least 25 cases by the end of the survey. Abbreviations include SD, standard deviation; HAZ, height-for-age; WAZ, weight-for-age; WHZ, weight-for-height; DMY, day month year; MY, month year.

[1] The percent of implausible values for HAZ, WAZ, and WHZ have a global standard of 1.0% used here instead of Target B (WHO/UNICEF 2019).

[2] Target B for HAZ SD = 1.59; WAZ SD = 1.23; WHZ SD = 1.30; HAZ skew = 0.37; WAZ skew = 0.10; WHZ skew = 0.14; HAZ kurtosis = 1.13; WAZ kurtosis = 0.96; WHZ kurtosis = 1.12; Height index = 15%; Height heaping 6%; Weight index 3%; Only height measured = 0.05%; Only weight measured 0.4%; Incorrectly measured 8.2%; Measured incomplete 3.9%.

[3] Skewness highlighted based on the absolute deviation target using their absolute deviation from 0.

[4] Kurtosis highlighted based on the absolute deviation target using their absolute deviation from 3.

[5] There is no target for Incorrect weight digit.

[6] The number 1 indicates the best ranked team, cells are highlighted if teams ranked below the target team using the PCA scores.

4.6 Team Performance during a Survey

Looking beyond a team's final indicator values, we can also look at a team's performance during the survey. Again, we use Guatemala, Ethiopia, and Egypt to look at survey performance using both Target A and B (see Appendix for other study countries). We examined the standard deviation and percent of implausible values of HAZ, a commonly assessed data quality indicator that had a spread of values across 147 countries (Table 11). Here you can see the survey divided into quarters based on the days in the field.

Guatemala's fieldwork did not generate enough cases to assess these indicators by week, although quarters have enough cases to make a meaningful assessment survey performance over time. Guatemala had exceptional survey performance, with every team meeting Target A for the standard deviation of HAZ for each quarter of the survey. This meant that the total indicator value for the standard deviation of HAZ was achieved in all 16 teams. Although teams consistently met this target through the survey, the standard deviation decreased from quarters one to three, though increased in most of the teams from quarters three to four. We do not know if these changes are significant. Implausible values of HAZ were also an easy target to meet, except for one team in the second quarter.

Table 11 **Quarterly team values for the standard deviation and percent of implausible values of HAZ by team and survey total in Guatemala**

	HAZ SD						% HAZ implausible					
Team No.	**Q1**	**Q2**	**Q3**	**Q4**	**Total**	**Quarters team met target[1]**	**Q1**	**Q2**	**Q3**	**Q4**	**Total**	**Quarters team met target[2]**
1	1.24	1.20	1.11	1.03	**1.21**	**4/4**	0.3%	0.0%	1.0%	0.0%	**0.3%**	**4/4**
3	1.16	1.10	1.38	1.11	**1.21**	**4/4**	0.0%	0.0%	0.0%	0.0%	**0.0%**	**4/4**
4	1.22	0.98			**1.18**	**2/2**	0.0%	0.0%			**0.0%**	**2/2**
5		1.25	1.13	1.18	**1.17**	**3/3**		0.0%	0.4%	0.4%	**0.4%**	**3/3**
6	1.25	1.10	1.00	1.23	**1.21**	**4/4**	0.0%	0.0%	0.0%	0.0%	**0.0%**	**4/4**
7	1.26	1.13	0.96	1.08	**1.18**	**4/4**	0.0%	0.0%	0.0%	0.7%	**0.2%**	**4/4**
8	1.21	1.20	0.99	1.02	**1.19**	**4/4**	0.0%	0.0%	0.0%	0.0%	**0.0%**	**4/4**
9	1.04	1.29	1.25	1.16	**1.24**	**4/4**	0.0%	0.0%	0.4%	0.0%	**0.1%**	**4/4**
10	1.21	1.08	1.07	1.26	**1.19**	**4/4**	0.0%	0.4%	0.0%	0.6%	**0.2%**	**4/4**
11	1.27	1.20	1.13	1.16	**1.22**	**4/4**	0.7%	0.0%	0.0%	0.0%	**0.2%**	**4/4**
12	1.31	1.18	1.10	1.19	**1.25**	**4/4**	0.0%	1.1%	0.0%	0.0%	**0.3%**	**3/4**
13	1.31	0.96	1.09	1.12	**1.13**	**4/4**	0.0%	0.0%	0.0%	0.3%	**0.1%**	**4/4**
14	1.30	1.17		(0.72)	**1.25**	**3/3**	0.0%	0.0%		(0.0%)	**0.0%**	**3/3**
15		1.11	1.06	1.08	**1.16**	**3/3**		0.6%	0.4%	0.0%	**0.3%**	**3/3**
16	0.99	1.18	1.03	1.24	**1.17**	**4/4**	0.0%	0.0%	0.0%	0.0%	**0.0%**	**4/4**
17				0.97	**0.97**	**1/1**				0.0%	**0.0%**	**1/1**
Total	**1.24**	**1.18**	**1.11**	**1.15**	**1.20**	**4/4**	**0.1%**	**0.2%**	**0.2%**	**0.2%**	**0.1%**	**4/4**
	Percent of teams who met the target					**No. of teams**	**Percent of teams who met the target**					**No. of teams**
	Q1	**Q2**	**Q3**	**Q4**	**Total**		**Q1**	**Q2**	**Q3**	**Q4**	**Total**	
	100%	100%	100%	100%	**100%**	16	100%	93%	100%	100%	**100%**	16

Note: Estimates that did not meet targets are highlighted in blue. Some teams have been excluded if they did not have at least 25 cases at the end of the survey. Quarterly values shown in parentheses are based on <25 cases. Abbreviations include SD standard deviation; HAZ height-for-age. All implausible values are rounded to nearest tenth of a percent.
[1] Target A for the standard deviation of HAZ is 1.41.
[2] The percent of implausible values for HAZ, WAZ, and WHZ have a global standard of 1.0% used here instead of Target A (WHO/UNICEF 2019).

In Ethiopia, a country whose data quality was mid-range, only 30% of the 33 teams were able to meet Target B for the standard deviation of HAZ by the end of the survey (Table 12). Only one team met the target every quarter. Although there were seven teams who met the target three out of four quarters, two of these teams were still unable to meet the indicator by the survey's end. This indicated that one very poor quarter held weight over their final indicator performance. Ten of the 33 teams did not meet the target for any quarter. Each quarter's total value for this indicator was very similar and no quarter emerged with the best performance. A higher percentage of teams was able to meet the target for the percent of implausible values in each quarter; only 2 of the 33 teams were able to achieve the target all four quarters. Teams 1, 7, and 29 were the only teams to achieve targets for both indicators in every quarter.

Table 12 Quarterly team values for the standard deviation and percent of implausible values of HAZ in Ethiopia

	HAZ SD						% HAZ Implausible					
Team No.	**Q1**	**Q2**	**Q3**	**Q4**	**Total**	**Quarters team met target**	**Q1**	**Q2**	**Q3**	**Q4**	**Total**	**Quarters team met target**
1	1.44	1.16	1.17	1.23	**1.30**	**4/4**	0.0%	0.0%	0.0%	0.0%	**0.0%**	**4/4**
2	1.57	1.56	1.08	1.98	**1.59**	**3/4**	0.0%	1.1%	4.1%	1.3%	**1.7%**	**1/4**
3	1.61	1.50	1.78	1.32	**1.55**	**2/4**	1.1%	1.2%	0.0%	1.5%	**1.0%**	**1/4**
4	1.94	1.80	1.98	1.78	**1.89**	**0/4**	2.9%	5.2%	3.0%	2.4%	**3.6%**	**0/4**
5	1.76	1.82	1.89	1.68	**1.83**	**0/4**	2.4%	2.9%	2.9%	0.0%	**2.2%**	**1/4**
6	1.80	1.61	1.63	1.96	**1.70**	**0/4**	1.6%	0.0%	0.7%	0.0%	**0.6%**	**3/4**
7	1.46	1.20	1.08	1.31	**1.27**	**4/4**	0.0%	0.0%	0.0%	0.0%	**0.0%**	**4/4**
8	1.22	1.56	1.93	1.46	**1.57**	**3/4**	0.0%	0.0%	1.7%	1.3%	**0.8%**	**2/4**
9	1.60	1.39	1.42	1.63	**1.52**	**2/4**	0.0%	0.0%	0.0%	1.4%	**0.4%**	**3/4**
10	1.54	1.41	1.47	1.74	**1.55**	**3/4**	0.0%	1.9%	0.0%	2.0%	**1.0%**	**2/4**
11	1.81	1.68	1.57	1.62	**1.67**	**1/4**	0.0%	1.6%	0.0%	0.0%	**0.6%**	**3/4**
12	1.89	2.04	1.89	1.38	**1.88**	**1/4**	0.9%	3.3%	3.5%	0.0%	**2.1%**	**2/4**
13	1.66	1.85	1.55	2.36	**1.87**	**1/4**	0.0%	2.2%	0.0%	8.7%	**2.6%**	**2/4**
14	1.52	1.80	1.67	1.68	**1.67**	**1/4**	1.3%	1.9%	0.0%	1.3%	**1.2%**	**1/4**
15	1.44	1.87	1.53	1.94	**1.69**	**2/4**	1.2%	0.0%	0.0%	1.7%	**0.8%**	**2/4**
16	2.01	1.99	1.85	1.81	**1.98**	**0/4**	2.7%	2.7%	0.0%	2.6%	**1.9%**	**1/4**
17	2.13	1.83	1.92	2.29	**2.09**	**0/4**	2.5%	0.0%	0.0%	7.2%	**2.6%**	**2/4**
18	1.84	1.72	1.71	1.73	**1.76**	**0/4**	0.0%	0.9%	2.6%	1.2%	**1.3%**	**2/4**
19	1.84	1.62	1.71	2.01	**1.84**	**0/4**	0.0%	2.1%	0.0%	0.0%	**0.6%**	**3/4**
20	1.63	1.76	2.01	2.30	**1.93**	**0/4**	1.1%	3.6%	1.8%	0.0%	**1.7%**	**1/4**
21	1.87	2.18	1.57	1.75	**1.84**	**1/4**	1.2%	3.9%	0.0%	0.0%	**1.0%**	**2/4**
22	1.76	2.08	2.03	1.85	**1.98**	**0/4**	2.9%	4.2%	9.9%	1.2%	**4.6%**	**0/4**
23	1.81	1.60	1.54	1.86	**1.75**	**1/4**	1.9%	1.4%	0.0%	0.0%	**0.9%**	**2/4**
24	1.45	1.61	1.97	1.62	**1.66**	**1/4**	0.0%	0.0%	2.3%	0.0%	**0.4%**	**3/4**
25	1.58	1.46	1.34	1.70	**1.58**	**3/4**	0.0%	0.0%	0.0%	0.0%	**0.0%**	**4/4**
26	1.42	1.29	1.70	1.40	**1.50**	**3/4**	0.0%	0.0%	1.3%	1.7%	**0.9%**	**2/4**
27	1.90	1.85	1.30	(1.28)	**1.70**	**2/4**	0.9%	0.0%	1.5%	(4.5%)	**1.3%**	**2/4**
28	2.05	1.45	1.68	(1.24)	**1.77**	**2/4**	1.1%	0.0%	0.0%	(0.0%)	**0.4%**	**3/4**
29	1.19	1.10	1.26	(1.09)	**1.15**	**4/4**	0.0%	0.0%	0.0%	(0.0%)	**0.0%**	**4/4**
30	1.17	1.32	1.96	1.49	**1.63**	**3/4**	0.0%	0.0%	1.9%	1.9%	**1.4%**	**2/4**
31	1.16	1.62	1.39	1.53	**1.53**	**3/4**	0.0%	0.0%	0.0%	0.0%	**0.0%**	**4/4**
32	1.92	1.92	1.77	1.96	**1.93**	**0/4**	1.2%	2.3%	0.0%	0.0%	**1.2%**	**2/4**
33	1.82	1.97	1.57	(2.04)	**1.80**	**1/4**	2.3%	4.9%	4.5%	(0.0%)	**3.9%**	**1/4**
Total	**1.76**	**1.77**	**1.72**	**1.80**	1.77	**0/4**	**1.0%**	**1.7%**	**1.4%**	**1.3%**	**1.4%**	**1/4**
	Percent of teams who met the target					**No. of teams**	**Percent of teams who met the target**					**No. of teams**
	Q1	**Q2**	**Q3**	**Q4**	**Total**		**Q1**	**Q2**	**Q3**	**Q4**	**Total**	
	39%	36%	45%	33%	**30%**	33	55%	48%	61%	52%	**45%**	33

Note: Estimates that did not meet targets are highlighted in blue. Some teams have been excluded if they did not have at least 25 cases at the end of the survey. Values shown in parentheses are based on <25 cases. Abbreviations include SD standard deviation; HAZ height-for-age. All implausible values are rounded to nearest tenth of a percent.
[1] Target B for the standard deviation of HAZ is 1.59.
[2] The percent of implausible values for HAZ, WAZ, and WHZ have a global standard of 1.0% used here instead of Target B (WHO/UNICEF 2019).

In Egypt, only 21% of teams meet Target B for the standard deviation of HAZ by the end of the survey (Table 13). Only one team met the target every quarter. Eleven of the 14 teams either met the target in only one quarter or did not meet the target any quarter. The first quarter was the most successful for all teams—although the first quarter's value for the standard deviation of HAZ did not meet Target B, 6 of the 14 teams met the target that quarter, which was more teams than any other quarter. The quarters show improvement in the percent of teams that are able to meet the targets for the percent of implausible values, though this is not reflected among the teams. Teams that improved one quarter may not have sustained improvement through the subsequent quarter.

Table 13 Quarterly team values for the standard deviation and percent of implausible values of HAZ in Egypt

	HAZ SD						% HAZ Implausible					
Team No.	**Q1**	**Q2**	**Q3**	**Q4**	**Total**	**Quarters team met target[1]**	**Q1**	**Q2**	**Q3**	**Q4**	**Total**	**Quarters team met target[2]**
1	1.36	1.64	2.03	2.42	**2.12**	**1/4**	2.4%	4.0%	4.0%	10.6%	**7.0%**	**0/4**
2	2.34	2.01	2.10	1.95	**2.19**	**0/4**	1.2%	4.8%	7.0%	7.6%	**5.0%**	**0/4**
3	2.38	2.46	2.38	2.53	**2.47**	**0/4**	9.1%	8.7%	6.1%	13.7%	**9.3%**	**0/4**
4	1.32	1.94	1.78	1.64	**1.70**	**1/4**	1.1%	2.5%	0.3%	2.1%	**1.4%**	**1/4**
5	1.54	1.69	1.56	1.23	**1.49**	**3/4**	1.5%	1.7%	1.6%	0.7%	**1.3%**	**1/4**
6	1.88	1.77	2.04	1.85	**1.90**	**0/4**	4.4%	1.5%	2.2%	1.5%	**2.3%**	**0/4**
7	1.43	2.09	2.04	2.03	**2.03**	**1/4**	7.6%	2.1%	5.9%	8.4%	**5.8%**	**0/4**
8	2.17	1.98	2.50	2.62	**2.32**	**0/4**	3.7%	1.5%	6.3%	6.2%	**4.1%**	**0/4**
9	1.59	1.93	1.98	1.83	**1.96**	**1/4**	2.3%	3.5%	3.9%	1.3%	**2.8%**	**0/4**
10	1.76	1.45	1.43	1.43	**1.55**	**3/4**	2.3%	0.8%	1.4%	0.5%	**1.3%**	**2/4**
11	2.12	2.42	2.21	2.18	**2.35**	**0/4**	11.3%	11.8%	5.5%	8.7%	**9.6%**	**0/4**
12	1.96	2.05	1.62	1.87	**1.93**	**0/4**	7.1%	5.8%	0.4%	1.3%	**4.5%**	**1/4**
13	1.41	1.39	1.31	1.38	**1.37**	**4/4**	0.7%	0.0%	0.2%	0.0%	**0.2%**	**4/4**
14	1.47	1.70	1.75	2.10	**1.73**	**1/4**	1.6%	3.7%	2.1%	9.6%	**3.3%**	**0/4**
Total	**1.88**	**2.20**	**2.17**	**2.37**	**2.16**	**0/4**	**4.0%**	**4.0%**	**3.2%**	**5.6%**	**4.2%**	**0/4**
	Percent of teams who met the target					**No. of teams**	**Percent of teams who met the target**					**No. of teams**
	Q1	**Q2**	**Q3**	**Q4**	**Total**		**Q1**	**Q2**	**Q3**	**Q4**	**Total**	
	50%	14%	21%	21%	**21%**	14	7%	14%	21%	21%	**7%**	14

Note: Estimates that did not meet targets are highlighted in blue. Some teams have been excluded if they did not have at least 25 cases at the end of the survey. Values shown in parentheses are based on <25 cases. All implausible values are rounded to nearest tenth of a percent.

[1] Target B for the standard deviation of HAZ is 1.59.

[2] The percent of implausible values for HAZ, WAZ, and WHZ have a global standard of 1.0% used here instead of Target B (WHO/UNICEF 2019).

5 DISCUSSION

The current study is a comprehensive assessment of anthropometry data quality indicators that can be used to identify poorly performing teams during fieldwork. We find that there was substantial team variation in data quality indicators in the lower quality surveys and little variation in the higher quality surveys. The use of implausible anthropometry z-score values, anthropometry z-score standard deviations, or both, appear to be among the most useful data quality indicators. Retaining additional indicators that may occur rarely (such as data incompleteness) is also important for identifying outlier teams. In general, patterns of improvements or degeneration by teams as fieldwork progressed was not seen. Use of a composite score to identify poorly performing teams shows promise but requires further examination of data quality indicators individually to provide precise selection of teams who are performing suboptimally.

5.1 What Indicators Can be Used to Assess Anthropometry Data Quality During Fieldwork, and Are Any Indicators Redundant?

The multidimensional nature of anthropometry requires a variety of data quality indicators that can capture the different components of anthropometry. There were 26 indicators identified in this study as potentially useful for monitoring anthropometry data quality. We organized these indicators into elements related to height, weight, or both (20 indicators), and elements related to date of birth (6 indicators). We suggest excluding half of the indicators used to identify quality issues for anthropometry (13 of the 26 indicators), based on team variation, PCA factor loadings, and correlation coefficients of these indicators.

Height and weight indicators

Incompleteness of height and weight measurements, while not an issue in all surveys that were examined, can cause selection bias if not remedied (Rutstein 2014). For instance, this indicator had noticeable PCA loadings in Ethiopia, where the teams had a large range of incompleteness. Measuring only height or only weight were exceptionally rare occurrences. These indicators were not available for the correlation analysis or PCA in some countries due to the lack of variance. When available, these indicators showed no evidence of usefulness.

Six indicators—the standard deviations and the implausible values of WAZ, HAZ, and WHZ—offered variance among teams, had the highest factor loadings in the height and weight PCA analysis, and were highly correlated in the lowest quality surveys. Additionally, there is a strong evidence base for using these indicators post-survey (Mei and Grummer-Strawn 2007; WHO/UNICEF 2019). These findings suggest that these six indicators are important measures of data quality. The correlation between these indicators suggests the potential to reduce to fewer indicators. Among the six indicators, those related to HAZ and WHZ showed a greater range between teams compared to WAZ, and also are more relevant indicators given that stunting (HAZ < -2SD), wasting (WHZ < -2 SD), and obesity (WHZ > 2 SD) are commonly used for policy and programmatic purposes while underweight (WAZ < -2SD) is not (United Nations 2017).

The skew and kurtosis of the anthropometry z-scores distributions were typically right skewed and leptokurtic in the surveys that were examined. However, the WHO growth standards for which the assumption of normality is drawn are based on a healthy population and it is conceivable that unusual distributions may occur in populations that are more heterogeneous (WHO/UNICEF 2019). Given that we identified teams outside the normal ranges for skew and kurtosis even in the high-performing surveys further brings the use of these indicators into question. Additionally, apart from WHZ skewness, these indicators were negligible in the PCA analysis. The WHZ skewness deserves further attention because the more extreme cases observed in the right of the tail of WHZ distribution (children classified as obese) can be the result of measurement error or a double burden of malnutrition (N. C. D. Risk Factor Collaboration 2017). Lack of knowledge about the expected shape of the distribution of a malnourished population, and lack of contributing evidence in other things considered, suggest that skew and kurtosis would not add clarity to fieldwork monitoring.

The digit preference indicators for height and weight showed variation across teams. Digit preference was more common for height digits than weight digits, which would be expected because height is read off a ruler and weight from a numerical display. However, the factor loadings for these indicators were negligible in most cases. Additionally, the index of dissimilarity of weight is not based on the final digit of weight and may not be as valuable as the index of dissimilarity of a final digit in identifying data quality issues. The index of dissimilarity is sensitive to sample size and would likely benefit from a method that takes this into account, such as the chi-square test of homogeneity used by SMART, and the WHO Monica blood pressure study (Kuulasmaa, Hense, and Tolonen 1998; Standardized Monitoring & Assessment of Relief & Transitions (SMART)).

The indicator for incorrectly measured children was not a rare occurrence, although it had negligible loadings in the PCA results. Research should be done to determine the extent to which this indicator yields poor data quality, especially given only small adjustments are made for measuring a child who is standing versus being measured lying down.

Date of birth indicators

Anthropometry indices are particularly sensitive to the quality of date of birth information since children grow rapidly. Similar to previous findings we showed that team performance on month and year of birth incompleteness was nearly perfect across surveys (Pullum 2006) while there was variation by teams for day, month, and year incompleteness. This variation included some very problematic cases such as in Chad, with 87% incompleteness in the worst-performing team. Although the latter indicator did not contribute to the PCA factor loadings, it remains important because, in some cases, it may be necessary to return to households to collect complete date of birth data.

Given the need for a more sensitive indicator of date of birth, we explored the use of digit preference and HAZ and WAZ intervals. While the digit preference indicators appeared to perform well, these indicators have the same limitation as the height and weight index, and a different approach to detecting digit preference may be warranted. In contrast, the HAZ and WAZ intervals as a measure of month of birth misreporting show promise (Larsen, Headey, and Masters 2019). We found that the HAZ and WAZ intervals were highly correlated in four of the six study countries and had exceptionally high factor loadings in the date of birth PCA in every country except Nigeria. Though the HAZ and WAZ intervals were correlated, the median HAZ interval among teams was larger than the median WAZ interval in every country. These findings suggest that only one of the two indicators is needed, and that the HAZ interval would likely be the more robust indicator. In addition to reflecting data quality, these intervals may be prone to a confounding relationship between birth month, seasonality, and child growth. Thus testing the validity of these indicators is needed (Dorelien 2015).

5.2 Can We Detect Poorly Performing Teams during Fieldwork?

To identify poorly performing teams, it is necessary to apply a criterion that can ascertain the quality of each team's data. An important outcome of this study is the development of anthropometry data quality indicator targets to define a threshold of what constitutes good data quality. These targets augment our ability to detect teams that are performing poorly during data collection and might also be applicable in the interpretation of the data quality post survey.

Using a data-driven approach, we defined two separate targets levels, Target A and Target B, based on the top 25th percentile and the median from 147 DHS surveys. The decision to develop two target levels recognizes the different contexts where The DHS Program and similar programs operate and allows for flexibility in selecting achievable targets when considering the context or the quality of the previous survey's data. We did not create a specific algorithm for selecting suitable target levels for a survey nor whether the same target level should be applied across indicators. A nonprescriptive approach allows for experienced implementors to use criteria such as past survey performance, country infrastructure and terrain, and implementation agency capacity to select a target level.

In our study, meaningful targets for some but not all data quality indicators were identified. First, we compared our targets to global targets for the only anthropometry data quality indicator for which they existed: implausible anthropometry z-score values. Our constructed target values for implausible HAZ and WHZ for Target A (0.7% and 1.0%, respectively) are relatively comparable to the 1% threshold recommended by UNICEF-WHO, but are higher in the case of Target B (HAZ 1.6%, WHZ 2.0%). Implausible WAZ values from our two constructed targets were lower than the UNICEF-WHO 1% target (0.1% and 0.3%) (WHO/UNICEF 2019).

Our targets for anthropometry z-score standard deviations are higher at both target levels than previously recommended WHO cutoffs for determining data quality using standard deviations (WHO Expert Committee 1995). More recent recommendations from UNICEF-WHO acknowledge the need to revise these cutoffs, and this work contributes to filling this need (WHO/UNICEF 2019).

The constructed targets for the shape of the distribution (skew and kurtosis) and digit preference were problematic. Skew and kurtosis are heavily influenced by the number of cases in the distribution. Using whole survey estimates from the 147 countries makes the targets difficult to apply to survey data stratified by team and week, where the number of cases could be small. Digit preference is affected similarly. The index of dissimilarity is likely diminished when using all cases in a survey because digit preference may be occurring on different digits among different teams, creating a canceling effect. Additionally, digit preference has limited meaning without considering the number of cases, which should be used to determine the allowable index of dissimilarity. These issues would manifest in targets being unreasonably low and difficult to meet, which is confirmed in our analysis.

Like digit preference, targets for incompleteness may be unreasonably low simply because higher targets would be acceptable in real-time data collection and we want to avoid unnecessary flagging of teams that are performing acceptably. A wider threshold could be applied to make this target less sensitive in order to only detect gross issues.

Although targets are critical to detecting poorly performing teams and real-time data quality, field work monitoring can be an overwhelming endeavor given that anthropometry is only one of many areas monitored in multitopic surveys like DHS surveys. Given the need for pragmatism, we developed a summary measure using PCA to distill anthropometry data quality and detect below-standard performance during fieldwork. We divided this approach into two main components: PCA using measurements of height and weight, and PCA using measurements of date of birth. A robust summary measure could supersede the need for targets if poor performance could be identified through the measure.

The PCA using height and weight measurements did not convey meaningful results across all countries, although the percent of variance explained by the principal component was much greater in the lower quality surveys, and the team rankings were more meaningful as well in those countries. Due to the range in variance and inconsistency in the sign and magnitude of loadings, the use of PCA to create a summary measure for height and weight raises concerns. These loadings indicate that these indicators are not one-dimensional but are multidimensional, and the PCA is not capturing the variance in one component. Moreover, when inspecting the team ranking results of the date of birth PCA, it is unclear why the Perfect Team was often ranked below other teams. The lack of variance among the few date of birth indicators made it difficult to differentiate among the teams in the PCA. The findings of the PCAs suggest that summary measures may be possible, but not in a uniform approach across situations. Though low-quality survey data had more meaningful results than high-quality survey data, a summary measure must be sufficiently robust to identify poorly performing teams in any country.

Nevertheless, this may not fully negate the usefulness of the team rankings in providing an overall view of how teams are performing in relation to each other and against a Target Team. Examining indicators independently, the same teams that were identified as performing above the threshold in the composite score were those identified as performing well or poorly using individual indicators.

5.3 Is the Level of Data Quality Consistent over Time during Fieldwork?

When examining the two robust indicators—standard deviation and implausible values of HAZ—to understand team and survey performance over time, we did not find a pattern of improvement or decline in quarterly performance. Generally, most teams met the target in all quarters in high-quality surveys and did not meet the target in any quarter in the low-quality surveys. While often both standard deviation and percent of implausible values were flagged, there are cases where a team was able to achieve the target for one indicator without the other. Based on current evidence, we may not be able to predict if teams will improve or decline. This makes early and constant monitoring critical to ensure data quality.

5.4 Limitations and Future Research

There are several limitations to this work. We are limited by the lack of a gold standard that can be used to validate the data quality indicators in this study. This is especially challenging for certain indicators, such as those related to anthropometry z-score distributions, because they are an artifact of both measurement error and heterogeneity in the population.

We understand the indicators we selected may not fully capture all anthropometry data quality issues, and there are known, available indicators that would have been possible to include using our data source. We excluded age and sex ratios, which have been used to judge selection bias (Corsi, Perkins, and Subramanian

2017). Our rationale for not including these indicators is the lack of agreement on an appropriate age and sex ratio across contexts, and the concern that requiring indicators that incorporate a country's reference population is likely impractical for use in real-time data collection (Corsi, Perkins, and Subramanian 2017). Moreover, age displacement indicators are already monitored because this is where selection bias is most likely to occur in DHS surveys (Pullum and Staveteig 2017).

There are also important considerations for the approach we used to derive the thresholds. As previously mentioned, using aggregate-level estimates to create targets that are applied to team performance may not reflect the type of variation that may be typical among teams within a survey, inadvertently creating harsh targets. In some cases this may inappropriately flag nonissues, for instance, previous research has used more generous thresholds for the index of dissimilarity (Randall and Coast 2016). Secondly, our analysis was restricted to DHS surveys and it is possible that the thresholds would change if other survey sources were included. Finally, and most importantly, adopting an outcome-based approach rather than a data-dependent method could potentially result in more meaningful thresholds.

In this study we do not separate height and weight data quality. More research should center around differentiating measurement error for height, weight, date of birth data using existing indicators and new indicators. For instance, UNICEF-WHO now recommends anthropometry remeasurements in the field. As this procedure becomes more commonplace, this may offer an opportunity to distinguish between the components of anthropometry measurement error (WHO/UNICEF 2019).

There is a need to determine which of the remaining indicators to retain and which new indicators to include. Building on our work, an analysis of the impact of data quality indicators on stunting and wasting estimates would greatly contribute to the evidence and would result in a more informed selection of indicators. There would also be the potential to develop a more relevant composite score based by weighting indicators according to their relative importance. Future work should consider interpretability by field work monitors, ability to detect poor performance early in fieldwork, and the impact of these indicators on malnutrition estimates.

6 CONCLUSIONS

There is an increasing demand for high-quality and internationally comparable data to hold countries accountable for meeting the SDG targets and evaluate the impact of nutrition programs. Population-based surveys are an important source of nutritional status estimates with The DHS Program recognized as a long-standing gold standard of survey research. The implementation of such large-scale surveys is complex and challenging, particularly when collecting data on something as sensitive as anthropometry where even small measurement errors can lead to misclassification of malnutrition.

Relatively limited research has been devoted to finding the best approach to assess anthropometry data quality during fieldwork despite the attention paid to monitoring data collection. We found that indicators exist that can provide insight into the quality of the anthropometric data during fieldwork. Further, we reduced our set of 26 indicators in half and feel confident that, with further research, this list of indicators could be reduced further into an even more manageable package of indicators to monitor fieldwork. We use a data-based system to create targets—creating more meaningful interpretation of indicators to detect poor team performance. Lastly, we find selecting poorly performing teams using a summary measure to have varying value based on the quality of the survey data, suggesting that summary measures may be useful if created in a context-specific situation. Monitoring data collectors during fieldwork provides an opportunity to make course corrections in real time and has the potential to yield higher-quality data.

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APPENDICES

Table A1 Summary of Pearson's correlation coefficients for all data quality indicators in Guatemala

	HAZ implausible	WAZ implausible	WHZ implausible	HAZ sd	WAZ sd	WHZ sd	HAZ skewness	WAZ skewness	WHZ skewness	HAZ kurtosis	WAZ kurtosis	WHZ kurtosis	Height index	Height heaping	Weight index	Incorrect weight digit	Only height measured	Only weight measured	Incorrectly measured	Measured incomplete	Day of birth index	Month of birth index	HAZ Jan-Dec interval	WAZ Jan-Dec interval	DMY of birth incomplete	MY of birth incomplete*
HAZ implausible	1.00	-0.16	0.27	0.20	-0.15	-0.38	0.14	-0.40	-0.19	0.29	-0.05	-0.12	-0.12	-0.03	-0.24	-0.33		0.32	-0.42	0.32	-0.21	-0.13	-0.13	-0.28	-0.07	
WAZ implausible	-0.16	1.00	0.09	0.44	0.61	0.19	-0.13	-0.08	-0.06	0.08	-0.49	-0.17	0.01	0.18	-0.17	-0.14		0.19	-0.06	0.19	-0.13	0.01	-0.38	-0.10	0.20	
WHZ implausible	0.27	0.09	1.00	0.23	0.31	-0.24	-0.20	-0.09	-0.42	-0.21	0.13	-0.45	-0.20	-0.14	-0.15	-0.11		0.10	-0.16	0.10	-0.35	-0.21	-0.13	-0.05	-0.16	
HAZ sd	0.20	0.44	0.23	1.00	0.45	-0.58	0.23	-0.43	-0.52	0.00	-0.30	-0.42	-0.06	0.39	-0.70	0.15		0.25	-0.20	0.25	-0.83	-0.75	-0.74	-0.55	0.60	
WAZ sd	-0.15	0.61	0.31	0.45	1.00	0.29	-0.21	0.25	0.08	-0.06	0.19	0.04	-0.05	-0.08	0.06	0.01		-0.05	0.29	-0.05	-0.15	-0.10	-0.02	0.16	0.48	
WHZ sd	-0.38	0.19	-0.24	-0.58	0.29	1.00	-0.41	0.49	0.53	0.08	0.30	0.52	0.14	-0.25	0.74	-0.25		-0.01	0.31	-0.01	0.77	0.73	0.66	0.52	-0.04	
HAZ skewness	0.14	-0.13	-0.20	0.23	-0.21	-0.41	1.00	-0.04	-0.05	0.47	-0.12	-0.07	-0.30	-0.02	-0.37	0.38		0.16	0.06	0.16	-0.28	-0.49	-0.30	-0.40	0.12	
WAZ skewness	-0.40	-0.08	-0.09	-0.43	0.25	0.49	-0.04	1.00	0.62	-0.24	0.60	0.37	0.04	-0.51	0.64	0.23		-0.23	0.60	-0.23	0.55	0.44	0.50	0.45	-0.07	
WHZ skewness	-0.19	-0.06	-0.42	-0.52	0.08	0.53	-0.05	0.62	1.00	-0.23	0.24	0.32	0.33	-0.22	0.76	-0.11		-0.18	0.29	-0.18	0.77	0.71	0.57	0.55	0.04	
HAZ kurtosis	0.29	0.08	-0.21	0.00	-0.06	0.08	0.47	-0.24	-0.23	1.00	0.00	0.23	-0.24	-0.09	-0.24	0.00		-0.08	-0.04	-0.08	-0.06	-0.18	-0.03	-0.30	-0.12	
WAZ kurtosis	-0.05	-0.49	0.13	-0.30	0.19	0.30	-0.12	0.60	0.24	0.00	1.00	0.23	0.10	-0.40	0.48	0.04		-0.29	0.53	-0.29	0.33	0.20	0.67	0.44	-0.07	
WHZ kurtosis	-0.12	-0.17	-0.45	-0.42	0.04	0.52	-0.07	0.37	0.32	0.23	0.23	1.00	0.08	-0.05	0.32	0.04		-0.24	0.48	-0.24	0.39	0.29	0.45	0.22	0.16	
Height index	-0.12	0.01	-0.20	-0.06	-0.05	0.14	-0.30	0.04	0.33	-0.24	0.10	0.08	1.00	0.51	0.43	-0.04		-0.11	0.09	-0.11	0.37	0.37	0.19	0.08	0.16	
Height heaping	-0.03	0.18	-0.14	0.39	-0.08	-0.25	-0.02	-0.51	-0.22	-0.09	-0.40	-0.05	0.51	1.00	-0.32	-0.07		0.03	-0.20	0.03	-0.22	-0.23	-0.18	-0.15	0.33	
Weight index	-0.24	-0.17	-0.15	-0.70	0.06	0.74	-0.37	0.64	0.76	-0.24	0.48	0.32	0.43	-0.32	1.00	0.00		-0.12	0.33	-0.12	0.91	0.81	0.74	0.62	-0.21	
Unexpected weight digit	-0.33	-0.14	-0.11	0.15	0.01	-0.25	0.38	0.23	-0.11	0.00	0.04	0.04	-0.04	-0.07	0.00	1.00		-0.22	0.28	-0.22	-0.18	-0.46	-0.24	-0.18	0.06	
Height measured only*																										
Weight measured only	0.32	0.19	0.10	0.25	-0.05	-0.01	0.16	-0.23	-0.18	-0.08	-0.29	-0.24	-0.11	0.03	-0.12	-0.22		1.00	-0.24	1.00	-0.12	0.01	-0.30	-0.38	0.23	
Measured complete	-0.42	-0.06	-0.16	-0.20	0.29	0.31	0.06	0.60	0.29	-0.04	0.53	0.48	0.09	-0.20	0.33	0.28		-0.24	1.00	-0.24	0.26	0.13	0.46	0.51	-0.02	
Incorrectly measured	0.32	0.19	0.10	0.25	-0.05	-0.01	0.16	-0.23	-0.18	-0.08	-0.29	-0.24	-0.11	0.03	-0.12	-0.22		1.00	-0.24	1.00	-0.12	0.01	-0.30	-0.38	0.23	
Day of birth index	-0.21	-0.13	-0.35	-0.83	-0.15	0.77	-0.28	0.55	0.77	-0.06	0.33	0.39	0.37	-0.22	0.91	-0.18		-0.12	0.26	-0.12	1.00	0.90	0.79	0.64	-0.37	
Month of birth index	-0.13	0.01	-0.21	-0.75	-0.10	0.73	-0.49	0.44	0.71	-0.18	0.20	0.29	0.37	-0.23	0.81	-0.46		0.01	0.13	0.01	0.90	1.00	0.67	0.54	-0.31	
HAZ Jan-Dec interval	-0.13	-0.38	-0.13	-0.74	-0.02	0.66	-0.30	0.50	0.57	-0.03	0.67	0.45	0.19	-0.18	0.74	-0.24		-0.30	0.46	-0.30	0.79	0.67	1.00	0.82	-0.31	
WAZ Jan-Dec interval	-0.28	-0.10	-0.05	-0.55	0.16	0.52	-0.40	0.45	0.55	-0.30	0.44	0.22	0.08	-0.15	0.62	-0.18		-0.38	0.51	-0.38	0.64	0.54	0.82	1.00	-0.38	
DMY of birth incomplete	-0.07	0.20	-0.16	0.60	0.48	-0.04	0.12	-0.07	0.04	-0.12	-0.07	0.16	0.16	0.33	-0.21	0.06		0.23	-0.02	0.23	-0.37	-0.31	-0.31	-0.38	1.00	
MY of birth incomplete*																										

*indicator had zero variance

Legend
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1.0

Table A2 Summary of Pearson's correlation coefficients for all data quality indicators in Nepal

	HAZ implausible	WAZ implausible	WHZ implausible	HAZ sd	WAZ sd	WHZ sd	HAZ skewness	WAZ skewness	WHZ skewness	HAZ kurtosis	WAZ kurtosis	WHZ kurtosis	Height index	Height heaping	Weight index	Incorrect weight digit*	Only height measured*	Only weight measured	Incorrectly measured	Measured incomplete	Day of birth index	Month of birth index	HAZ Jan-Dec interval	WAZ Jan-Dec interval	DMY of birth incomplete*	MY of birth incomplete*
HAZ implausible	1.00	0.21	0.32	0.12	-0.10	0.10	-0.11	0.00	0.38	0.00	-0.02	0.27	0.33	0.69	-0.07			0.28	0.23	-0.38	0.03	0.52	0.17	-0.16		
WAZ implausible	0.21	1.00	0.13	0.45	0.43	0.07	-0.31	-0.35	-0.17	-0.17	0.10	-0.19	0.55	0.36	0.32			-0.14	-0.21	-0.09	-0.08	0.02	0.11	-0.03		
WHZ implausible	0.32	0.13	1.00	0.43	0.02	0.72	0.25	-0.06	0.53	0.24	0.00	0.23	0.27	0.03	0.31			0.22	-0.14	-0.37	0.48	-0.02	0.14	0.15		
HAZ sd	0.12	0.45	0.43	1.00	0.54	0.51	0.28	0.28	0.50	0.02	-0.06	0.12	0.57	0.21	0.40			-0.23	-0.24	-0.42	-0.01	0.34	0.15	0.31		
WAZ sd	-0.10	0.43	0.02	0.54	1.00	0.15	0.04	0.28	0.04	-0.15	0.32	-0.04	0.37	-0.08	0.56			-0.21	-0.53	-0.40	0.00	0.11	0.02	0.07		
WHZ sd	0.10	0.07	0.72	0.51	0.15	1.00	0.30	-0.05	0.38	0.21	-0.10	0.56	0.23	-0.20	0.35			0.13	-0.35	-0.56	0.59	0.20	0.01	0.45		
HAZ skewness	-0.11	-0.31	0.25	0.28	0.04	0.30	1.00	0.48	0.38	0.84	0.33	0.14	0.23	0.13	-0.05			0.34	0.00	-0.14	0.00	-0.01	-0.35	-0.19		
WAZ skewness	0.00	-0.35	-0.06	0.28	0.28	-0.05	0.48	1.00	0.49	0.13	-0.22	-0.04	0.22	0.18	0.17			-0.08	0.17	-0.09	0.16	0.37	-0.16	-0.20		
WHZ skewness	0.38	-0.17	0.53	0.50	0.04	0.38	0.38	0.49	1.00	0.15	-0.17	0.15	0.25	0.15	0.26			-0.13	0.27	-0.54	0.15	0.42	-0.11	0.03		
HAZ kurtosis	0.00	-0.17	0.24	0.02	-0.15	0.21	0.84	0.13	0.15	1.00	0.47	0.20	0.21	0.17	-0.19			0.52	0.03	-0.13	-0.05	-0.16	-0.29	-0.25		
WAZ kurtosis	-0.02	0.10	0.00	-0.06	0.32	-0.10	0.33	-0.22	-0.17	0.47	1.00	0.02	0.10	0.01	-0.19			0.39	-0.49	-0.22	-0.50	-0.17	-0.40	-0.31		
WHZ kurtosis	0.27	-0.19	0.23	0.12	-0.04	0.56	0.14	-0.04	0.15	0.20	0.02	1.00	0.18	-0.02	0.19			0.16	-0.33	-0.67	0.29	0.55	0.24	0.59		
Height index	0.33	0.55	0.27	0.57	0.37	0.23	0.23	0.22	0.25	0.21	0.10	0.18	1.00	0.58	0.31			-0.16	-0.06	-0.33	0.06	0.48	0.02	-0.05		
Height heaping	0.69	0.36	0.03	0.21	-0.08	-0.20	0.13	0.18	0.15	0.17	0.01	-0.02	0.58	1.00	-0.24			0.08	0.34	0.01	-0.22	0.46	0.07	-0.31		
Weight index	-0.07	0.32	0.31	0.40	0.56	0.35	-0.05	0.17	0.26	-0.19	-0.19	0.19	0.31	-0.24	1.00			-0.30	-0.20	-0.41	0.52	0.07	0.32	0.33		
Unexpected weight digit*																										
Height measured only*																										
Weight measured only	0.28	-0.14	0.22	-0.23	-0.21	0.13	0.34	-0.08	-0.13	0.52	0.39	0.16	-0.16	0.08	-0.30			1.00	-0.31	0.03	0.09	-0.14	-0.31	-0.48		
Measured complete	0.23	-0.21	-0.14	-0.24	-0.53	-0.35	0.00	0.17	0.27	0.03	-0.49	-0.33	-0.06	0.34	-0.20			-0.31	1.00	0.34	-0.06	-0.08	0.16	-0.16		
Incorrectly measured	-0.38	-0.09	-0.37	-0.42	-0.40	-0.56	-0.14	-0.09	-0.54	-0.13	-0.22	-0.67	-0.33	0.01	-0.41			0.03	0.34	1.00	-0.19	-0.59	0.02	-0.34		
Day of birth index	0.03	-0.08	0.48	-0.01	0.00	0.59	0.00	0.16	0.15	-0.05	-0.50	0.29	0.06	-0.22	0.52			0.09	-0.06	-0.19	1.00	0.08	0.12	0.16		
Month of birth index	0.52	0.02	-0.02	0.34	0.11	0.20	-0.01	0.37	0.42	-0.16	-0.17	0.55	0.48	0.46	0.07			-0.14	-0.08	-0.59	0.08	1.00	-0.03	0.17		
HAZ Jan-Dec interval	0.17	0.11	0.14	0.15	0.02	0.01	-0.35	-0.16	-0.11	-0.29	-0.40	0.24	0.02	0.07	0.32			-0.31	0.16	0.02	0.12	-0.03	1.00	0.63		
WAZ Jan-Dec interval	-0.16	-0.03	0.15	0.31	0.07	0.45	-0.19	-0.20	0.03	-0.25	-0.31	0.59	-0.05	-0.31	0.33			-0.48	-0.16	-0.34	0.16	0.17	0.63	1.00		
DMY of birth incomplete*																										
MY of birth incomplete*																										

*indicator had zero variance

Legend
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1.0

Table A3 Summary of Pearson's correlation coefficients for all data quality indicators in Ethiopia

	HAZ implausible	WAZ implausible	WHZ implausible	HAZ sd	WAZ sd	WHZ sd	HAZ skewness	WAZ skewness	WHZ skewness	HAZ kurtosis	WAZ kurtosis	WHZ kurtosis	Height index	Height heaping	Weight index	Incorrect weight digit	Only height measured	Only weight measured	Incorrectly measured	Measured incomplete	Day of birth index	Month of birth index	HAZ Jan-Dec interval	WAZ Jan-Dec interval	DMY of birth incomplete	MY of birth incomplete*
HAZ implausible	1.00	0.24	0.72	0.67	0.47	0.42	0.20	0.16	-0.16	-0.02	-0.05	0.33	-0.07	-0.11	-0.12	0.07	0.08	0.07	-0.08	0.20	-0.07	0.12	0.18	0.08	0.25	
WAZ implausible	0.24	1.00	0.07	0.27	0.33	0.30	0.14	-0.15	0.15	0.08	-0.02	0.34	-0.16	-0.11	-0.07	0.15	-0.01	-0.31	-0.16	-0.25	0.05	0.15	0.27	0.07	-0.21	
WHZ implausible	0.72	0.07	1.00	0.53	0.38	0.33	0.11	0.05	0.03	0.13	0.15	0.15	0.10	0.03	-0.11	0.17	0.28	-0.16	-0.06	0.30	0.07	-0.04	0.06	-0.02	0.16	
HAZ sd	0.67	0.27	0.53	1.00	0.81	0.61	0.17	0.22	-0.03	-0.12	0.08	0.20	0.15	0.16	-0.02	0.23	0.10	0.10	-0.38	0.44	0.03	0.21	0.37	0.39	0.29	
WAZ sd	0.47	0.33	0.38	0.81	1.00	0.56	-0.16	0.17	0.20	-0.33	0.21	0.16	0.28	0.34	-0.06	0.31	0.11	0.05	-0.45	0.35	0.19	0.31	0.50	0.51	0.24	
WHZ sd	0.42	0.30	0.33	0.61	0.56	1.00	0.27	0.20	0.10	0.12	0.10	0.29	0.28	0.26	-0.16	0.33	0.08	-0.25	-0.43	0.11	0.06	0.07	0.00	0.14	0.18	
HAZ skewness	0.20	0.14	0.11	0.17	-0.16	0.27	1.00	0.34	-0.03	0.70	0.07	0.29	-0.08	-0.17	0.10	-0.06	-0.07	-0.16	0.03	-0.03	-0.18	0.02	-0.01	0.07	-0.10	
WAZ skewness	0.16	-0.15	0.05	0.22	0.17	0.20	0.34	1.00	0.20	0.11	0.22	0.21	0.18	0.10	-0.09	0.04	-0.09	-0.14	-0.11	-0.18	-0.26	0.13	0.25	0.29	0.00	
WHZ skewness	-0.16	0.15	0.03	-0.03	0.20	0.10	-0.03	0.20	1.00	0.01	0.20	0.25	0.07	0.05	-0.15	0.15	-0.03	-0.27	-0.15	-0.19	-0.03	0.21	0.08	0.15	-0.13	
HAZ kurtosis	-0.02	0.08	0.13	-0.12	-0.33	0.12	0.70	0.11	0.01	1.00	0.01	0.00	-0.04	-0.14	0.13	-0.18	-0.04	-0.27	0.15	-0.20	-0.13	-0.05	-0.17	-0.12	-0.23	
WAZ kurtosis	-0.05	-0.02	0.15	0.08	0.21	0.10	0.07	0.22	0.20	0.01	1.00	0.27	0.21	0.19	0.03	0.17	-0.07	-0.41	-0.08	-0.06	0.17	0.10	0.35	0.46	-0.17	
WHZ kurtosis	0.33	0.34	0.15	0.20	0.16	0.29	0.29	0.21	0.25	0.00	0.27	1.00	-0.23	-0.24	-0.31	0.02	-0.11	-0.12	0.00	-0.10	0.08	-0.05	-0.08	0.11	-0.05	
Height index	-0.07	-0.16	0.10	0.15	0.28	0.28	-0.08	0.18	0.07	-0.04	0.21	-0.23	1.00	0.95	0.14	0.33	-0.05	-0.02	-0.15	0.40	0.28	0.28	0.24	0.33	0.31	
Height heaping	-0.11	-0.11	0.03	0.16	0.34	0.26	-0.17	0.10	0.05	-0.14	0.19	-0.24	0.95	1.00	0.11	0.33	-0.04	0.04	-0.23	0.37	0.30	0.28	0.27	0.32	0.38	
Weight index	-0.12	-0.07	-0.11	-0.02	-0.06	-0.16	0.10	-0.09	-0.15	0.13	0.03	-0.31	0.14	0.11	1.00	-0.23	-0.15	0.06	0.01	0.32	0.06	-0.06	0.27	0.02	-0.22	
Unexpected weight digit	0.07	0.15	0.17	0.23	0.31	0.33	-0.06	0.04	0.15	-0.18	0.17	0.02	0.33	0.33	-0.23	1.00	0.19	-0.05	-0.09	0.10	0.12	-0.03	0.27	0.20	0.06	
Height measured only*	0.08	-0.01	0.28	0.10	0.11	0.08	-0.07	-0.09	-0.03	-0.04	-0.07	-0.11	-0.05	-0.04	-0.15	0.19	1.00	-0.18	0.01	0.00	0.06	-0.06	0.03	-0.04	0.02	
Weight measured only	0.07	-0.31	-0.16	0.10	0.05	-0.25	-0.16	-0.14	-0.27	-0.27	-0.41	-0.12	-0.02	0.04	0.06	-0.05	-0.18	1.00	0.14	0.50	0.14	0.09	0.00	0.00	0.46	
Measured complete	-0.08	-0.16	-0.06	-0.38	-0.45	-0.43	0.03	-0.11	-0.15	0.15	-0.08	0.00	-0.15	-0.23	0.01	-0.09	0.01	0.14	1.00	-0.13	-0.05	-0.40	-0.20	-0.21	-0.22	
Incorrectly measured	0.20	-0.25	0.30	0.44	0.35	0.11	-0.03	-0.18	-0.19	-0.20	-0.06	-0.10	0.40	0.37	0.32	0.10	0.00	0.50	-0.13	1.00	0.36	0.17	0.13	0.15	0.44	
Day of birth index	-0.07	0.05	0.07	0.03	0.19	0.06	-0.18	-0.26	-0.03	-0.13	0.17	0.08	0.28	0.30	0.06	0.12	0.06	0.14	-0.05	0.36	1.00	0.38	0.11	0.20	0.25	
Month of birth index	0.12	0.15	-0.04	0.21	0.31	0.07	0.02	0.13	0.21	-0.05	0.10	-0.05	0.28	0.28	-0.06	-0.03	-0.06	0.09	-0.40	0.17	0.38	1.00	0.41	0.39	0.44	
HAZ Jan-Dec interval	0.18	0.27	0.06	0.37	0.50	0.00	-0.01	0.25	0.08	-0.17	0.35	-0.08	0.24	0.27	0.27	0.27	0.03	0.00	-0.20	0.13	0.11	0.41	1.00	0.75	0.00	
WAZ Jan-Dec interval	0.08	0.07	-0.02	0.39	0.51	0.14	0.07	0.29	0.15	-0.12	0.46	0.11	0.33	0.32	0.02	0.20	-0.04	0.00	-0.21	0.15	0.20	0.39	0.75	1.00	0.18	
DMY of birth incomplete	0.25	-0.21	0.16	0.29	0.24	0.18	-0.10	0.00	-0.13	-0.23	-0.17	-0.05	0.31	0.38	-0.22	0.06	0.02	0.46	-0.22	0.44	0.25	0.44	0.00	0.18	1.00	
MY of birth incomplete*																										

*indicator had no variance

Legend
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1.0

Table A4 Summary of Pearson's correlation coefficients for all data quality indicators in Chad

	HAZ implausible	WAZ implausible	WHZ implausible	HAZ sd	WAZ sd	WHZ sd	HAZ skewness	WAZ skewness	WHZ skewness	HAZ kurtosis	WAZ kurtosis	WHZ kurtosis	Height index	Height heaping	Weight index	Incorrect weight digit	Height measured only	Weight measured only	Measured complete	Incorrectly measured	Day of birth preference	Month of birth preference	HAZ Jan-Dec interval	WAZ Jan-Dec interval	DMY of birth incomplete	MY of birth incomplete
HAZ implausible	1.00	0.47	0.50	0.73	0.84	0.63	0.26	0.57	0.68	-0.19	0.27	0.05	0.20	0.36	0.24	0.44	0.27	0.06	0.04	0.08	0.38	0.06	-0.37	0.09	-0.09	-0.08
WAZ implausible	0.47	1.00	0.44	0.45	0.41	0.21	0.13	0.05	0.46	0.00	0.05	0.03	0.32	0.34	0.55	0.46	-0.04	0.38	-0.09	0.54	0.17	0.27	-0.05	0.13	0.21	0.19
WHZ implausible	0.50	0.44	1.00	0.60	0.67	0.49	0.03	0.49	0.47	-0.12	0.36	-0.03	-0.17	-0.09	0.41	0.27	0.00	0.31	-0.34	0.19	0.15	0.06	-0.28	-0.16	-0.11	0.05
HAZ sd	0.73	0.45	0.60	1.00	0.87	0.69	0.27	0.54	0.37	-0.40	0.01	-0.07	0.15	0.25	0.44	0.42	0.23	-0.08	-0.03	0.26	0.20	0.28	-0.43	-0.24	0.13	-0.02
WAZ sd	0.84	0.41	0.67	0.87	1.00	0.75	0.14	0.51	0.53	-0.36	0.13	-0.09	-0.04	0.14	0.28	0.37	0.17	0.05	-0.05	0.06	0.12	0.06	-0.52	-0.09	-0.09	-0.04
WHZ sd	0.63	0.21	0.49	0.69	0.75	1.00	0.18	0.32	0.21	-0.17	0.13	-0.20	0.10	0.19	0.36	0.44	0.24	-0.01	-0.27	0.06	-0.10	-0.14	-0.31	-0.07	-0.21	0.04
HAZ skewness	0.26	0.13	0.03	0.27	0.14	0.18	1.00	0.62	0.22	0.55	0.40	0.05	-0.03	0.00	0.25	0.44	-0.20	0.24	0.02	-0.04	0.26	0.31	0.07	0.13	0.07	-0.33
WAZ skewness	0.57	0.05	0.49	0.54	0.51	0.32	0.62	1.00	0.61	0.16	0.46	-0.06	-0.17	-0.10	0.31	0.39	0.12	0.02	-0.07	-0.24	0.38	0.32	-0.22	-0.03	-0.13	-0.21
WHZ skewness	0.68	0.46	0.47	0.37	0.53	0.21	0.22	0.61	1.00	0.01	0.36	0.22	-0.13	-0.01	0.32	0.27	0.18	0.16	-0.09	0.00	0.33	0.30	-0.20	0.12	0.00	-0.08
HAZ kurtosis	-0.19	0.00	-0.12	-0.40	-0.36	-0.17	0.55	0.16	0.01	1.00	0.46	0.00	-0.14	-0.24	0.24	0.32	-0.32	0.33	-0.20	-0.28	-0.10	-0.14	0.31	0.35	-0.16	-0.17
WAZ kurtosis	0.27	0.05	0.36	0.01	0.13	0.13	0.40	0.46	0.36	0.46	1.00	0.23	-0.20	-0.13	-0.04	0.18	-0.14	0.49	0.00	-0.17	0.19	-0.25	0.15	0.20	-0.22	-0.06
WHZ kurtosis	0.05	0.03	-0.03	-0.07	-0.09	-0.20	0.05	-0.06	0.22	0.00	0.23	1.00	0.07	0.23	-0.22	-0.34	-0.13	-0.07	0.29	0.33	0.21	-0.13	0.13	0.00	0.02	-0.18
Height index	0.20	0.32	-0.17	0.15	-0.04	0.10	-0.03	-0.17	-0.13	-0.14	-0.20	0.07	1.00	0.93	0.19	0.09	-0.01	-0.03	0.22	0.52	0.45	0.15	0.30	0.30	-0.19	0.07
Height heaping	0.36	0.34	-0.09	0.25	0.14	0.19	0.00	-0.10	-0.01	-0.24	-0.13	0.23	0.93	1.00	0.05	0.01	-0.06	-0.02	0.26	0.55	0.44	0.06	0.18	0.28	-0.22	-0.08
Weight index	0.24	0.55	0.41	0.44	0.28	0.36	0.25	0.31	0.32	0.24	-0.04	-0.22	0.19	0.05	1.00	0.55	0.00	-0.01	-0.32	0.18	0.00	0.36	-0.03	0.06	0.01	0.19
Unexpected weight digit	0.44	0.46	0.27	0.42	0.37	0.44	0.44	0.39	0.27	0.32	0.18	-0.34	0.09	0.01	0.55	1.00	0.09	0.14	-0.25	-0.20	0.03	0.14	-0.25	0.09	-0.14	0.4
Height measured only*	0.27	-0.04	0.00	0.23	0.17	0.24	-0.20	0.12	0.18	-0.32	-0.14	-0.13	-0.01	-0.06	0.00	0.09	1.00	-0.36	-0.14	0.03	0.00	0.08	-0.31	-0.23	0.28	0.21
Weight measured only	0.06	0.38	0.31	-0.08	0.05	-0.01	0.24	0.02	0.16	0.33	0.49	-0.07	-0.03	-0.02	-0.01	0.14	-0.36	1.00	-0.32	0.22	0.20	0.03	0.22	0.45	-0.16	-0.19
Measured complete	0.04	-0.09	-0.34	-0.03	-0.05	-0.27	0.02	-0.07	-0.09	-0.20	0.00	0.29	0.22	0.26	-0.32	-0.25	-0.14	-0.32	1.00	-0.09	0.24	-0.15	0.14	-0.10	-0.04	0.14
Incorrectly measured	0.08	0.54	0.19	0.26	0.06	0.06	-0.04	-0.24	0.00	-0.28	-0.17	0.33	0.52	0.55	0.18	-0.20	0.03	0.22	-0.09	1.00	0.28	0.28	0.15	-0.03	0.31	-0.13
Day of birth index	0.38	0.17	0.15	0.20	0.12	-0.10	0.26	0.38	0.33	-0.10	0.19	0.21	0.45	0.44	0.00	0.03	0.00	0.20	0.24	0.28	1.00	0.46	0.19	0.29	-0.09	-0.05
Month of birth index	0.06	0.27	0.06	0.28	0.06	-0.14	0.31	0.32	0.30	-0.14	-0.25	-0.13	0.15	0.06	0.36	0.14	0.08	0.03	-0.15	0.28	0.46	1.00	-0.12	-0.07	0.34	-0.11
HAZ Jan-Dec interval	-0.37	-0.05	-0.28	-0.43	-0.52	-0.31	0.07	-0.22	-0.20	0.31	0.15	0.13	0.30	0.18	-0.03	-0.25	-0.31	0.22	0.14	0.15	0.19	-0.12	1.00	0.59	0.02	0.08
WAZ Jan-Dec interval	0.09	0.13	-0.16	-0.24	-0.09	-0.07	0.13	-0.03	0.12	0.35	0.20	0.00	0.30	0.28	0.06	0.09	-0.23	0.45	-0.10	-0.03	0.29	-0.07	0.59	1.00	-0.32	0
DMY of birth incomplete	-0.09	0.21	-0.11	0.13	-0.09	-0.21	0.07	-0.13	0.00	-0.16	-0.22	0.02	-0.19	-0.22	0.01	-0.14	0.28	-0.16	-0.04	0.31	-0.09	0.34	0.02	-0.32	1.00	-0.06
MY of birth incomplete	-0.08	0.19	0.05	-0.02	-0.04	0.04	-0.33	-0.21	-0.08	-0.17	-0.06	-0.18	0.07	-0.08	0.19	0.40	0.21	-0.19	0.14	-0.13	-0.05	-0.11	0.08	0.00	-0.06	1.00

*indicator had zero variance

Legend
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1.0

Table A5 Summary of Pearson's correlation coefficients for all data quality indicators in Egypt

	HAZ implausible	WAZ implausible	WHZ implausible	HAZ sd	WAZ sd	WHZ sd	HAZ skewness	WAZ skewness	WHZ skewness	HAZ kurtosis	WAZ kurtosis	WHZ kurtosis	Height index	Height heaping	Weight index	Incorrect weight digit	Only height measured	Only weight measured	Incorrectly measured	Measured incomplete	Day of birth index	Month of birth index	HAZ Jan-Dec interval	WAZ Jan-Dec interval	DMY of birth incomplete	MY of birth incomplete*
HAZ implausible	1.00	0.70	0.82	0.88	0.78	0.81	-0.59	-0.13	0.59	-0.81	-0.56	-0.75	0.54	0.39	0.65	-0.04	0.04	0.45	0.69	0.23	-0.10	0.23	0.41	0.57	-0.04	
WAZ implausible	0.70	1.00	0.94	0.77	0.92	0.86	-0.64	0.02	0.64	-0.64	-0.74	-0.65	0.35	0.01	0.33	-0.12	-0.12	-0.07	0.05	-0.28	0.04	-0.02	0.51	0.72	-0.22	
WHZ implausible	0.82	0.94	1.00	0.80	0.98	0.91	-0.67	0.00	0.76	-0.72	-0.73	-0.77	0.41	0.07	0.40	-0.11	-0.05	0.07	0.23	-0.15	-0.07	0.10	0.41	0.68	-0.15	
HAZ sd	0.88	0.77	0.80	1.00	0.77	0.91	-0.58	0.01	0.50	-0.89	-0.38	-0.81	0.45	0.20	0.54	-0.04	0.00	0.26	0.44	-0.02	-0.05	0.13	0.40	0.46	-0.14	
WAZ sd	0.78	0.92	0.98	0.77	1.00	0.90	-0.69	-0.02	0.76	-0.73	-0.74	-0.74	0.39	0.10	0.32	-0.10	-0.06	0.12	0.20	-0.23	-0.04	0.22	0.41	0.65	-0.17	
WHZ sd	0.81	0.86	0.91	0.91	0.90	1.00	-0.68	-0.03	0.67	-0.83	-0.52	-0.83	0.54	0.14	0.49	-0.02	0.04	0.22	0.28	-0.13	-0.09	0.22	0.34	0.50	-0.12	
HAZ skewness	-0.59	-0.64	-0.67	-0.58	-0.69	-0.68	1.00	0.56	-0.72	0.74	0.52	0.72	-0.52	-0.33	-0.60	-0.01	0.02	-0.20	-0.28	0.19	-0.14	-0.08	-0.50	-0.69	0.22	
WAZ skewness	-0.13	0.02	0.00	0.01	-0.02	-0.03	0.56	1.00	-0.19	0.23	-0.01	0.10	-0.51	-0.13	-0.58	-0.15	-0.04	-0.22	-0.34	-0.14	-0.10	-0.28	-0.05	-0.30	-0.06	
WHZ skewness	0.59	0.64	0.76	0.50	0.76	0.67	-0.72	-0.19	1.00	-0.52	-0.49	-0.73	0.45	0.08	0.42	-0.05	-0.02	0.01	0.17	-0.09	-0.13	0.16	0.12	0.38	-0.23	
HAZ kurtosis	-0.81	-0.64	-0.72	-0.89	-0.73	-0.83	0.74	0.23	-0.52	1.00	0.41	0.89	-0.52	-0.35	-0.57	0.05	0.00	-0.35	-0.49	0.04	-0.07	-0.30	-0.35	-0.48	0.14	
WAZ kurtosis	-0.56	-0.74	-0.73	-0.38	-0.74	-0.52	0.52	-0.01	-0.49	0.41	1.00	0.44	-0.32	-0.31	-0.24	0.04	-0.01	-0.06	-0.14	-0.01	-0.26	-0.08	-0.48	-0.73	-0.02	
WHZ kurtosis	-0.75	-0.65	-0.77	-0.81	-0.74	-0.83	0.72	0.10	-0.73	0.89	0.44	1.00	-0.56	-0.27	-0.60	0.04	-0.09	-0.22	-0.31	0.01	0.06	-0.15	-0.15	-0.38	0.14	
Height index	0.54	0.35	0.41	0.45	0.39	0.54	-0.52	-0.51	0.45	-0.52	-0.32	-0.56	1.00	0.32	0.83	0.29	0.34	0.41	0.42	0.49	0.08	0.50	-0.12	0.13	0.28	
Height heaping	0.39	0.01	0.07	0.20	0.10	0.14	-0.33	-0.13	0.08	-0.35	-0.31	-0.27	0.32	1.00	0.31	-0.28	-0.20	0.45	0.57	0.24	-0.11	0.20	0.42	0.23	-0.22	
Weight index	0.65	0.33	0.40	0.54	0.32	0.49	-0.60	-0.58	0.42	-0.57	-0.24	-0.60	0.83	0.31	1.00	0.36	0.39	0.41	0.55	0.53	0.09	0.14	0.05	0.32	0.31	
Unexpected weight digit	-0.04	-0.12	-0.11	-0.04	-0.10	-0.02	-0.01	-0.15	-0.05	0.05	0.04	0.04	0.29	-0.28	0.36	1.00	0.96	0.39	-0.02	0.50	0.65	0.08	-0.31	-0.22	0.87	
Height measured only	0.04	-0.12	-0.05	0.00	-0.06	0.04	0.02	-0.04	-0.02	0.00	-0.01	-0.09	0.34	-0.20	0.39	0.96	1.00	0.46	0.01	0.56	0.54	0.10	-0.39	-0.25	0.91	
Weight measured only	0.45	-0.07	0.07	0.26	0.12	0.22	-0.20	-0.22	0.01	-0.35	-0.06	-0.22	0.41	0.45	0.41	0.39	0.46	1.00	0.58	0.41	0.10	0.36	0.10	0.01	0.35	
Measured complete	0.69	0.05	0.23	0.44	0.20	0.28	-0.28	-0.34	0.17	-0.49	-0.14	-0.31	0.42	0.57	0.55	-0.02	0.01	0.58	1.00	0.58	-0.05	0.42	0.25	0.24	0.08	
Incorrectly measured	0.23	-0.28	-0.15	-0.02	-0.23	-0.13	0.19	-0.14	-0.09	0.04	-0.01	0.01	0.49	0.24	0.53	0.50	0.56	0.41	0.58	1.00	0.26	0.31	-0.35	-0.26	0.69	
Day of birth index	-0.10	0.04	-0.07	-0.05	-0.04	-0.09	-0.14	-0.10	-0.13	-0.07	-0.26	0.06	0.08	-0.11	0.09	0.65	0.54	0.10	-0.05	0.26	1.00	-0.01	0.11	0.08	0.51	
Month of birth index	0.23	-0.02	0.10	0.13	0.22	0.22	-0.08	-0.28	0.16	-0.30	-0.08	-0.15	0.50	0.20	0.14	0.08	0.10	0.36	0.42	0.31	-0.01	1.00	-0.34	-0.24	0.23	
HAZ Jan-Dec interval	0.41	0.51	0.41	0.40	0.41	0.34	-0.50	-0.05	0.12	-0.35	-0.48	-0.15	-0.12	0.42	0.05	-0.31	-0.39	0.10	0.25	-0.35	0.11	-0.34	1.00	0.80	-0.45	
WAZ Jan-Dec interval	0.57	0.72	0.68	0.46	0.65	0.50	-0.69	-0.30	0.38	-0.48	-0.73	-0.38	0.13	0.23	0.32	-0.22	-0.25	0.01	0.24	-0.26	0.08	-0.24	0.80	1.00	-0.26	
DMY of birth incomplete	-0.04	-0.22	-0.15	-0.14	-0.17	-0.12	0.22	-0.06	-0.23	0.14	-0.02	0.14	0.28	-0.22	0.31	0.87	0.91	0.35	0.08	0.69	0.51	0.23	-0.45	-0.26	1.00	
MY of birth incomplete*																										

***indicator had zero variance**

Legend
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1.0

Table A6 Summary of Pearson's correlation coefficients for all data quality indicators in Nigeria

	HAZ implausible	WAZ implausible	WHZ implausible	HAZ sd	WAZ sd	WHZ sd	HAZ skewness	WAZ skewness	WHZ skewness	HAZ kurtosis	WAZ kurtosis	WHZ kurtosis	Height index	Height heaping	Weight index	Incorrect weight digit	Only height measured	Only weight measured	Incorrectly measured	Measured incomplete	Day of birth index	Month of birth index	HAZ Jan-Dec interval	WAZ Jan-Dec interval	DMY of birth incomplete	MY of birth incomplete
HAZ implausible	1.00	0.67	0.83	0.77	0.80	0.88	0.44	0.58	0.42	-0.31	-0.25	-0.64	0.10	0.01	0.78	0.57	0.21	0.05	0.45	0.01	0.42	0.39	-0.12	0.10	0.25	-0.12
WAZ implausible	0.67	1.00	0.67	0.61	0.61	0.63	0.30	0.49	0.29	-0.06	-0.14	-0.56	0.28	0.10	0.68	0.70	0.20	0.30	0.45	0.00	0.29	0.21	-0.02	-0.06	0.28	-0.1
WHZ implausible	0.83	0.67	1.00	0.81	0.80	0.81	0.21	0.52	0.49	-0.45	-0.22	-0.51	0.03	-0.04	0.87	0.80	0.21	0.07	0.43	0.16	0.30	0.22	-0.10	0.12	0.45	-0.11
HAZ sd	0.77	0.61	0.81	1.00	0.90	0.85	0.55	0.59	0.45	-0.44	-0.36	-0.59	0.36	0.19	0.71	0.64	0.25	0.06	0.49	0.29	0.48	0.37	0.08	0.25	0.42	-0.16
WAZ sd	0.80	0.61	0.80	0.90	1.00	0.87	0.51	0.64	0.45	-0.44	-0.35	-0.60	0.35	0.18	0.68	0.56	0.37	0.04	0.58	0.25	0.50	0.46	0.08	0.24	0.39	-0.15
WHZ sd	0.88	0.63	0.81	0.85	0.87	1.00	0.46	0.56	0.51	-0.41	-0.38	-0.71	0.21	0.08	0.79	0.63	0.22	0.08	0.46	0.13	0.55	0.39	-0.08	0.18	0.34	-0.17
HAZ skewness	0.44	0.30	0.21	0.55	0.51	0.46	1.00	0.40	-0.03	0.23	-0.31	-0.53	0.41	0.26	0.14	0.13	0.17	-0.14	0.37	0.01	0.51	0.47	0.04	0.08	0.13	0.09
WAZ skewness	0.58	0.49	0.52	0.59	0.64	0.56	0.40	1.00	0.36	-0.18	0.20	-0.32	0.19	0.21	0.56	0.39	0.18	-0.10	0.20	-0.12	0.29	0.20	-0.02	-0.02	0.02	0.09
WHZ skewness	0.42	0.29	0.49	0.45	0.45	0.51	-0.03	0.36	1.00	-0.49	-0.23	-0.01	0.21	0.15	0.43	0.35	0.31	0.16	0.29	0.03	0.27	0.13	-0.07	0.03	0.14	-0.23
HAZ kurtosis	-0.31	-0.06	-0.45	-0.44	-0.44	-0.41	0.23	-0.18	-0.49	1.00	0.28	0.08	-0.02	0.06	-0.39	-0.33	-0.19	0.03	-0.18	-0.24	-0.08	-0.10	0.03	-0.25	-0.36	0.29
WAZ kurtosis	-0.25	-0.14	-0.22	-0.36	-0.35	-0.38	-0.31	0.20	-0.23	0.28	1.00	0.38	-0.17	0.03	-0.11	-0.21	-0.11	-0.11	-0.35	-0.27	-0.25	-0.22	0.13	-0.06	-0.29	0.15
WHZ kurtosis	-0.64	-0.56	-0.51	-0.59	-0.60	-0.71	-0.53	-0.32	-0.01	0.08	0.38	1.00	-0.18	-0.02	-0.55	-0.44	-0.11	-0.06	-0.37	-0.17	-0.54	-0.34	0.15	-0.05	-0.30	-0.01
Height index	0.10	0.28	0.03	0.36	0.35	0.21	0.41	0.19	0.21	-0.02	-0.17	-0.18	1.00	0.80	0.06	0.02	0.44	0.14	0.43	0.34	0.45	0.29	0.21	0.14	0.07	-0.18
Height heaping	0.01	0.10	-0.04	0.19	0.18	0.08	0.26	0.21	0.15	0.06	0.03	-0.02	0.80	1.00	0.04	-0.09	0.33	0.04	0.20	0.32	0.18	-0.06	0.09	0.03	-0.05	-0.18
Weight index	0.78	0.68	0.87	0.71	0.68	0.79	0.14	0.56	0.43	-0.39	-0.11	-0.55	0.06	0.04	1.00	0.76	0.06	0.02	0.29	0.03	0.27	0.04	-0.07	0.15	0.31	-0.03
Unexpected weight digit	0.57	0.70	0.80	0.64	0.56	0.63	0.13	0.39	0.35	-0.33	-0.21	-0.44	0.02	-0.09	0.76	1.00	0.01	0.01	0.37	-0.03	0.12	0.04	-0.09	0.02	0.41	0.05
Height measured only*	0.21	0.20	0.21	0.25	0.37	0.22	0.17	0.18	0.31	-0.19	-0.11	-0.11	0.44	0.33	0.06	0.01	1.00	0.12	0.36	0.14	0.44	0.48	-0.12	-0.04	0.20	-0.16
Weight measured only	0.05	0.30	0.07	0.06	0.04	0.08	-0.14	-0.10	0.16	0.03	-0.11	-0.06	0.14	0.04	0.02	0.01	0.12	1.00	-0.07	0.51	0.17	0.14	0.04	-0.02	0.18	-0.19
Measured complete	0.45	0.45	0.43	0.49	0.58	0.46	0.37	0.20	0.29	-0.18	-0.35	-0.37	0.43	0.20	0.29	0.37	0.36	-0.07	1.00	0.04	0.11	0.15	0.01	0.10	0.21	-0.16
Incorrectly measured	0.01	0.00	0.16	0.29	0.25	0.13	0.01	-0.12	0.03	-0.24	-0.27	-0.17	0.34	0.32	0.03	-0.03	0.14	0.51	0.04	1.00	0.18	0.19	0.24	0.28	0.31	-0.17
Day of birth index	0.42	0.29	0.30	0.48	0.50	0.55	0.51	0.29	0.27	-0.08	-0.25	-0.54	0.45	0.18	0.27	0.12	0.44	0.17	0.11	0.18	1.00	0.67	-0.09	-0.01	0.25	-0.12
Month of birth index	0.39	0.21	0.22	0.37	0.46	0.39	0.47	0.20	0.13	-0.10	-0.22	-0.34	0.29	-0.06	0.04	0.04	0.48	0.14	0.15	0.19	0.67	1.00	0.16	0.17	0.24	-0.13
HAZ Jan-Dec interval	-0.12	-0.02	-0.10	0.08	0.08	-0.08	0.04	-0.02	-0.07	0.03	0.13	0.15	0.21	0.09	-0.07	-0.09	-0.12	0.04	0.01	0.24	-0.09	0.16	1.00	0.78	-0.11	0.15
WAZ Jan-Dec interval	0.10	-0.06	0.12	0.25	0.24	0.18	0.08	-0.02	0.03	-0.25	-0.06	-0.05	0.14	0.03	0.15	0.02	-0.04	-0.02	0.10	0.28	-0.01	0.17	0.78	1.00	0.02	0.06
DMY of birth incomplete	0.25	0.28	0.45	0.42	0.39	0.34	0.13	0.02	0.14	-0.36	-0.29	-0.30	0.07	-0.05	0.31	0.41	0.20	0.18	0.21	0.31	0.25	0.24	-0.11	0.02	1.00	-0.02
MY of birth incomplete	-0.12	-0.10	-0.11	-0.16	-0.15	-0.17	0.09	0.09	-0.23	0.29	0.15	-0.01	-0.18	-0.18	-0.03	0.05	-0.16	-0.19	-0.16	-0.17	-0.12	-0.13	0.15	0.06	-0.02	1.00

Legend
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1.0

Table A7 Height and weight indicator totals by team and team rankings using PCA scores in Nepal

Team No.	% Invalid HAZ[1]	% Invalid WAZ[1]	% Invalid WHZ[1]	HAZ SD[2]	WAZ SD[2]	WHZ SD[2]	HAZ skew[2,3]	WAZ skew[2,3]	WHZ skew[2,3]	HAZ kurtosis[2,4]	WAZ kurtosis[2,4]	WHZ kurtosis[2,4]	Height index[2]	Height heaping[2]	Weight index[2]	Incorrect weight digit[5]	Only height measured[2]	Only weight measured[2]	Incorrectly measured[2]	Measured incomplete[2]	Relative team ranking using PCA scores[6]
1	0.0%	0.0%	0.8%	1.43	1.22	1.09	0.52	0.48	0.34	3.54	3.32	3.08	19%	2%	17%	0%	0%	0%	0%	2%	16
2	0.0%	0.0%	0.0%	1.16	1.07	1.07	-0.09	-0.09	-0.35	3.90	3.37	5.51	14%	1%	14%	0%	0%	0%	0%	1%	11
3	0.0%	0.0%	2.0%	1.55	1.04	1.43	0.59	-0.01	0.43	4.43	2.86	4.90	17%	1%	13%	0%	0%	0%	0%	1%	10
4	1.1%	0.0%	1.1%	1.18	0.98	0.99	-0.13	-0.12	0.27	2.89	3.08	2.92	10%	5%	10%	0%	0%	0%	2%	5%	2
5	0.0%	0.0%	0.0%	1.39	1.04	1.10	0.55	0.15	0.31	4.03	2.90	4.08	14%	3%	14%	0%	0%	0%	1%	2%	12
6	0.0%	0.0%	0.3%	1.27	1.02	0.97	0.12	-0.12	-0.05	3.28	3.74	3.13	15%	2%	7%	0%	0%	0%	0%	6%	8
7	0.3%	0.0%	0.0%	1.34	1.10	1.10	0.00	-0.05	0.05	3.05	3.55	3.68	10%	2%	5%	0%	0%	<1%	0%	0%	9
8	0.0%	0.0%	0.0%	1.18	0.99	0.99	0.10	0.18	-0.25	3.06	2.91	3.40	17%	6%	6%	0%	0%	0%	1%	7%	3
9	0.0%	0.0%	0.7%	1.32	1.02	1.06	0.81	0.22	0.17	7.06	3.35	3.10	11%	3%	8%	0%	0%	1%	1%	6%	4
10	0.8%	0.8%	0.8%	1.56	1.16	1.12	-0.14	-0.18	-0.17	3.16	3.37	3.12	25%	7%	14%	0%	0%	0%	0%	3%	15
11	1.8%	0.0%	0.9%	1.29	1.04	1.19	0.19	0.09	0.07	3.69	3.13	4.98	15%	6%	9%	0%	0%	1%	0%	2%	5
12	0.0%	0.0%	0.0%	1.39	1.04	0.98	0.04	0.08	-0.33	2.81	2.70	3.40	13%	4%	8%	0%	0%	0%	1%	9%	6
13	0.0%	0.0%	0.7%	1.21	1.04	1.13	1.04	-0.16	-0.38	8.52	4.05	3.86	16%	4%	7%	0%	0%	1%	0%	5%	7
14	0.0%	0.0%	0.0%	1.15	0.99	1.07	0.06	0.00	-0.15	3.64	2.68	2.64	13%	2%	9%	0%	0%	0%	2%	8%	1
15	0.0%	0.0%	0.0%	1.39	1.11	1.05	0.74	0.22	-0.08	4.08	3.47	3.30	14%	5%	9%	0%	0%	0%	1%	7%	14
16	1.4%	0.0%	0.7%	1.47	1.03	1.09	0.93	0.33	0.65	6.98	3.29	4.59	26%	9%	8%	0%	0%	0%	2%	0%	13
Survey Total	**0.3%**	**0.0%**	**0.4%**	**1.35**	**1.08**	**1.10**	**0.32**	**0.03**	**0.07**	**4.39**	**3.46**	**3.91**	**10%**	**2%**	**2%**	**0%**	**0%**	**<1%**	**1%**	**4%**	

Note: Abbreviations include SD, Standard deviation; HAZ, height-for-age; WAZ, weight-for-age; WHZ, weight-for-height; DMY, day month year; MY, month year.

[1] The percent of implausible values for HAZ, WAZ, and WHZ have a global standard of 1.0% used here instead of Target A.

[2] Target A for HAZ SD = 1.41; WAZ SD = 1.13; WHZ SD = 1.17; HAZ skew = 0.24; WAZ skew = 0.05; WHZ skew = 0.07; HAZ kurtosis = 0.77; WAZ kurtosis = 0.75; WHZ kurtosis = 0.89; Height index = 10%; Height heaping 3%; Weight index 2%; Only height measured = 0.01%; Only weight measured 0.2%; Incorrectly measured 3.1%; Measured incomplete 1.1%.

[3] Skewness highlighted based on the absolute deviation target using their absolute deviation from 0.

[4] Kurtosis highlighted based on the absolute deviation target using their absolute deviation from 3.

[5] There is no target for Incorrect weight digit.

[6] The number 1 indicates the best ranked team, cells are highlighted if teams ranked below the target team using the PCA scores.

Table A8 Height and weight indicator totals by team and team rankings using PCA scores in Chad

Team No.	% Invalid HAZ[1]	% Invalid WAZ[1]	% Invalid WHZ[1]	HAZ SD[2]	WAZ SD[2]	WHZ SD[2]	HAZ skew[2,3]	WAZ skew[2,3]	WHZ skew[2,3]	HAZ kurtosis[2,4]	WAZ kurtosis[2,4]	WHZ kurtosis[2,4]	Height index[2]	Height heaping[2]	Weight index[2]	Incorrect weight digit[5]	Only height measured[2]	Only weight measured[2]	Incorrectly measured[2]	Measured incomplete[2]	Relative team ranking using PCA scores[6]
1	1.0%	3.1%	1.2%	1.78	1.23	1.29	0.72	0.23	-0.46	4.13	3.30	3.77	16%	5%	6%	3%	0%	0%	9%	5%	2
2	2.6%	15.6%	1.7%	2.14	1.44	1.49	0.36	-0.26	-0.14	2.87	3.00	4.99	35%	18%	8%	1%	0%	0%	13%	18%	20
3	2.3%	2.9%	2.8%	2.02	1.41	1.49	0.85	0.47	-0.09	4.20	4.94	3.39	13%	3%	7%	5%	0%	2%	4%	5%	17
4	1.8%	4.9%	3.6%	1.84	1.34	1.12	0.53	0.14	0.43	4.23	4.10	4.64	10%	1%	8%	4%	0%	2%	5%	10%	9
5	2.9%	2.8%	2.7%	2.17	1.50	1.44	0.52	0.31	-0.13	3.37	3.08	3.31	15%	4%	9%	6%	0%	1%	3%	5%	22
6	1.6%	1.5%	0.9%	1.92	1.37	1.23	0.33	0.03	-0.27	3.06	3.26	3.35	16%	5%	4%	2%	0%	1%	10%	3%	6
7	3.2%	9.8%	2.5%	1.91	1.34	1.15	0.20	0.03	0.00	2.92	3.52	3.66	38%	17%	6%	1%	0%	2%	11%	12%	12
8	3.2%	0.9%	3.8%	1.96	1.48	1.31	0.33	0.52	0.28	3.62	4.61	4.90	10%	3%	7%	<1%	0%	<1%	9%	3%	19
9	5.3%	4.8%	6.4%	2.43	1.98	1.73	0.33	0.51	0.40	2.61	3.46	3.17	8%	4%	8%	3%	0%	1%	4%	7%	24
10	2.0%	4.8%	1.4%	2.07	1.43	1.14	0.49	0.12	0.00	3.38	3.18	3.91	11%	2%	7%	2%	0%	<!%	17%	5%	13
11	3.1%	1.3%	1.1%	1.99	1.47	1.21	0.61	0.41	0.11	3.11	3.69	4.30	14%	5%	5%	1%	0%	<1%	27%	3%	14
12	1.3%	0.6%	0.9%	1.79	1.28	1.23	0.45	0.34	0.25	3.38	3.39	3.81	14%	5%	7%	2%	0%	<1%	8%	1%	5
13	2.1%	6.0%	2.1%	2.11	1.42	1.30	0.36	0.23	0.01	2.65	2.95	3.64	13%	2%	7%	1%	<1%	0%	3%	10%	16
14	6.8%	2.0%	1.8%	2.27	1.74	1.59	0.76	0.60	0.54	3.92	3.79	3.71	29%	14%	9%	8%	<1%	<1%	10%	4%	23
15	4.2%	2.6%	2.1%	1.88	1.47	1.53	0.21	0.03	0.29	3.15	3.76	3.82	11%	3%	5%	1%	<1%	<1%	9%	4%	18
17	2.0%	2.1%	0.6%	1.72	1.37	1.25	0.33	-0.28	-0.20	3.50	3.56	3.93	13%	6%	4%	1%	0%	2%	9%	6%	4
18	0.5%	2.0%	0.9%	1.88	1.40	1.35	0.25	-0.19	-0.30	3.15	3.31	3.77	14%	4%	6%	1%	0%	<1%	10%	5%	7
19	2.1%	0.8%	1.4%	1.81	1.35	1.24	0.23	-0.29	-0.16	3.34	3.33	4.38	9%	3%	5%	2%	0%	<1%	6%	4%	8
20	1.6%	2.4%	1.2%	1.81	1.33	1.15	0.29	-0.08	-0.18	3.53	3.50	3.04	13%	4%	7%	1%	0%	<1%	13%	6%	3
21	1.9%	1.2%	2.3%	1.94	1.40	1.36	0.07	-0.16	-0.14	3.02	3.39	3.33	19%	4%	8%	6%	<1%	0%	13%	3%	15
22	0.3%	1.0%	1.0%	1.68	1.22	1.26	0.21	-0.12	-0.16	4.12	2.98	2.97	17%	2%	9%	2%	0%	1%	3%	3%	1
24	2.6%	2.6%	3.5%	2.11	1.49	1.44	0.30	0.21	-0.29	3.29	3.47	3.37	18%	6%	7%	3%	<1%	<1%	9%	4%	21
25	1.7%	3.4%	1.7%	1.87	1.39	1.20	0.15	0.12	-0.07	3.15	3.42	4.25	15%	7%	4%	1%	<1%	0%	10%	5%	10
26	1.5%	1.7%	1.1%	1.92	1.38	1.41	0.31	-0.21	-0.55	3.43	3.59	3.86	22%	8%	6%	1%	0%	1%	13%	5%	11
Survey Total	**2.4%**	**2.8%**	**2.0%**	**1.98**	**1.49**	**1.37**	**0.40**	**0.17**	**<0.01**	**3.38**	**3.56**	**3.70**	**10%**	**3%**	**3%**	**2%**	**<1%**	**1%**	**10%**	**5%**	

Note: Abbreviations include SD, Standard deviation; HAZ, height-for-age; WAZ, weight-for-age; WHZ, weight-for-height; DMY, day month year; MY, month year.

[1] The percent of implausible values for HAZ, WAZ, and WHZ have a global standard of 1.0% used here instead of Target B.

[2] Target B for HAZ SD = 1.59; WAZ SD = 1.23; WHZ SD = 1.30; HAZ skew = 0.37; WAZ skew = 0.10; WHZ skew = 0.14; HAZ kurtosis = 1.13; WAZ kurtosis = 0.96; WHZ kurtosis = 1.12; Height index = 15%; Height heaping 6%; Weight index 3%; Only height measured = 0.05%; Only weight measured 0.4%; Incorrectly measured 8.2%; Measured incomplete 3.9%.

[3] Skewness highlighted based on the absolute deviation target using their absolute deviation from 0.

[4] Kurtosis highlighted based on the absolute deviation target using their absolute deviation from 3.

[5] There is no target for Incorrect weight digit.

[6] The number 1 indicates the best ranked team, cells are highlighted if teams ranked below the target team using the PCA scores.

Table A9 Height and weight indicator totals by team and team rankings using PCA scores in Nigeria

Team No.	% Invalid HAZ[1]	% Invalid WAZ[1]	% Invalid WHZ[1]	HAZ SD[2]	WAZ SD[2]	WHZ SD[2]	HAZ skew[2,3]	WAZ skew[2,3]	WHZ skew[2,3]	HAZ kurtosis[2,4]	WAZ kurtosis[2,4]	WHZ kurtosis[2,4]	Height index[2]	Height heaping[2]	Weight index[2]	Incorrect weight digit[5]	Only height measured[2]	Only weight measured[2]	Incorrectly measured[2]	Measured incomplete[2]	Relative team ranking using PCA scores[6]
1	5.6%	2.1%	4.3%	1.95	1.39	1.78	0.50	0.19	0.13	3.75	3.80	3.23	34%	16%	14%	6%	<1%	1%	6%	2%	26
2	8.6%	4.4%	10.2%	2.36	1.82	2.10	0.56	0.39	0.19	3.19	3.07	2.88	21%	7%	17%	3%	<1%	<1%	13%	5%	34
3	2.0%	2.2%	2.6%	1.63	1.24	1.19	0.22	0.11	-0.22	3.87	4.64	3.32	28%	12%	7%	1%	1%	<1%	13%	2%	16
4	2.4%	2.8%	2.2%	1.66	1.27	1.35	0.37	-0.26	-0.33	3.55	3.73	3.24	18%	5%	4%	1%	0%	1%	18%	4%	17
5	3.0%	2.3%	3.6%	1.81	1.40	1.45	-0.14	0.42	0.13	3.34	4.95	4.23	18%	7%	7%	3%	0%	1%	3%	4%	14
6	1.4%	0.9%	1.4%	1.52	1.18	1.26	-0.06	-0.16	0.22	3.25	4.20	4.02	12%	3%	4%	1%	0%	1%	2%	2%	1
7	2.9%	3.1%	3.1%	1.86	1.35	1.47	0.15	-0.13	0.15	2.90	3.91	3.80	28%	13%	8%	2%	<1%	<1%	5%	7%	10
8	1.3%	2.2%	2.3%	1.56	1.14	1.31	0.27	-0.06	-0.04	3.60	3.58	4.61	14%	5%	5%	3%	0%	1%	4%	2%	4
9	4.5%	1.2%	2.0%	1.91	1.37	1.48	0.57	0.79	-0.20	3.45	4.61	3.52	16%	7%	8%	4%	<1%	1%	3%	1%	24
10	3.7%	4.2%	4.5%	2.07	1.47	1.51	0.49	0.04	-0.18	3.55	3.85	3.75	35%	17%	8%	2%	<1%	1%	10%	9%	20
11	8.2%	6.1%	9.6%	2.00	1.37	1.65	-0.05	-0.06	-0.07	3.65	4.02	3.22	18%	4%	15%	11%	<1%	3%	7%	7%	32
12	5.5%	5.7%	6.2%	2.09	1.41	1.54	0.65	0.04	0.01	3.46	3.30	3.29	18%	5%	4%	2%	<1%	1%	8%	7%	22
13	4.9%	2.0%	7.5%	1.94	1.34	1.54	0.32	0.45	0.17	3.67	4.67	4.22	27%	11%	11%	4%	<1%	1%	8%	2%	25
14	1.7%	4.8%	2.7%	1.85	1.42	1.45	0.30	-0.11	-0.13	3.03	3.57	3.44	36%	5%	5%	2%	<1%	1%	10%	6%	19
15	2.3%	0.8%	3.1%	1.59	1.18	1.42	-0.06	-0.10	-0.01	3.66	3.89	4.14	13%	2%	11%	8%	0%	<1%	4%	1%	18
16	7.2%	4.5%	8.2%	2.28	1.74	1.62	0.91	0.66	-0.01	3.79	3.93	3.49	34%	13%	9%	8%	<1%	1%	12%	5%	30
17	14.7%	3.5%	12.8%	2.29	1.79	2.28	0.65	0.41	0.17	3.31	2.82	2.16	30%	11%	17%	23%	<1%	1%	21%	2%	36
18	7.3%	4.0%	9.5%	2.24	1.52	1.92	0.56	0.54	0.29	3.38	4.44	2.67	33%	11%	19%	15%	<1%	1%	10%	3%	35
19	7.9%	2.4%	5.6%	2.19	1.43	1.87	0.80	0.14	0.03	3.88	3.54	2.93	18%	3%	7%	7%	<1%	<1%	9%	2%	27
20	17.3%	2.3%	11.5%	2.13	1.58	2.03	0.56	0.48	0.01	3.18	3.99	2.56	14%	4%	18%	2%	<1%	<1%	6%	2%	33
21	2.3%	4.4%	3.0%	1.82	1.25	1.27	0.35	0.11	-0.17	3.95	3.92	3.27	29%	14%	6%	2%	0%	1%	3%	5%	12
22	1.9%	1.6%	2.3%	1.65	1.22	1.22	0.47	0.25	-0.37	4.14	4.40	3.56	13%	3%	8%	7%	0%	0%	3%	1%	11
23	1.1%	3.4%	0.9%	1.70	1.26	1.30	0.03	0.04	-0.20	3.38	3.53	3.81	14%	4%	5%	2%	0%	1%	4%	5%	6
24	3.9%	2.5%	4.6%	1.94	1.31	1.46	0.34	-0.09	0.36	3.30	3.43	4.55	22%	9%	6%	6%	<1%	1%	5%	3%	21
25	6.2%	2.8%	5.7%	1.99	1.49	1.53	0.44	0.13	-0.19	3.56	3.79	3.28	19%	3%	11%	8%	0%	<1%	7%	2%	29
26	0.9%	1.3%	1.7%	1.59	1.13	1.14	0.13	-0.17	-0.05	3.74	3.28	3.56	17%	7%	7%	2%	<1%	1%	3%	2%	2
27	1.4%	1.2%	1.6%	1.55	1.19	1.21	0.30	-0.14	-0.11	4.00	4.20	3.93	8%	2%	5%	2%	0%	<1%	5%	2%	3
28	6.9%	1.8%	11.3%	1.89	1.51	1.52	0.01	0.30	0.57	3.28	4.22	4.43	19%	6%	11%	9%	1%	<1%	17%	1%	31
29	2.1%	1.0%	1.3%	1.81	1.30	1.33	0.27	-0.03	-0.19	3.15	3.45	3.69	20%	7%	4%	1%	<1%	<1%	11%	1%	9
30	2.5%	2.3%	3.2%	1.88	1.41	1.56	0.58	-0.06	-0.15	3.79	3.19	3.00	28%	6%	3%	2%	<1%	1%	6%	3%	15
31	4.2%	2.0%	3.4%	2.02	1.34	1.25	0.46	0.15	0.03	3.52	3.66	4.38	34%	9%	8%	8%	0%	<1%	14%	1%	23
32	2.0%	2.1%	2.5%	1.84	1.28	1.25	0.19	-0.11	-0.17	3.21	4.22	4.50	23%	9%	5%	0%	<1%	<1%	4%	3%	8
33	9.5%	6.8%	19.2%	2.54	1.69	1.99	0.15	0.36	0.10	2.46	3.44	2.84	10%	2%	24%	29%	<1%	<1%	8%	5%	37
34	1.5%	0.4%	2.4%	1.63	1.19	1.26	0.08	0.15	-0.45	3.53	5.13	4.13	14%	6%	6%	4%	0%	0%	3%	1%	7
35	5.1%	1.8%	6.2%	2.14	1.40	1.60	0.50	-0.07	-0.10	3.66	3.86	3.15	22%	5%	11%	12%	0%	0%	14%	2%	28
36	1.2%	3.0%	1.8%	1.54	1.20	1.17	0.23	-0.32	-0.52	3.92	3.74	3.84	18%	8%	5%	1%	0%	<1%	4%	4%	5
37	2.9%	1.8%	3.7%	1.65	1.23	1.22	0.40	-0.16	-0.55	4.21	4.99	3.92	14%	5%	6%	3%	<1%	1%	3%	2%	13
Survey Total	**5.1%**	**2.9%**	**5.4%**	**2.06**	**1.53**	**1.61**	**0.31**	**0.00**	**-0.09**	**3.30**	**3.57**	**3.51**	**18%**	**7%**	**6%**	**6%**	<1%	**1%**	**8%**	**3%**	

Note: Abbreviations include SD, Standard deviation; HAZ, height-for-age; WAZ, weight-for-age; WHZ, weight-for-height; DMY, day month year; MY, month year.

[1] The percent of implausible values for HAZ, WAZ, and WHZ have a global standard of 1.0% used here instead of Target B.

[2] Target B for HAZ SD = 1.59; WAZ SD = 1.23; WHZ SD = 1.30; HAZ skew = 0.37; WAZ skew = 0.10; WHZ skew = 0.14; HAZ kurtosis = 1.13; WAZ kurtosis = 0.96; WHZ kurtosis = 1.12; Height index = 15%; Height heaping 6%; Weight index 3%; Only height measured = 0.05%; Only weight measured 0.4%; Incorrectly measured 8.2%; Measured incomplete 3.9%.

[3] Skewness highlighted based on the absolute deviation target using their absolute deviation from 0.

[4] Kurtosis highlighted based on the absolute deviation target using their absolute deviation from 3.

[5] There is no target for Incorrect weight digit.

[6] The number 1 indicates the best ranked team, cells are highlighted if teams ranked below the target team using the PCA scores.

Table A10 Date of birth indicator totals by team and team rankings using PCA scores in Guatemala

Team No.	Day of birth index[1]	Month of birth index[1]	HAZ Interval[1]	WAZ Interval[1]	DMY incomplete[1]	MY incomplete[1]	Team rankings using PCA scores[2]
1	7%	4%	0.46	0.34	<1%	0%	15
3	7%	8%	0.18	0.06	1%	0%	3
4	8%	6%	0.15	0.20	<1%	0%	4
5	10%	8%	0.23	0.15	1%	0%	13
6	7%	6%	0.33	0.33	0%	0%	12
7	5%	5%	0.19	0.22	1%	0%	7
8	7%	6%	0.19	0.20	1%	0%	6
9	9%	6%	0.31	0.24	1%	0%	11
10	8%	5%	0.27	0.05	<1%	0%	2
11	8%	6%	0.07	0.19	1%	0%	8
12	7%	7%	0.03	0.03	<1%	0%	1
13	8%	5%	0.15	0.10	1%	0%	5
14	9%	7%	0.12	0.23	<1%	0%	9
15	8%	8%	0.23	0.20	0%	0%	14
16	8%	5%	0.20	0.22	0%	0%	10
17	22%	16%	0.83	0.53	<1%	0%	16
Survey Total	**2%**	**4%**	**0.12**	**0.08**	**<1%**	**0%**	

Note: Abbreviations include HAZ, height-for-age; WAZ, weight-for-age; WHZ, weight-for-height; DMY, day month year; MY, month year.
[1] Target A for Day of birth index = 5%; Month of birth index 3%; HAZ interval 0.13; WAZ interval 0.08; DMY of birth incomplete 2.2%; MY of birth incomplete 0.6%.
[2] The number 1 indicates the best ranked team, cells are highlighted if teams ranked below the target team using the PCA scores.

Table A11 Date of birth indicator totals by team and team rankings using PCA scores in Nepal

Team No.	Day of birth index[1]	Month of birth index[1]	HAZ Interval[1]	WAZ Interval[1]	DMY incomplete[1]	MY incomplete[1]	Team rankings using PCA scores[2]
1	22%	11%	0.48	0.10	0%	0%	7
2	19%	11%	1.23	0.94	0%	0%	15
3	24%	11%	0.85	1.03	0%	0%	14
4	18%	9%	1.20	0.29	0%	0%	13
5	19%	13%	0.30	0.42	0%	0%	10
6	12%	10%	0.02	0.06	0%	0%	1
7	14%	12%	0.08	0.47	0%	0%	5
8	20%	13%	0.06	0.13	0%	0%	3
9	17%	8%	0.06	<0.01	0%	0%	2
10	17%	11%	0.79	0.30	0%	0%	12
11	22%	14%	0.56	0.14	0%	0%	8
12	16%	10%	1.86	0.68	0%	0%	16
13	18%	8%	0.25	0.04	0%	0%	4
14	21%	8%	0.31	0.11	0%	0%	6
15	14%	10%	0.47	0.43	0%	0%	11
16	15%	15%	0.62	0.31	0%	0%	9
Survey Total	**5%**	**5%**	**0.04**	**0.09**	**0%**	**0%**	

Note: Abbreviations include HAZ, height-for-age; WAZ, weight-for-age; WHZ, weight-for-height; DMY, day month year; MY, month year.
[1] Target A for Day of birth index = 5%; Month of birth index 3%; HAZ interval 0.13; WAZ interval 0.08; DMY of birth incomplete 2.2%; MY of birth incomplete 0.6%.
[2] The number 1 indicates the best ranked team, cells are highlighted if teams ranked below the target team using the PCA scores.

Table A12 Date of birth indicator totals by team and team rankings using PCA scores in Ethiopia

Team No.	Day of birth index[1]	Month of birth index[1]	HAZ Interval[1]	WAZ Interval[1]	DMY incomplete[1]	MY incomplete[1]	Team rankings using PCA scores[2]
1	11%	7%	0.23	0.18	<1%	0%	11
2	14%	10%	0.33	0.26	0%	0%	14
3	15%	10%	0.08	0.02	1%	0%	3
4	16%	23%	1.32	0.78	<1%	0%	33
5	14%	17%	0.91	0.43	10%	0%	25
6	19%	19%	0.09	0.18	23%	0%	9
7	15%	8%	0.06	0.01	1%	0%	2
8	12%	11%	0.32	0.37	0%	0%	18
9	12%	7%	0.10	0.44	2%	0%	13
10	15%	8%	0.82	0.35	1%	0%	22
11	12%	9%	0.58	0.25	1%	0%	19
12	12%	8%	0.10	0.08	1%	0%	4
13	10%	8%	0.20	0.21	11%	0%	8
14	17%	7%	0.56	0.61	1%	0%	23
15	15%	24%	1.01	1.04	29%	0%	32
16	16%	12%	0.56	0.24	18%	0%	17
17	18%	18%	1.04	0.67	0%	0%	30
18	16%	10%	0.20	0.17	5%	0%	10
19	12%	9%	0.53	0.49	<1%	0%	21
20	13%	8%	1.15	0.76	1%	0%	29
21	16%	10%	0.14	0.02	1%	0%	5
22	13%	10%	0.58	0.38	17%	0%	20
23	14%	9%	0.74	0.83	3%	0%	27
24	21%	12%	1.10	1.04	7%	0%	31
25	16%	10%	0.83	0.55	2%	0%	24
26	15%	10%	0.71	0.01	0%	0%	16
27	14%	10%	1.13	0.45	8%	0%	26
28	18%	12%	0.00	0.42	13%	0%	12
29	16%	13%	0.12	0.04	0%	0%	7
30	16%	9%	0.03	0.20	6%	0%	6
31	14%	10%	0.55	0.10	<1%	0%	15
32	13%	8%	0.90	0.79	<1%	0%	28
33	16%	4%	0.07	0.15	13%	0%	1
Survey Total	**7%**	**7%**	**0.34**	**0.27**	**6%**	**0%**	

Note: Abbreviations include HAZ, height-for-age; WAZ, weight-for-age; WHZ, weight-for-height; DMY, day month year; MY, month year.

[1] Target B for Day of birth index = 7%; Month of birth index 4%; HAZ interval 0.25; WAZ interval 0.17; DMY of birth incomplete 4.3%; MY of birth incomplete 1.5%.

[2] The number 1 indicates the best ranked team, cells are highlighted if teams ranked below the target team using the PCA scores.

Table A13 Date of birth indicator totals by team and team rankings using PCA scores in Chad

Team No.	Day of birth index[1]	Month of birth index[1]	HAZ Interval[1]	WAZ Interval[1]	DMY incomplete[1]	MY incomplete[1]	Team rankings using PCA scores[2]
1	27%	12%	0.81	0.37	20%	0%	16
2	22%	10%	0.93	0.23	38%	0%	14
3	24%	10%	0.85	0.39	28%	0%	17
4	22%	14%	0.59	0.42	32%	0%	12
5	20%	13%	0.01	0.16	7%	0%	2
6	17%	10%	0.68	0.31	36%	0%	11
7	47%	16%	0.89	0.72	7%	0%	22
8	28%	7%	0.77	0.56	2%	0%	18
9	22%	12%	0.02	0.26	13%	0%	4
10	26%	14%	0.89	0.30	84%	0%	15
11	33%	11%	0.33	0.14	<1%	0%	9
12	20%	15%	0.93	0.63	2%	0%	19
13	26%	18%	0.29	0.22	87%	0%	8
14	29%	13%	0.20	0.83	9%	0%	13
15	20%	7%	0.46	0.16	29%	0%	10
16							24
17	23%	6%	0.96	1.16	3%	0%	1
18	19%	14%	0.08	0.12	1%	0%	3
19	17%	8%	0.03	0.14	43%	0%	7
20	11%	10%	0.40	0.16	53%	0%	23
21	21%	9%	0.67	0.38	15%	<1%	21
22	17%	9%	0.93	0.66	2%	0%	6
24	19%	8%	0.27	0.10	2%	0%	5
25	18%	7%	0.20	0.07	6%	0%	20
26	14%	6%	0.90	0.67	9%	0%	16
Survey Total	**15%**	**7%**	**0.39**	**0.23**	**21%**	**<1%**	

Note: Abbreviations include HAZ, height-for-age; WAZ, weight-for-age; WHZ, weight-for-height; DMY, day month year; MY, month year.
[1] Target B for Day of birth index = 7%; Month of birth index 4%; HAZ interval 0.25; WAZ interval 0.17; DMY of birth incomplete 4.3%; MY of birth incomplete 1.5%.
[2] The number 1 indicates the best ranked team, cells are highlighted if teams ranked below the target team using the PCA scores.

Table A14 Date of birth indicator totals by team and team rankings using PCA scores in Egypt

Team No.	Day of birth index[1]	Month of birth index[1]	HAZ Interval[1]	WAZ Interval[1]	DMY incomplete[1]	MY incomplete[1]	Team rankings using PCA scores[2]
1	15%	5%	0.87	0.87	3%	0%	14
2	13%	8%	0.18	0.40	3%	0%	5
3	15%	7%	0.79	0.81	1%	0%	12
4	12%	7%	0.35	0.06	1%	0%	4
5	11%	5%	0.49	0.33	4%	0%	7
6	21%	6%	0.95	0.55	1%	0%	13
7	14%	8%	0.82	0.52	2%	0%	11
8	17%	5%	0.60	0.20	<1%	0%	10
9	11%	6%	0.43	0.23	2%	0%	6
10	12%	6%	0.08	0.09	<1%	0%	3
11	12%	7%	0.67	0.39	<1%	0%	8
12	22%	7%	0.08	0.12	14%	0%	2
13	20%	6%	0.52	0.39	2%	0%	9
14	16%	9%	0.13	<0.01	6%	0%	1
Survey Total	**14%**	**5%**	**0.41**	**0.31**	**3%**	**0%**	

Note: Abbreviations include HAZ, height-for-age; WAZ, weight-for-age; WHZ, weight-for-height; DMY, day month year; MY, month year.
[1] Target B for Day of birth index = 7%; Month of birth index 4%; HAZ interval 0.25; WAZ interval 0.17; DMY of birth incomplete 4.3%; MY of birth incomplete 1.5%.
[2] The number 1 indicates the best ranked team, cells are highlighted if teams ranked below the target team using the PCA scores.

Table A15 Date of birth indicator totals by team and team rankings using PCA scores in Nigeria

Team No.	Day of birth index[1]	Month of birth index[1]	HAZ Interval[1]	WAZ Interval[1]	DMY incomplete[1]	MY incomplete[1]	Team rankings using PCA scores[2]
1	21%	9%	0.30	0.39	1%	0%	28
2	18%	6%	0.68	0.71	3%	0%	26
3	13%	6%	0.33	0.16	3%	0%	18
4	9%	7%	0.36	0.32	2%	0%	9
5	13%	8%	1.23	0.54	1%	0%	15
6	13%	7%	0.48	0.26	2%	0%	17
7	15%	10%	0.85	0.74	2%	0%	24
8	9%	7%	1.00	0.61	1%	0%	5
9	12%	7%	0.12	0.17	0%	0%	8
10	12%	7%	1.23	0.58	1%	0%	11
11	16%	8%	0.66	0.25	3%	0%	25
12	18%	11%	0.40	0.51	2%	0%	31
13	13%	8%	0.29	0.19	2%	0%	19
14	20%	19%	0.92	0.72	4%	0%	36
15	11%	7%	0.65	0.51	<1%	0%	7
16	22%	19%	1.27	0.52	3%	0%	37
17	17%	10%	0.01	0.15	3%	0%	29
18	25%	8%	0.33	0.08	2%	0%	32
19	19%	17%	0.38	0.03	2%	0%	33
20	22%	16%	0.26	0.54	1%	0%	34
21	12%	6%	0.49	0.26	1%	0%	10
22	11%	6%	0.91	0.44	2%	<1%	1
23	7%	7%	0.02	0.06	1%	0%	2
24	13%	8%	0.21	0.11	5%	0%	27
25	13%	12%	1.46	0.49	1%	0%	23
26	12%	5%	0.28	0.06	<1%	0%	3
27	14%	7%	0.17	0.00	3%	0%	21
28	11%	10%	0.20	0.14	<1%	0%	14
29	12%	6%	0.20	0.02	2%	0%	12
30	31%	16%	0.10	0.13	1%	0%	35
31	12%	5%	0.44	0.19	1%	0%	4
32	15%	8%	1.00	0.63	1%	0%	20
33	14%	8%	0.05	0.39	6%	0%	30
34	11%	7%	0.53	0.23	2%	0%	13
35	10%	8%	1.58	1.29	2%	0%	16
36	13%	8%	0.17	0.10	3%	0%	22
37	10%	7%	0.15	0.17	1%	0%	6
Survey Total	**10%**	**6%**	**0.56**	**0.36**	**2%**	**<1%**	

Note: Abbreviations include HAZ, height-for-age; WAZ, weight-for-age; WHZ, weight-for-height; DMY, day month year; MY, month year.
[1] Target B for Day of birth index = 7%; Month of birth index 4%; HAZ interval 0.25; WAZ interval 0.17; DMY of birth incomplete 4.3%; MY of birth incomplete 1.5%.
[2] The number 1 indicates the best ranked team, cells are highlighted if teams ranked below the target team using the PCA scores.

Table A16 Quarterly team values for the standard deviation and percent of implausible values of HAZ by team and survey total in Nepal

Team No.	HAZ SD Q1	Q2	Q3	Q4	Total	Quarters team met target[1]	HAZ implausible Q1	Q2	Q3	Q4	Total	Quarters team met target[2]
1	1.39	1.31	1.59	1.11	**1.43**	**3/4**	0.0%	0.0%	0.0%	0.0%	**0.0%**	**4/4**
2	1.23	1.04	0.88	(1.21)	**1.16**	**4/4**	0.0%	0.0%	0.0%	(0.0)%	**0.0%**	**4/4**
3	1.10	1.56	(1.45)	(1.91)	**1.55**	**1/4**	0.0%	0.0%	(0.0)%	(0.0)%	**0.0%**	**4/4**
4	1.07	(1.17)	(1.18)	1.06	**1.18**	**4/4**	2.7%	(0.0)%	(0.0)%	0.0%	**1.1%**	**3/4**
5	1.15	1.42	1.63	(1.23)	**1.39**	**2/4**	0.0%	0.0%	0.0%	(0.0)%	**0.0%**	**4/4**
6	1.17	1.25	1.30	1.30	**1.27**	**4/4**	0.0%	0.0%	0.0%	0.0%	**0.0%**	**4/4**
7	1.32	1.28	1.16	1.38	**1.34**	**4/4**	1.2%	0.0%	0.0%	0.0%	**0.3%**	**4/4**
8	1.21	1.26	0.91	1.17	**1.18**	**4/4**	0.0%	0.0%	0.0%	0.0%	**0.0%**	**4/4**
9	1.22	1.06	1.61	1.24	**1.32**	**3/4**	0.0%	0.0%	0.0%	0.0%	**0.0%**	**4/4**
10	1.19	1.85	1.71	(1.05)	**1.56**	**2/4**	0.0%	2.7%	0.0%	(0.0)%	**0.8%**	**3/4**
11	1.10	(1.72)	1.37	(0.97)	**1.29**	**3/4**	0.0%	4.0%	3.3%	(0.0)%	**1.8%**	**1/4**
12	1.35	1.52	1.04	1.13	**1.39**	**3/4**	0.0%	0.0%	0.0%	0.0%	**0.0%**	**4/4**
13	1.09	1.72	1.05	0.80	**1.21**	**3/4**	0.0%	0.0%	0.0%	0.0%	**0.0%**	**4/4**
14	1.08	0.99	1.42	(0.89)	**1.15**	**3/4**	0.0%	0.0%	0.0%	(0.0)%	**0.0%**	**4/4**
15	1.23	1.49	1.52	(0.70)	**1.39**	**2/4**	0.0%	0.0%	0.0%	(0.0)%	**0.0%**	**4/4**
16	1.20	1.35	1.32	(2.50)	**1.47**	**3/4**	0.0%	0.0%	2.9%	(6.3)%	**1.4%**	**1/4**
Total	**1.21**	**1.40**	**1.39**	**1.36**	1.35	**4/4**	**0.3%**	**0.3%**	**0.3%**	**0.2%**	0.3%	**4/4**
	Percent of teams who met the target					**No. of**	**Percent of teams who met the target**					**No. of**
	Q1	**Q2**	**Q3**	**Q4**	**Total**	**teams**	**Q1**	**Q2**	**Q3**	**Q4**	**Total**	**teams**
	100%	56%	56%	88%	**75%**	16	88%	88%	88%	94%	**81%**	16

Note: Estimates that did not meet targets are highlighted in blue. Some teams have been excluded if they did not have at least 25 cases at the end of the survey. Values shown in parentheses are based on <25 cases. Abbreviations include SD standard deviation; HAZ height-for-age. All implausible values are rounded to the nearest tenth of a percent.
[1] Target A for the standard deviation of HAZ is 1.41.
[2] The percent of implausible values for HAZ, WAZ, and WHZ have a global standard of 1.0% used here instead of Target A (WHO/UNICEF 2019).

Table A17 Quarterly team values for the standard deviation and percent of implausible values of HAZ by team and survey total in Chad

Team No.	HAZ SD Q1	HAZ SD Q2	HAZ SD Q3	HAZ SD Q4	HAZ SD Total	Quarters team met target[1]	% HAZ Implausible Q1	% HAZ Implausible Q2	% HAZ Implausible Q3	% HAZ Implausible Q4	% HAZ Implausible Total	Quarters team met target[2]
1	1.44	1.71	1.80	2.04	**1.78**	**1/4**	0.0%	0.9%	1.3%	1.2%	**1.0%**	**2/4**
2	2.04	(3.03)	(2.13)	(2.82)	**2.14**	**0/4**	2.2%	(10.0%)	(0.0%)	(0.0%)	**2.6%**	**2/4**
3	1.81	2.04	2.18	1.69	**2.02**	**0/4**	1.7%	3.6%	1.4%	2.7%	**2.3%**	**0/4**
4	1.69	1.71	1.83	2.01	**1.84**	**0/4**	4.0%	1.9%	1.1%	1.5%	**1.8%**	**0/4**
5	1.83	2.22	2.32	2.22	**2.17**	**0/4**	4.5%	0.9%	3.3%	3.0%	**2.9%**	**1/4**
6	1.97	1.90	2.19	1.78	**1.92**	**0/4**	1.2%	2.8%	1.9%	1.0%	**1.6%**	**1/4**
7	1.86	1.98	1.83		**1.91**	**0/3**	1.6%	1.0%	10.0%		**3.2%**	**0/3**
8	2.22	2.09	2.18	1.67	**1.96**	**0/4**	3.6%	10.5%	0.8%	1.3%	**3.2%**	**1/4**
9	2.29	2.34	2.69	2.33	**2.43**	**0/4**	4.3%	8.3%	4.0%	4.9%	**5.3%**	**0/4**
10	2.10	2.21	1.85	1.98	**2.07**	**0/4**	2.5%	2.9%	0.0%	2.4%	**2.0%**	**1/4**
11	2.18	1.85	1.68	1.85	**1.99**	**0/4**	3.1%	3.2%	1.5%	4.3%	**3.1%**	**0/4**
12	1.80	2.24	1.80	1.43	**1.79**	**1/4**	2.7%	1.2%	1.0%	0.6%	**1.3%**	**2/4**
13	2.23	2.22	1.96	1.89	**2.11**	**0/4**	5.5%	2.3%	1.7%	0.0%	**2.1%**	**1/4**
14	2.60	2.27	2.13	2.10	**2.27**	**0/4**	13.1%	11.8%	2.4%	1.9%	**6.8%**	**0/4**
15	2.31	1.92	1.74	1.53	**1.88**	**1/4**	10.5%	4.3%	2.4%	0.8%	**4.2%**	**1/4**
17	1.82	1.66	1.78	1.43	**1.72**	**1/4**	4.3%	1.6%	1.6%	0.0%	**2.0%**	**1/4**
18	2.03	1.79	1.77	1.89	**1.88**	**0/4**	0.0%	0.0%	1.1%	0.8%	**0.5%**	**3/4**
19	1.89	1.62	1.91	1.87	**1.81**	**0/4**	3.3%	1.3%	2.5%	1.2%	**2.1%**	**0/4**
20	2.28	1.78	1.69	1.52	**1.81**	**1/4**	3.6%	0.9%	2.2%	0.0%	**1.6%**	**2/4**
21	2.00	1.96	1.78	2.05	**1.94**	**0/4**	3.3%	0.0%	1.8%	3.8%	**1.9%**	**1/4**
22	1.85	1.84	1.51	1.46	**1.68**	**2/4**	0.0%	0.9%	0.0%	0.0%	**0.3%**	**4/4**
24	2.14	2.25	2.11	1.91	**2.11**	**0/4**	2.3%	4.6%	1.1%	2.6%	**2.6%**	**0/4**
25	1.94	1.74	2.02	1.71	**1.87**	**0/4**	3.9%	1.5%	0.9%	0.0%	**1.7%**	**2/4**
26	1.82	2.01	1.84	1.91	**1.92**	**0/4**	1.0%	1.6%	0.8%	2.7%	**1.5%**	**2/4**
Total	**2.04**	**2.01**	**2.00**	**1.88**	**1.98**	**0/4**	**3.5%**	**2.8%**	**1.8%**	**1.7%**	**2.4%**	**0/4**

	Percent of teams who met the target					No. of teams	Percent of teams met the target					No. of teams
	Q1	**Q2**	**Q3**	**Q4**	**Total**		**Q1**	**Q2**	**Q3**	**Q4**	**Total**	
	4%	0%	4%	22%	**7%**	24	17%	25%	29%	43%	**13%**	24

Note: Estimates that did not meet targets are highlighted in blue. Some teams have been excluded if they did not have at least 25 cases at the end of the survey. Values shown in parentheses are based on <25 cases. Abbreviations include SD standard deviation; HAZ height-for-age. All implausible values are rounded to the nearest tenth of a percent.

[1] Target B for the standard deviation of HAZ is 1.59.

[2] The percent of implausible values for HAZ, WAZ, and WHZ have a global standard of 1.0% used here instead of Target B (WHO/UNICEF 2019).

Table A18 Quarterly team values for the standard deviation and percent of implausible values of HAZ by team and survey total in Nigeria

Team No.	HAZ SD Q1	HAZ SD Q2	HAZ SD Q3	HAZ SD Q4	HAZ SD Total	Quarters team met target[1]	% HAZ Implausible Q1	% HAZ Implausible Q2	% HAZ Implausible Q3	% HAZ Implausible Q4	% HAZ Implausible Total	Quarters team met target[2]
1	1.85	2.08	1.92	1.69	**1.95**	**0/4**	6.7%	4.8%	5.7%	6.1%	**5.6%**	**0/4**
2	2.22	2.58	2.38	2.23	**2.36**	**0/4**	8.6%	9.9%	8.4%	8.0%	**8.6%**	**0/4**
3	1.82	1.57	1.58	1.53	**1.63**	**3/4**	2.4%	4.5%	1.5%	0.0%	**2.0%**	**1/4**
4	1.69	1.61	1.64	1.66	**1.66**	**0/4**	2.1%	2.1%	3.1%	2.5%	**2.4%**	**0/4**
5	1.73	1.86	1.89	1.57	**1.81**	**1/4**	4.2%	2.4%	2.3%	2.6%	**3.0%**	**0/4**
6	1.49	1.44	1.65	1.46	**1.52**	**3/4**	1.5%	2.3%	0.7%	0.8%	**1.4%**	**2/4**
7	1.90	1.77	2.05	1.59	**1.86**	**0/4**	1.8%	2.5%	5.7%	2.1%	**2.9%**	**0/4**
8	1.60	1.52	1.50	1.56	**1.56**	**3/4**	2.4%	2.7%	0.0%	0.0%	**1.3%**	**2/4**
9	1.71	1.93	2.04	1.91	**1.91**	**0/4**	6.2%	4.5%	2.5%	3.5%	**4.5%**	**0/4**
10	2.16	1.98	2.16	1.72	**2.07**	**0/4**	6.9%	3.3%	1.3%	1.8%	**3.7%**	**0/4**
11	2.12	2.08	1.81	1.81	**2.00**	**0/4**	7.7%	20.9%	0.0%	3.1%	**8.2%**	**1/4**
12	1.96	2.19	2.30	1.93	**2.09**	**0/4**	6.3%	4.1%	7.4%	4.9%	**5.5%**	**0/4**
13	2.22	1.59	1.54	2.17	**1.94**	**1/4**	4.8%	4.7%	5.3%	5.4%	**4.9%**	**0/4**
14	1.63	1.84	1.84	1.91	**1.85**	**0/4**	1.6%	2.5%	1.9%	0.9%	**1.7%**	**1/4**
15	1.78	1.47	1.46	1.54	**1.59**	**3/4**	2.5%	1.8%	3.4%	0.0%	**2.3%**	**1/4**
16	2.28	2.36	2.08	2.31	**2.28**	**0/4**	6.5%	6.0%	6.4%	9.8%	**7.2%**	**0/4**
17	2.22	2.17	2.07	2.56	**2.29**	**0/4**	8.7%	20.1%	11.1%	17.5%	**14.7%**	**0/4**
18	2.61	2.18	2.16	2.12	**2.24**	**0/4**	12.9%	7.8%	3.8%	6.8%	**7.3%**	**0/4**
19	2.24	2.36	1.95	1.99	**2.19**	**0/4**	5.1%	4.7%	8.6%	11.3%	**7.9%**	**0/4**
20	2.15	2.24	2.02	1.83	**2.13**	**0/4**	2.1%	9.4%	23.9%	31.3%	**17.3%**	**0/4**
21	1.69	1.95	1.62	1.94	**1.82**	**0/4**	3.1%	0.0%	1.3%	4.3%	**2.3%**	**1/4**
22	1.58	2.05	1.51	1.53	**1.65**	**3/4**	2.3%	2.6%	1.3%	1.3%	**1.9%**	**0/4**
23	1.64	1.95	1.78	1.54	**1.70**	**1/4**	1.2%	0.0%	1.4%	1.2%	**1.1%**	**1/4**
24	2.11	1.82	1.67	1.93	**1.94**	**0/4**	4.9%	5.7%	1.6%	2.1%	**3.9%**	**0/4**
25	2.11	2.06	1.67	1.96	**1.99**	**0/4**	13.4%	4.3%	5.7%	4.1%	**6.2%**	**0/4**
26	1.29	1.88	1.36	1.46	**1.59**	**3/4**	1.4%	0.9%	0.0%	1.0%	**0.9%**	**3/4**
27	1.58	1.35	1.45	1.70	**1.55**	**3/4**	2.5%	0.0%	2.1%	1.0%	**1.4%**	**2/4**
28	2.03	1.89	1.67	1.97	**1.89**	**0/4**	7.9%	4.3%	7.1%	9.4%	**6.9%**	**0/4**
29	1.80	1.78	1.81	1.81	**1.81**	**0/4**	2.4%	1.5%	1.7%	2.6%	**2.1%**	**0/4**
30	1.96	1.88	1.92	1.79	**1.88**	**0/4**	3.1%	1.7%	3.7%	1.7%	**2.5%**	**0/4**
31	1.65	1.89	2.30	2.00	**2.02**	**0/4**	6.2%	4.3%	4.2%	3.0%	**4.2%**	**0/4**
32	1.84	1.88	1.75	1.67	**1.84**	**0/4**	2.2%	2.1%	0.0%	3.9%	**2.0%**	**1/4**
33	1.93	2.44	2.58	2.67	**2.54**	**0/4**	6.9%	4.6%	8.2%	17.8%	**9.5%**	**0/4**
34	1.70	1.57	1.62	1.62	**1.63**	**1/4**	0.0%	2.2%	1.9%	2.0%	**1.5%**	**1/4**
35	1.99	2.10	2.31	2.18	**2.14**	**0/4**	4.6%	5.1%	6.8%	1.6%	**5.1%**	**0/4**
36	1.76	1.35	1.49	1.45	**1.54**	**3/4**	1.6%	1.7%	0.0%	1.2%	**1.2%**	**1/4**
37	1.58	1.40	1.74	1.98	**1.65**	**2/4**	2.9%	1.5%	2.8%	5.4%	**2.9%**	**0/4**
Total	**2.00**	**2.05**	**2.09**	**2.10**	**2.06**	**0/4**	**4.7%**	**4.7%**	**5.2%**	**5.9%**	**5.1%**	**0/4**

	Percent of teams who met the target					No. of teams	Percent of teams who met the target					No. of teams
	Q1	**Q2**	**Q3**	**Q4**	**Total**		**Q1**	**Q2**	**Q3**	**Q4**	**Total**	
	14%	22%	22%	24%	**14%**	37	3%	11%	16%	19%	**3%**	37

Note: Estimates that did not meet targets are highlighted in blue. Some teams have been excluded if they did not have at least 25 cases at the end of the survey. Values shown in parentheses are based on <25 cases. Abbreviations include SD standard deviation; HAZ height-for-age. All implausible values are rounded to the nearest tenth of a percent.

[1] Target B for the standard deviation of HAZ is 1.59.

[2] The percent of implausible values for HAZ, WAZ, and WHZ have a global standard of 1.0% used here instead of Target B (WHO/UNICEF 2019).