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EVALUATION OF IMPLAUSIBLE ANTHROPOMETRIC VALUES BY DATA COLLECTION TEAM IN DEMOGRAPHIC AND HEALTH SURVEYS 2010–2020

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Evaluation of Implausible Anthropometric Values by Data Collection Team in Demographic and Health Surveys 2010–20

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ABSTRACT

High quality anthropometry data is required to inform country and global decisions on nutrition policies and programs in low and middle-income countries. In this report, we examine and compare data quality between data collection teams that measure anthropometric data in Demographic and Health Surveys (DHS) surveys. The goal is to inform continuous quality improvement efforts at The DHS Program.

All available DHS data from 2010–20 with height and weight measurements for children age 0–59 months of age were included. The percentage of implausible anthropometric data per collection team was examined within the same survey and compared across surveys. Implausible anthropometric data were defined as height-for-age *z* scores (HAZ) below –6 SD or above +6 SD, weight-for-height *z* scores (WHZ) below –5 SD or above +5 SD, and weight-for-age *z* scores (WAZ) below –6 SD or above +5 SD. The acceptable level of implausible anthropometric data was defined as less than 1% according to World Health Organization recommendations.

A total of 90 DHS surveys with HAZ, WHZ, and WAZ were identified in the persons recode data files. This resulted in a total sample of 871,629; 871,069; and 875,277 children, respectively. By survey, the number of surveys with a percent implausible less than 1% for HAZ, WHZ, and WAZ was 41, 32, and 80 of 90 surveys, respectively. The median of the mean percentage of implausible HAZ, WHZ and WAZ across surveys was 1.4%, 1.3% and 0.2%, respectively, while the median of the inter-quartile range of implausible HAZ, WHZ, and WAZ values was 1.1%, 1.3% and 0.3%, respectively. By teams, the median percentage of teams with implausible HAZ, WHZ, and WAZ values above the 1% threshold was 42%, 50%, and 1.4%, respectively. Team variability was common across all regions, but decreased over time.

The DHS Program supports surveys in areas with hard-to-reach populations and insecure environments and this may partially contribute to variations in data quality between surveys and teams. Our findings suggest that poor performance by teams contributes to overall survey quality. In many surveys, there was team variability that declined in more recent surveys. This reinforces the importance of training and data quality measures that improve the quality of anthropometric data.

KEY WORDS: anthropometry, anthropometric data quality, demographic and health surveys, evaluation, implausible *z* scores, global targets, monitoring, nutritional status, population-based surveys, real-time data collection, stunting, Sustainable Development Goals, underweight, wasting

ACRONYMS AND ABBREVIATIONS

DHS	Demographic and Health Surveys
HAZ	height-for-age *z* score
ID	identification
IQR	interquartile range
SDG	sustainable development goal
SMART	Standardized Monitoring and Assessment of Relief and Transitions
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
WAZ	weight-for-age *z* score
WHO	World Health Organization
WHZ	weight-for-height *z* score

1 INTRODUCTION

Actions that address malnutrition remain a global priority as evidenced by the United Nations Sustainable Development Goal (SDG) "to end all forms of hunger and malnutrition by 2030" (United Nations Department of Economic and Social Affairs Statisics Division 2020). Anthropometric indicators for children under age 5 are used to track and monitor child nutritional status in order to inform country and global decision-making on nutrition policies and programs in low and middle-income countries (Development Initiatives 2020). The Demographic and Health Surveys (DHS) Program is one of the major sources of population-level anthropometric data in low and middle-income countries. This report continues the series of DHS reports that focus on anthropometric data quality in DHS surveys and more specifically, assesses data quality at the level of the data collection team (Allen et al. 2019; Assaf, Kothari, and Pullum 2015; Namaste, Benedict, and Henry 2018; Pullum et al. 2020).

High quality, reliable anthropometric estimates are essential for designing appropriate nutrition and health interventions and tracking SDGs. Recent global guidelines on anthropometric data collection for children under age 5 recommend several quality assessment parameters to assess the quality of anthropometric data. The only anthropometric data quality indicator with an agreed upon threshold is the implausible anthropometric *z* score value (poor data quality defined as greater than or equal to 1%) (WHO 1995; WHO/UNICEF 2019). Implausible *z* score values are outliers or extreme values that are based on the 2006 World Health Organization (WHO) Child Growth standards cut-offs for the anthropometric indicators (WHO Multicentre Growth Reference Study Group 2006b). Implausible *z* score values are considered to be biologically incompatible with life for a child given their age and sex. Implausible *z* score values can occur due to errors in the measurement of children, inaccurate birth date information, and transcription errors (WHO/UNICEF 2019).

The DHS surveys collect height or length, weight, sex and date of birth information to calculate anthropometric *z* scores in children under age 5. The surveys include intensive monitoring and supervision during data collection (Allen et al. 2019; Namaste, Benedict, and Henry 2018). Field check tables, which summarize recently collected data, are used to assess data collection team performance according to various measures of data quality during data collection (Arnold and Khan 2018). For anthropometry, these measures include data completeness, the percentage of implausible anthropometric *z* scores, and in the last decade, digit preference of height and weight, and age heaping (Allen et al. 2019).

Previous studies have examined various indicators of anthropometric data quality in population-based surveys including the percentage of implausible values (Allen et al. 2019; Assaf, Kothari, and Pullum 2015; Corsi, Perkins, and Subramanian 2017; Grellety and Golden 2018; Perumal et al. 2020). Assaf et al. found considerable cluster-level variation in height-for-age *z* scores that could be due to heterogeneity between the clusters, disparity in the quality of the measurements taken by the teams working in different clusters, or a combination thereof (Assaf, Kothari, and Pullum 2015). Corsi et al., Grellety et al., and Perumal et al. reported variation in anthropometry data quality across surveys and time (Corsi, Perkins, and Subramanian 2017; Grellety and Golden 2018; Perumal et al. 2020). However, these studies did not examine data quality within individual surveys.

In large population-based surveys like the DHS, multiple teams collect data. Understanding the variation in implausible values by data collection teams can inform ongoing DHS data quality assurance. To date, only Allen et al. 2019 examined implausible values by team in a small number of surveys. Further research is needed. Therefore, this report aims to examine and compare implausible anthropometric *z* score values by data collection team using data from DHS surveys conducted between 2010 and 2020.

2 DATA AND METHODS

2.1 Data

Data from all DHS surveys with child anthropometric data conducted between 2010 and 2020 were included in the analysis. The DHS surveys collect anthropometric data from children age 0–59 months. Specially trained data collectors collect date of birth, sex, height/length, and weight information by following standardized procedures and protocols (ICF 2021). Each team has a dedicated team supervisor who is assigned a unique identification (ID). Surveys were excluded if the team supervisor ID variable was missing in the dataset. In addition, team supervisor IDs with fewer than 30 observations were excluded.

2.2 Methods for assessing implausible values

For each survey, the persons recode dataset was used to compute the anthropometric variables using the updated WHO *igrowup* Stata macro, which applies the WHO 2006 Child Growth Standards. The *z* scores for height-for-age (HAZ), weight-for-height (WHZ), and weight-for-age (WAZ) were calculated for children age 0–59 months. Adjustments were made to the height measurement if the incorrect measurement position (standing or lying down) was used. For children between age 9 and 24 months who were reported measured standing, 0.7 cm was added to their recorded height. For children over age 24 months who were reported measured lying down, 0.7 cm was subtracted from their recorded height. These adjustments deviated slightly from the WHO *igrowup* Stata macro. When children under age 9 months were reported measured standing, no height adjustment (adding 0.7cm) was made because a child at that age was assumed to be measured lying down (WHO/UNICEF 2019). All children with complete data on month and year of birth were included, and day of birth was imputed as 15 if the day of birth was missing.

Implausible values for anthropometry were defined as flagged using the 2006 WHO recommended flagging system. These were defined as HAZ below –6 SD or above +6 SD, WHZ below –5 SD or above +5 SD, and WAZ below –6 SD or above +5 SD (WHO Multicentre Growth Reference Study Group 2006b). Flagged values were also computed using the WHO *igrowup* Stata macro. The reference tables for the *igrowup* macro for weight-for-height exclude children whose height or length is outside the ranges of 45–110 cm for children younger than 24 months and 65–120 cm for children 24 months and older (WHO/UNICEF 2019). However, for our analyses, we included these values in our denominator for WHZ.

For the implausible anthropometric values, the WHO-UNICEF data quality threshold for implausible values is *z* score values less than 1% (WHO/UNICEF 2019). In each survey, the mean, median, minimum, maximum, 25th quartile, 75th quartile, and interquartile range were calculated for the percentage of implausible anthropometric values by data collection teams. Frequency weights using the unweighted number of cases for each team as a weight were applied.

For the analyses, surveys were grouped into six regions loosely based on WHO definitions and The DHS Program world regional groupings. These were North Africa/West Asia/Europe (NAfr/WAsia/Eur), South and South-East Asia Region (S/SEA), and Latin America and the Caribbean (LAC). For African countries, the region was further grouped into three subregions: West Africa (WAfr), East Africa (EAfr), and Central and South Africa (C/SAfR). Surveys were also grouped by years as 2010–14 surveys and 2015–20 surveys.

3 RESULTS

3.1 Surveys included in the analysis

In total, data from 55 countries and 90 surveys were available for analysis (Table 1). There were 10 surveys from NAfr/WAsia/Eur, 14 surveys from S/SEA, 9 surveys from LAC, 29 surveys from WAfr, 13 surveys from EAfr, and 15 surveys from C/SAfr. Several countries had more than one survey available. One survey was excluded from the analysis because it was missing the supervisor ID variable and could not be linked to the anthropometric indicators. The total sample size for analysis of HAZ, WHZ, and WAZ was 871,629, 871,069, and 875,277, respectively. The overall sample size varied slightly by anthropometric indicator and substantially across countries as did the number of data collection teams. The country with the largest sample size for all three anthropometric indicators was India 2016, while the smallest sample size was in Armenia 2010. The median number of data collection teams per survey was 19 (interquartile range [IQR] 15 to 25.5), and ranged from three teams in Senegal 2012–13 to 875 teams in India 2016 (Table 1). Data from Benin 2011–12, Jordan 2017, and Papua New Guinea 2016–18 were suppressed in their respective country final reports because of concerns with data quality, but are included in these analyses.

Table 1 List of Demographic and Health Surveys included in the analysis

Country	Survey Year	Number of data collection teams	N HAZ	N WHZ	N WAZ
Albania	2017–18	28	2,648	2,640	2,727
Angola	2015–16	28	7,883	7,826	7,888
Armenia	2010	13	1,418	1,423	1,425
Armenia	2015–16	13	1,615	1,602	1,627
Bangladesh	2011	20	8,167	8,161	8,262
Bangladesh	2014	22	7,441	7,438	7,623
Bangladesh	2017	22	8,411	8,387	8,571
Benin	2011–12	29	13,179	13,289	13,379
Benin	2017–18	22	13,437	13,416	13,458
Burkina Faso	2010	20	7,096	7,093	7,110
Burundi	2010	18	3,689	3,688	3,701
Burundi	2016–17	21	6,421	6,413	6,423
Cambodia	2010	19	4,227	4,226	4,245
Cambodia	2014	19	5,052	5,052	5,077
Cameroon	2011	20	6,135	6,134	6,145
Cameroon	2018	17	5,326	5,303	5,328
Chad	2014–15	24	11,453	11,447	11,523
Colombia	2010	15	18,159	18,160	18,173
Comoros	2012	13	3,108	3,103	3,195
Congo	2011–12	16	5,059	5,059	5,065
Congo Democratic Republic	2013–14	139	9,103	9,098	9,111
Côte d'Ivoire	2011–12	18	3,956	3,952	3,967
Dominican Republic	2013	12	3,783	3,783	3,783
Egypt	2014	14	15,523	15,522	15,526
Ethiopia	2011	35	10,767	10,766	10,843
Ethiopia	2016	33	9,858	9,815	9,925
Ethiopia	2019	26	5,655	5,642	5,678
Gabon	2012	15	4,312	4,310	4,331
Gambia	2013	14	3,874	3,869	4,018
Gambia	2019–20	15	4,257	4,252	4,276
Ghana	2014	25	3,102	3,101	3,107
Guatemala	2014–15	16	12,398	12,398	12,399
Guinea	2012	15	3,675	3,673	3,673
Guinea	2018	20	4,135	4,110	4,139
Haiti	2012	15	4,796	4,796	4,802
Haiti	2016–17	15	6,836	6,815	6,836

Continued…

Table 1—*Continued*

Country	Survey Year	Number of data collection teams	N HAZ	N WHZ	N WAZ
Honduras	2011–12	18	11,185	11,183	11,227
India	2015–16	875	249,075	249,143	249,729
Jordan	2012	26	6,531	6,530	6,560
Jordan	2017–18	41	10,257	10,157	10,250
Kenya	2014	48	21,142	21,136	21,206
Kyrgyzstan	2012	10	4,677	4,679	4,706
Lesotho	2014	15	1,984	2,016	1,989
Liberia	2013	16	3,975	3,974	3,992
Liberia	2019–20	17	3,029	3,021	3,031
Malawi	2010	37	5,249	5,585	5,303
Malawi	2015–16	37	5,868	5,842	5,883
Maldives	2016–17	6	2,601	2,569	2,638
Mali	2018	23	9,694	9,649	9,708
Mozambique	2011	15	10,873	10,873	10,877
Myanmar	2015–16	22	4,763	4,762	4,861
Namibia	2013	29	2,710	2,672	2,682
Nepal	2011	16	2,500	2,591	2,509
Nepal	2016	16	2,516	2,514	2,520
Niger	2012	20	5,612	5,594	5,631
Nigeria	2013	37	28,937	28,886	29,077
Nigeria	2018	37	12,542	12,512	12,543
Pakistan	2012–13	20	3,786	3,782	3,830
Pakistan	2017–18	22	4,392	4,361	4,440
Papua New Guinea	2016–18	59	3,275	3,100	3,336
Peru	2010	26	9,503	9,502	9,518
Peru	2011	26	9,404	9,406	9,416
Peru	2012	27	9,978	9,978	9,985
Rwanda	2010	15	4,461	4,455	4,462
Rwanda	2014–15	17	3,912	3,910	3,916
Rwanda	2019–20	17	4,079	4,076	4,080
Senegal	2010–11	16	4,534	4,532	4,557
Senegal	2012–13	3	6,829	6,842	6,831
Senegal	2014	4	6,959	6,952	6,954
Senegal	2015	4	7,049	7,047	7,051
Senegal	2016	4	6,844	6,842	6,843
Senegal	2017	9	12,203	12,178	12,208
Senegal	2018	5	6,798	6,783	6,798
Senegal	2019	5	6,235	6,230	6,243
Sierra Leone	2013	24	5,952	5,947	5,990
Sierra Leone	2019	24	5,051	5,035	5,053
South Africa	2016	29	1,524	1,498	1,525
Tajikistan	2012	14	4,958	4,955	4,968
Tajikistan	2017	14	6,117	6,113	6,118
Tanzania	2010	14	7,817	7,813	7,838
Tanzania	2015–16	17	10,409	10,387	10,423
Timor-Leste	2016	20	7,031	6,926	7,276
Togo	2013–14	15	3,593	3,591	3,596
Uganda	2011	16	2,474	2,472	2,482
Uganda	2016	21	5,341	5,323	5,333
Yemen	2013	40	14,861	14,839	15,142
Zambia	2013–14	24	12,963	12,961	13,085
Zambia	2018	22	9,803	9,784	9,824
Zimbabwe	2010–11	15	5,548	5,542	5,578
Zimbabwe	2015	15	6,272	6,257	6,297
Total			**871,629**	**871,069**	**875,277**

3.2 Percent implausible by survey

Figure 1a–c shows the percent implausible for HAZ, WHZ, and WAZ for each survey. There was variation in the percent implausible by anthropometric indicator and across surveys:

- For HAZ, 41 out of 90 surveys (46%) had a total percent implausible at or below 1%, with the total percent implausible lowest in Peru 2012 (0%) and highest in Pakistan 2012–13 (11.6%) (Figure 1a).
- For WHZ, 32 out of 90 surveys (36%) had a total percent implausible at or below 1%, with the total percent implausible WHZ lowest in Burundi 2016–17 and Gambia 2019 (both 0%) and highest in Benin 2011–12 (16.3%) (Figure 1b).
- The total percent implausible for WAZ was lower overall than HAZ or WHZ, with 80 out of 90 surveys (89%) having a total percent implausible WAZ at or below 1%. The total percent implausible was lowest (0%) in 9 surveys (Guatemala 2014–2015, Peru 2010 and 2012, Burundi 2016–17, Congo 2011–2012, Gambia 2019–20, Zambia 2018, and Nepal 2011 and 2016) and highest in Gambia 2013 (3.9%) (Figure 1c).
- In general, for countries with more than one survey, the percent implausible declined with more recent surveys for all anthropometric indicators.

Figure 1a Total percent implausible HAZ, by survey

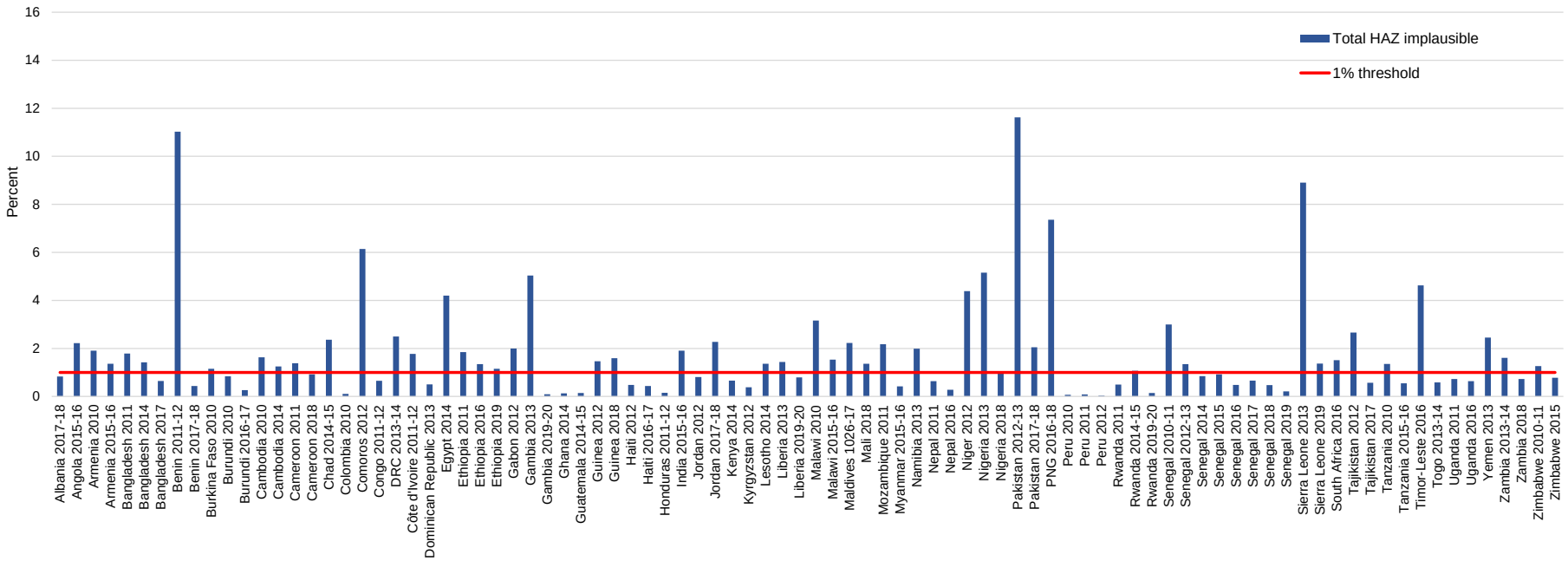


Figure 1b Total percent implausible WHZ, by survey

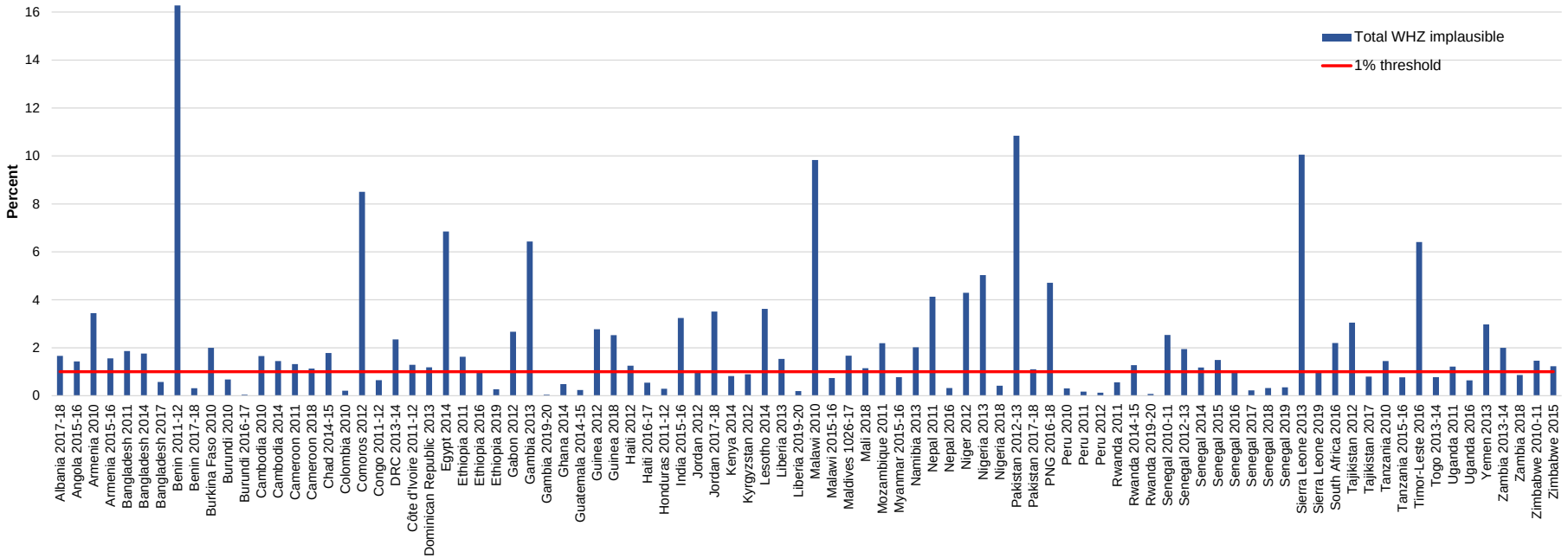
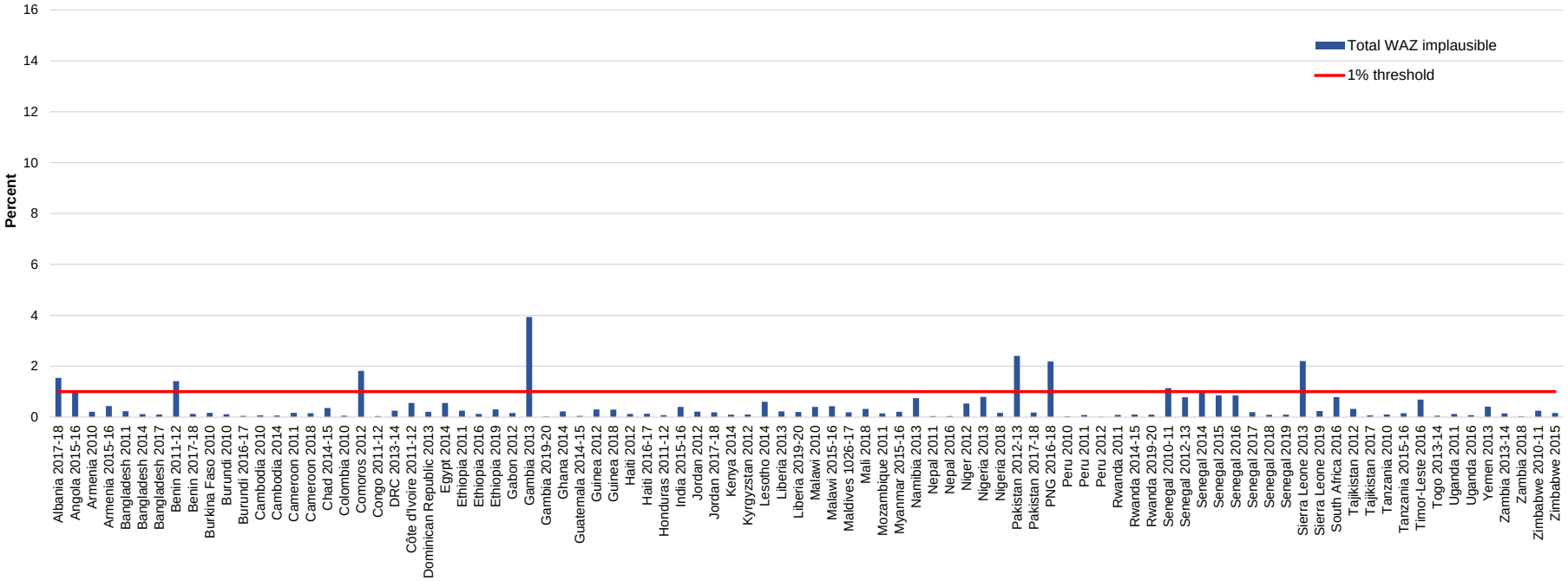


Figure 1c Total percent implausible WAZ, by survey



Summary of implausible HAZ, WHZ, and WAZ for each survey

This section presents the summary statistics of percent implausible for each anthropometric indicator by survey.

Height-for-age

Summary statistics of the percent implausible collapsed across all surveys are shown in Appendix Table 1. The median of the mean percent implausible across surveys was 1.4%. The median of median implausible across surveys was 0.8%. The median of IQR of the percent implausible was 1.1%. When examined by survey years, 2010–14 and 2015–20, the results were lower in more recent surveys: the median of the mean percent implausible was 1.4% versus 0.9%; the median of median was 1.1% versus 0.6%; and the median IQR 1.1% versus 1.0%.

Examining the results by surveys, the percent implausible HAZ varied across surveys (Table 2):

- The median percent implausible ranged from a high of 9.1% (IQR 5.8% to 16.9%) in Benin 2011–12 to 0% in 5 surveys: Ghana 2014 (IQR 0%), Peru 2010 and 2012 (IQR 0%, respectively), Gambia 2019 (IQR 0% to 0.3%), and Nepal 2016 (IQR 0% to 0.3%).

- The IQR for percent implausible was highest in Pakistan 2012–13 (16.3%), followed by Benin 2011–12 (11.1%), and lowest in Ghana 2014 and Peru 2010 and 2012 (all 0%).

- The lowest performing teams per survey, indicated by a maximum percent implausible above 25%, were found in Pakistan 2012–13 (49%), Gambia 2013 (47.3%), Papua New Guinea 2016–18 (40%), Sierra Leone 2013 (34.2%), Benin 2011–12 (28.5%), and Niger (27.7%).

- The best performing teams per survey, indicated by the minimum percent implausible values, ranged from 0% implausible in 69 surveys to 2.8% in Benin 2011–12 (Table 2).

Table 2 Summary statistics of percentage of implausible height-for-age *z* scores (HAZ) data, by survey

Country	Survey Year	N	Mean	Median	Min	Max	P25	P75	IQR
Albania	2017–18	2,648	0.8	0.7	0.0	5.6	0.0	1.1	1.1
Angola	2015–16	7,883	2.2	2.3	0.0	5.9	1.0	3.2	2.2
Armenia	2010	1,418	1.9	1.3	0.0	7.5	0.6	2.2	1.5
Armenia	2015–16	1,615	1.4	0.6	0.0	5.3	0.0	1.5	1.5
Bangladesh	2011	8,167	1.8	1.9	0.3	2.9	1.6	2.3	0.7
Bangladesh	2014	7,441	1.4	1.3	0.0	4.2	0.9	1.9	1.0
Bangladesh	2017	8,411	0.6	0.5	0.0	3.6	0.2	0.8	0.6
Benin	2011–12	13,179	11.0	9.1	2.8	28.5	5.8	16.9	11.1
Benin	2017–18	13,437	0.4	0.4	0.0	1.1	0.2	0.6	0.3
Burkina Faso	2010	7,096	1.2	1.0	0.0	2.5	0.6	1.8	1.3
Burundi	2010	3,689	0.8	0.5	0.0	5.0	0.5	0.9	0.4
Burundi	2016–17	6,421	0.3	0.3	0.0	0.8	0.0	0.4	0.4
Cambodia	2010	4,227	1.6	1.1	0.0	4.2	0.8	2.5	1.6
Cambodia	2014	5,052	1.2	1.1	0.0	5.7	0.4	1.3	0.9
Cameroon	2011	6,135	1.4	1.2	0.0	3.4	0.4	1.9	1.5
Cameroon	2018	5,326	0.9	0.8	0.0	4.2	0.0	1.1	1.1
Chad	2014–15	11,453	2.4	2.0	0.2	6.7	1.4	3.0	1.6
Colombia	2010	18,159	0.1	0.1	0.0	0.5	0.0	0.1	0.1
Comoros	2012	3,108	6.1	5.3	1.7	17.6	3.8	5.8	2.0
Congo	2011–12	5,059	0.7	0.6	0.0	2.4	0.2	1.2	0.9
Congo Democratic Republic	2013–14	9,103	2.5	1.8	0.0	13.3	0.0	4.1	4.1
Côte d'Ivoire	2011–12	3,956	1.8	1.5	0.0	4.5	0.9	2.1	1.1
Dominican Republic	2013	3,783	0.5	0.5	0.0	1.3	0.0	1.0	1.0
Egypt	2014	15,523	4.2	4.1	0.2	9.7	1.4	5.9	4.5
Ethiopia	2011	10,767	1.8	1.6	0.2	5.7	1.1	2.5	1.4
Ethiopia	2016	9,858	1.3	1.0	0.0	4.1	0.5	1.9	1.4
Ethiopia	2019	5,655	1.1	0.9	0.0	2.8	0.5	2.1	1.6
Gabon	2012	4,312	2.0	1.7	0.0	7.7	1.5	2.0	0.5
Gambia	2013	3,874	5.0	2.1	0.4	47.3	1.4	3.0	1.6
Gambia	2019–20	4,257	0.1	0.0	0.0	0.4	0.0	0.3	0.3
Ghana	2014	3,102	0.1	0.0	0.0	0.9	0.0	0.0	0.0
Guatemala	2014–15	12,398	0.1	0.2	0.0	0.4	0.0	0.3	0.3
Guinea	2012	3,675	1.5	0.9	0.3	3.2	0.8	2.4	1.6
Guinea	2018	4,135	1.6	1.0	0.0	6.1	0.7	2.4	1.7
Haiti	2012	4,796	0.5	0.3	0.0	1.9	0.0	0.9	0.9
Haiti	2016–17	6,836	0.4	0.3	0.0	1.5	0.2	0.4	0.2
Honduras	2011–12	11,185	0.2	0.1	0.0	0.6	0.0	0.3	0.3
India	2015–16	249,075	1.9	1.5	0.0	20.9	0.8	2.5	1.7
Jordan	2012	6,531	0.8	0.5	0.0	2.9	0.3	1.2	0.9
Jordan	2017–18	10,257	2.3	1.5	0.0	21.4	0.7	2.6	1.9
Kenya	2014	21,142	0.7	0.6	0.0	2.3	0.3	1.0	0.7
Kyrgyzstan	2012	4,677	0.4	0.4	0.0	1.0	0.2	0.5	0.3
Lesotho	2014	1,984	1.4	0.7	0.0	4.3	0.7	2.4	1.7
Liberia	2013	3,975	1.4	1.0	0.4	4.0	0.8	1.9	1.1
Liberia	2019–20	3,029	0.8	0.6	0.0	3.0	0.0	1.0	1.0
Malawi	2010	5,249	3.2	2.3	0.0	14.8	0.7	3.8	3.1
Malawi	2015–16	5,868	1.5	1.2	0.0	5.7	0.6	2.0	1.4
Maldives	2016–17	2,601	2.2	1.4	1.1	4.2	1.4	2.9	1.5
Mali	2018	9,694	1.4	0.7	0.0	8.1	0.5	1.4	1.0
Mozambique	2011	10,873	2.2	1.9	0.0	7.9	0.5	2.3	1.7
Myanmar	2015–16	4,763	0.4	0.2	0.0	2.5	0.0	0.7	0.7
Namibia	2013	2,710	2.0	1.2	0.0	10.3	0.7	3.0	2.2
Nepal	2011	2,500	0.6	0.5	0.0	2.8	0.0	0.7	0.7
Nepal	2016	2,516	0.3	0.0	0.0	1.7	0.0	0.3	0.3
Niger	2012	5,612	4.4	1.4	0.0	27.7	0.9	4.0	3.0
Nigeria	2013	28,937	5.2	4.4	0.9	17.1	2.2	7.5	5.3
Nigeria	2018	12,542	0.9	0.3	0.0	4.5	0.0	1.4	1.4
Pakistan	2012–13	3,786	11.6	7.2	0.0	49.0	1.5	17.9	16.3
Pakistan	2017–18	4,392	2.0	1.3	0.0	8.6	0.5	2.4	1.9
Papua New Guinea	2016–18	3,275	7.4	6.1	0.0	40.0	2.4	10.1	7.7
Peru	2010	9,503	0.1	0.0	0.0	0.8	0.0	0.0	0.0
Peru	2011	9,404	0.1	0.0	0.0	0.4	0.0	0.2	0.2
Peru	2012	9,978	0.0	0.0	0.0	0.4	0.0	0.0	0.0

Continued…

Table 2—*Continued*

Country	Survey Year	N	Mean	Median	Min	Max	P25	P75	IQR
Rwanda	2011	4,461	0.5	0.3	0.0	1.9	0.0	1.0	1.0
Rwanda	2014–15	3,912	1.1	0.7	0.0	5.1	0.0	0.9	0.9
Rwanda	2019–20	4,079	0.1	0.0	0.0	0.8	0.0	0.3	0.3
Senegal	2010–11	4,534	3.0	2.2	1.3	9.8	1.9	3.5	1.6
Senegal	2012–13	6,829	1.3	1.5	1.0	1.6	1.0	1.6	0.5
Senegal	2014	6,959	0.8	0.8	0.7	1.0	0.7	0.9	0.2
Senegal	2015	7,049	0.9	0.8	0.5	1.4	0.5	1.4	1.0
Senegal	2016	6,844	0.5	0.4	0.3	0.8	0.3	0.8	0.5
Senegal	2017	12,203	0.7	0.6	0.0	1.5	0.3	1.0	0.8
Senegal	2018	6,798	0.5	0.3	0.2	1.1	0.2	0.7	0.5
Senegal	2019	6,235	0.2	0.2	0.1	0.4	0.1	0.2	0.1
Sierra Leone	2013	5,952	8.9	6.8	0.3	34.2	3.7	10.5	6.8
Sierra Leone	2019	5,051	1.4	0.6	0.0	11.2	0.3	2.3	2.0
South Africa	2016	1,524	1.5	1.2	0.0	12.5	0.0	2.3	2.3
Tajikistan	2012	4,958	2.7	1.6	0.5	7.7	0.9	2.7	1.8
Tajikistan	2017	6,117	0.6	0.3	0.0	4.3	0.2	0.4	0.2
Tanzania	2010	7,817	1.4	1.3	0.0	3.0	0.9	1.8	0.9
Tanzania	2015–16	10,409	0.5	0.4	0.0	2.1	0.2	0.7	0.5
Timor-Leste	2016	7,031	4.6	4.3	1.1	9.1	2.7	6.5	3.9
Togo	2013–14	3,593	0.6	0.5	0.0	1.4	0.0	1.2	1.2
Uganda	2011	2,474	0.7	0.6	0.0	2.8	0.0	0.8	0.8
Uganda	2016	5,341	0.6	0.5	0.0	2.5	0.0	1.1	1.1
Yemen	2013	14,861	2.5	1.8	0.0	11.1	1.0	3.1	2.1
Zambia	2013–14	12,963	1.6	1.2	0.0	15.2	0.7	2.2	1.4
Zambia	2018	9,803	0.7	0.6	0.0	2.6	0.2	1.0	0.8
Zimbabwe	2010–11	5,548	1.3	0.9	0.0	3.3	0.4	2.0	1.6
Zimbabwe	2015	6,272	0.8	0.6	0.0	2.7	0.2	1.0	0.8

Note: Height-for-age *z* scores (HAZ) implausible defined as HAZ below –6 SD or above +6 SD.

Weight-for-height

For WHZ, the results of the summary statistics of the percent implausible collapsed across all surveys were similar to the HAZ (Appendix Table 1). The median of the mean percent implausible across surveys was 1.3%. The median of median implausible across surveys was 1.0%. The median of IQR of the percent implausible was 1.3%. When examined by survey years, 2010–14 and 2015–20, the results were lower in more recent surveys: the median of the mean percent implausible was 1.6% versus 0.9%; the median of median was 1.4% versus 0.5%; and the median IQR was 1.5% versus 0.9%.

Examining the results by surveys, the percent implausible WHZ varied across surveys (Table 3):

- The median percent implausible ranged from a high of 12% (IQR 6.8% to 27.8%) in Benin 2011–2012 to 0% in 9 surveys: Burundi 2016–17 (IQR 0%), Gambia 2019–20 (IQR 0%), Rwanda 2019–20 (IQR 0%), Peru 2011 (IQR 0% to 0.3%), Liberia 2019–20 (IQR 0% to 0.4%), Ethiopia 2019 (IQR 0% to 0.5%), Nepal 2011 (IQR 0% to 0.7%), Ghana 2014 (IQR 0% to 0.9%), and Malawi 2015–16 (IQR 0% to 1.4%).

- The IQR for percent implausible was highest in Benin 2011–12 (21%), followed by Sierra Leone 2013 (14%), and lowest in Burundi 2016–17, Gambia 2019–20 and Rwanda 2019–20 (all 0%).

- The lowest performing teams per survey, indicated by a maximum percent implausible above 25%, were found in Pakistan 2012–13 (58%), Gambia 2013 (54.3%), Benin 2011–12 (41.2%), Papua New Guinea 2016–18 (36.4%), Sierra Leone 2013 (32.8%), Niger (28.2%), Egypt 2014 (27.2%), and Malawi 2010 (26.3%).

- The best performing teams per survey, indicated by the minimum percent implausible values, ranged from 0% implausible in 60 surveys to 3.1% in Benin 2011–12 (Table 3).

Table 3 Summary statistics of the percentage of implausible weight-for-height *z* scores (WHZ) data, by survey

Country	Survey Year	N	Mean	Median	Min	Max	P25	P75	IQR
Albania	2017–18	2,640	1.7	1.5	0.0	6.7	0.8	2.0	1.2
Angola	2015–16	7,826	1.4	1.0	0.0	5.2	0.4	2.4	2.0
Armenia	2010	1,423	3.4	2.6	1.0	11.2	1.9	3.5	1.6
Armenia	2015–16	1,602	1.6	0.9	0.0	7.8	0.0	1.5	1.5
Bangladesh	2011	8,161	1.9	1.9	0.0	4.9	1.5	2.3	0.8
Bangladesh	2014	7,438	1.8	1.9	0.2	3.2	1.1	2.5	1.3
Bangladesh	2017	8,387	0.6	0.4	0.0	3.3	0.2	0.7	0.5
Benin	2011–12	13,289	16.3	12.0	3.1	41.2	6.8	27.8	21.0
Benin	2017–18	13,416	0.3	0.2	0.0	1.4	0.0	0.4	0.4
Burkina Faso	2010	7,093	2.0	1.3	0.0	6.8	0.8	2.3	1.5
Burundi	2010	3,688	0.7	0.4	0.0	4.4	0.0	1.0	1.0
Burundi	2016–17	6,413	0.0	0.0	0.0	0.4	0.0	0.0	0.0
Cambodia	2010	4,226	1.7	1.4	0.0	4.7	0.6	2.3	1.7
Cambodia	2014	5,052	1.4	1.0	0.0	5.3	0.4	1.9	1.5
Cameroon	2011	6,134	1.3	1.3	0.2	4.2	0.4	1.8	1.4
Cameroon	2018	5,303	1.1	1.0	0.3	3.5	0.7	1.6	0.9
Chad	2014–15	11,447	1.8	1.5	0.6	5.9	1.0	2.3	1.3
Colombia	2010	18,160	0.2	0.2	0.0	0.5	0.1	0.3	0.1
Comoros	2012	3,103	8.5	6.6	2.6	21.7	5.8	11.5	5.7
Congo	2011–12	5,059	0.7	0.5	0.0	2.7	0.4	0.8	0.4
Congo Democratic Republic	2013–14	9,098	2.4	1.8	0.0	13.0	0.0	3.2	3.2
Côte d'Ivoire	2011–12	3,952	1.3	1.0	0.0	2.7	0.4	2.4	2.0
Dominican Republic	2013	3,783	1.2	0.7	0.3	3.3	0.5	1.7	1.1
Egypt	2014	15,522	6.8	6.0	0.5	27.2	1.5	9.8	8.3
Ethiopia	2011	10,766	1.6	1.4	0.0	5.8	0.9	2.3	1.4
Ethiopia	2016	9,815	1.0	0.9	0.0	3.0	0.6	1.5	0.9
Ethiopia	2019	5,642	0.3	0.0	0.0	1.2	0.0	0.5	0.5
Gabon	2012	4,310	2.7	1.7	0.0	10.4	1.4	2.8	1.5
Gambia	2013	3,869	6.4	2.9	0.4	54.3	2.1	7.4	5.3
Gambia	2019–20	4,252	0.0	0.0	0.0	0.2	0.0	0.0	0.0
Ghana	2014	3,101	0.5	0.0	0.0	1.7	0.0	0.9	0.9
Guatemala	2014–15	12,398	0.2	0.2	0.0	0.6	0.1	0.3	0.2
Guinea	2012	3,673	2.8	2.4	0.0	6.8	1.7	4.0	2.3
Guinea	2018	4,110	2.5	1.7	0.0	9.3	0.5	3.8	3.3
Haiti	2012	4,796	1.3	0.9	0.0	4.0	0.6	1.7	1.1
Haiti	2016–17	6,815	0.5	0.3	0.0	1.6	0.0	1.0	1.0
Honduras	2011–12	11,183	0.3	0.3	0.0	1.0	0.1	0.4	0.3
India	2015–16	249,143	3.2	2.5	0.0	23.1	1.4	4.3	2.9
Jordan	2012	6,530	1.0	0.9	0.0	2.7	0.3	1.6	1.3
Jordan	2017–18	10,157	3.5	2.7	0.0	22.8	1.5	4.6	3.0
Kenya	2014	21,136	0.8	0.7	0.0	2.9	0.4	1.1	0.6
Kyrgyzstan	2012	4,679	0.9	0.9	0.2	1.4	0.7	1.4	0.7
Lesotho	2014	2,016	3.6	3.4	0.7	14.1	1.0	4.1	3.2
Liberia	2013	3,974	1.5	1.1	0.0	3.8	0.8	2.1	1.3
Liberia	2019–20	3,021	0.2	0.0	0.0	0.9	0.0	0.4	0.4
Malawi	2010	5,585	9.8	9.6	1.9	26.3	5.5	13.5	8.0
Malawi	2015–16	5,842	0.7	0.0	0.0	4.3	0.0	1.4	1.4
Maldives	2016–17	2,569	1.7	1.3	0.7	2.7	1.2	2.1	0.9
Mali	2018	9,649	1.2	0.5	0.0	7.6	0.4	1.1	0.7
Mozambique	2011	10,873	2.2	1.7	0.0	8.4	1.0	2.5	1.5
Myanmar	2015–16	4,762	0.8	0.5	0.0	12.5	0.0	1.3	1.3
Namibia	2013	2,672	2.0	1.5	0.0	8.3	0.0	2.9	2.9
Nepal	2011	2,591	4.1	3.2	0.0	9.3	2.0	6.8	4.7
Nepal	2016	2,514	0.3	0.0	0.0	1.9	0.0	0.7	0.7
Niger	2012	5,594	4.3	1.7	0.4	28.2	0.6	4.0	3.5
Nigeria	2013	28,886	5.0	3.9	0.9	18.8	2.1	7.4	5.3
Nigeria	2018	12,512	0.4	0.2	0.0	2.6	0.0	0.7	0.7
Pakistan	2012–13	3,782	10.8	5.9	0.0	58.0	1.6	12.1	10.5
Pakistan	2017–18	4,361	1.1	0.6	0.0	5.5	0.0	1.5	1.5
Papua New Guinea	2016–18	3,100	4.7	3.6	0.0	36.4	2.2	7.0	4.8
Peru	2010	9,502	0.3	0.2	0.0	1.1	0.0	0.5	0.5
Peru	2011	9,406	0.2	0.0	0.0	0.9	0.0	0.3	0.3
Peru	2012	9,978	0.1	0.0	0.0	0.8	0.0	0.2	0.2

Continued…

Table 3—*Continued*

Country	Survey Year	N	Mean	Median	Min	Max	P25	P75	IQR
Rwanda	2011	4,455	0.6	0.6	0.0	1.5	0.0	1.0	1.0
Rwanda	2014–15	3,910	1.3	0.4	0.0	7.0	0.3	1.2	0.9
Rwanda	2019–20	4,076	0.1	0.0	0.0	0.5	0.0	0.0	0.0
Senegal	2010–11	4,532	2.5	2.5	0.5	6.7	1.5	2.8	1.3
Senegal	2012–13	6,842	1.9	1.5	1.2	3.2	1.2	3.2	2.1
Senegal	2014	6,952	1.2	1.3	0.6	1.9	0.6	1.9	1.3
Senegal	2015	7,047	1.5	1.5	0.8	2.3	0.8	2.3	1.5
Senegal	2016	6,842	1.0	0.8	0.3	1.6	0.8	1.6	0.9
Senegal	2017	12,178	0.2	0.2	0.0	0.5	0.1	0.4	0.3
Senegal	2018	6,783	0.3	0.2	0.1	0.9	0.1	0.4	0.4
Senegal	2019	6,230	0.4	0.4	0.1	0.6	0.2	0.4	0.2
Sierra Leone	2013	5,947	10.1	6.1	1.7	32.8	3.5	17.5	14.0
Sierra Leone	2019	5,035	1.1	0.5	0.0	7.3	0.0	1.2	1.2
South Africa	2016	1,498	2.2	1.2	0.0	13.5	0.0	3.4	3.4
Tajikistan	2012	4,955	3.0	2.3	0.2	7.9	1.5	4.3	2.8
Tajikistan	2017	6,113	0.8	0.2	0.0	5.2	0.2	0.7	0.6
Tanzania	2010	7,813	1.4	1.4	0.2	3.2	1.0	2.2	1.1
Tanzania	2015–16	10,387	0.8	0.8	0.0	2.0	0.3	1.0	0.7
Timor-Leste	2016	6,926	6.4	5.7	0.4	14.8	4.5	9.3	4.8
Togo	2013–14	3,591	0.8	1.0	0.0	1.6	0.4	1.1	0.7
Uganda	2011	2,473	1.2	0.7	0.0	3.7	0.6	2.2	1.7
Uganda	2016	5,323	0.6	0.4	0.0	5.6	0.0	0.7	0.7
Yemen	2013	14,839	3.0	2.6	0.3	15.0	1.7	3.4	1.8
Zambia	2013–14	12,961	2.0	1.5	0.3	12.1	0.8	3.0	2.2
Zambia	2018	9,784	0.9	0.5	0.0	3.1	0.2	1.1	0.9
Zimbabwe	2010–11	5,542	1.5	0.9	0.0	4.1	0.4	2.7	2.3
Zimbabwe	2015	6,257	1.2	1.2	0.2	3.5	0.6	1.6	1.0

Note: Weight-for-height *z* scores (WHZ) implausible defined as WHZ below –5 SD or above +5 SD.

Weight-for-age

For WAZ, the summary statistics of the percent implausible collapsed across all surveys were substantially lower than for HAZ or WHZ (Appendix Table 1). The median of the mean percent implausible across surveys was 0.2%. The median of median implausible across surveys was 0%. The median of IQR of the percent implausible was 0.3%. When examined by survey years, 2010–14 and 2015–20, the results were the same: the median of the mean percent implausible was 0.2%; the median of median was 0%; and the median IQR was 0.3%.

Examining the results by surveys, the variation in the percent implausible was the lowest for all three anthropometric indicators but still varied across surveys (Table 4):

- The median percent implausible ranged from a high of 3.3% (IQR 2.1% to 5.9%) in Gambia 2013 to 0% in 58 surveys (Table 4).
- The IQR for percent implausible was highest in Gambia 2013 (3.8%), followed by Papua New Guinea 2016–18 (3.3%) and lowest at 0% in 20 surveys.
- The lowest performing teams per survey, indicated by a maximum percent implausible above 25%, was found in Pakistan 2012–13 (31.5%).
- The best performing teams per survey, indicated by the minimum percent implausible values, ranged from 0% implausible in 84 surveys to 0.6% in Senegal 2014 (Table 4).

Table 4 Summary statistics of the percentage of implausible weight-for-age *z* scores (WAZ) data, by survey

Country	Survey Year	N	Mean	Median	Min	Max	P25	P75	IQR
Albania	2017–18	2,727	1.5	1.0	0.0	8.0	0.0	2.5	2.5
Angola	2015–16	7,888	1.0	1.0	0.0	4.2	0.0	1.5	1.5
Armenia	2010	1,425	0.2	0.0	0.0	1.2	0.0	0.6	0.6
Armenia	2015–16	1,627	0.4	0.0	0.0	2.7	0.0	0.4	0.4
Bangladesh	2011	8,262	0.2	0.0	0.0	1.8	0.0	0.4	0.4
Bangladesh	2014	7,623	0.1	0.0	0.0	0.7	0.0	0.2	0.2
Bangladesh	2017	8,571	0.1	0.0	0.0	0.6	0.0	0.2	0.2
Benin	2011–12	13,379	1.4	1.0	0.0	7.5	0.5	1.7	1.2
Benin	2017–18	13,458	0.1	0.1	0.0	0.6	0.0	0.2	0.2
Burkina Faso	2010	7,110	0.2	0.0	0.0	1.0	0.0	0.3	0.3
Burundi	2010	3,701	0.1	0.0	0.0	1.0	0.0	0.0	0.0
Burundi	2016–17	6,423	0.0	0.0	0.0	0.4	0.0	0.0	0.0
Cambodia	2010	4,245	0.1	0.0	0.0	0.5	0.0	0.0	0.0
Cambodia	2014	5,077	0.1	0.0	0.0	0.4	0.0	0.0	0.0
Cameroon	2011	6,145	0.2	0.0	0.0	0.7	0.0	0.2	0.2
Cameroon	2018	5,328	0.2	0.0	0.0	0.8	0.0	0.3	0.3
Chad	2014–15	11,523	0.4	0.3	0.0	0.9	0.2	0.6	0.4
Colombia	2010	18,173	0.1	0.0	0.0	0.3	0.0	0.1	0.1
Comoros	2012	3,195	1.8	1.6	0.4	5.4	1.1	1.8	0.8
Congo	2011–12	5,065	0.0	0.0	0.0	0.4	0.0	0.0	0.0
Congo Democratic Republic	2013–14	9,111	0.3	0.0	0.0	2.8	0.0	0.0	0.0
Côte d'Ivoire	2011–12	3,967	0.6	0.5	0.0	2.3	0.0	0.8	0.8
Dominican Republic	2013	3,783	0.2	0.0	0.0	1.0	0.0	0.3	0.3
Egypt	2014	15,526	0.6	0.5	0.1	1.9	0.2	0.8	0.6
Ethiopia	2011	10,843	0.2	0.0	0.0	1.4	0.0	0.3	0.3
Ethiopia	2016	9,925	0.1	0.0	0.0	0.7	0.0	0.3	0.3
Ethiopia	2019	5,678	0.3	0.0	0.0	1.1	0.0	0.5	0.5
Gabon	2012	4,331	0.2	0.0	0.0	1.5	0.0	0.2	0.2
Gambia	2013	4,018	3.9	3.3	0.0	8.0	2.1	5.9	3.8
Gambia	2019–20	4,276	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Ghana	2014	3,107	0.2	0.0	0.0	1.7	0.0	0.0	0.0
Guatemala	2014–15	12,399	0.0	0.0	0.0	0.2	0.0	0.1	0.1
Guinea	2012	3,673	0.3	0.4	0.0	0.8	0.0	0.5	0.5
Guinea	2018	4,139	0.3	0.0	0.0	2.4	0.0	0.5	0.5
Haiti	2012	4,802	0.1	0.0	0.0	0.6	0.0	0.3	0.3
Haiti	2016–17	6,836	0.1	0.0	0.0	0.6	0.0	0.2	0.2
Honduras	2011–12	11,227	0.1	0.0	0.0	0.4	0.0	0.1	0.1
India	2015–16	249,729	0.4	0.3	0.0	8.7	0.0	0.6	0.6
Jordan	2012	6,560	0.2	0.3	0.0	1.0	0.0	0.3	0.3
Jordan	2017–18	10,250	0.2	0.0	0.0	2.8	0.0	0.2	0.2
Kenya	2014	21,206	0.1	0.0	0.0	0.5	0.0	0.2	0.2
Kyrgyzstan	2012	4,706	0.1	0.0	0.0	0.5	0.0	0.2	0.2
Lesotho	2014	1,989	0.6	0.0	0.0	4.2	0.0	0.8	0.8
Liberia	2013	3,992	0.2	0.0	0.0	0.8	0.0	0.4	0.4
Liberia	2019–20	3,031	0.2	0.0	0.0	1.5	0.0	0.0	0.0
Malawi	2010	5,303	0.4	0.0	0.0	1.3	0.0	0.7	0.7
Malawi	2015–16	5,883	0.4	0.0	0.0	1.6	0.0	0.9	0.9
Maldives	2016–17	2,638	0.2	0.1	0.0	2.8	0.0	0.2	0.2
Mali	2018	9,708	0.3	0.2	0.0	2.7	0.0	0.3	0.3
Mozambique	2011	10,877	0.1	0.1	0.0	0.5	0.0	0.2	0.2
Myanmar	2015–16	4,861	0.2	0.0	0.0	1.3	0.0	0.4	0.4
Namibia	2013	2,682	0.7	0.0	0.0	6.9	0.0	1.2	1.2
Nepal	2011	2,509	0.0	0.0	0.0	0.7	0.0	0.0	0.0
Nepal	2016	2,520	0.0	0.0	0.0	0.7	0.0	0.0	0.0
Niger	2012	5,631	0.5	0.0	0.0	4.5	0.0	1.0	1.0
Nigeria	2013	29,077	0.8	0.8	0.0	1.9	0.3	0.9	0.6
Nigeria	2018	12,543	0.2	0.0	0.0	1.2	0.0	0.3	0.3
Pakistan	2012–13	3,830	2.4	0.5	0.0	31.5	0.0	2.2	2.2
Pakistan	2017–18	4,440	0.2	0.0	0.0	1.5	0.0	0.4	0.4
Papua New Guinea	2016–18	3,336	2.2	1.4	0.0	11.1	0.0	3.3	3.3
Peru	2010	9,518	0.0	0.0	0.0	0.4	0.0	0.0	0.0
Peru	2011	9,416	0.1	0.0	0.0	0.4	0.0	0.2	0.2
Peru	2012	9,985	0.0	0.0	0.0	0.2	0.0	0.0	0.0

Continued…

Table 4—*Continued*

Country	Survey Year	N	Mean	Median	Min	Max	P25	P75	IQR
Rwanda	2011	4,462	0.1	0.0	0.0	0.3	0.0	0.3	0.3
Rwanda	2014–15	3,916	0.1	0.0	0.0	1.0	0.0	0.0	0.0
Rwanda	2019–20	4,080	0.1	0.0	0.0	0.7	0.0	0.0	0.0
Senegal	2010–11	4,557	1.1	1.1	0.0	2.9	0.5	1.8	1.2
Senegal	2012–13	6,831	0.8	0.9	0.5	1.0	0.5	1.0	0.4
Senegal	2014	6,954	1.0	1.1	0.6	1.4	0.6	1.4	0.8
Senegal	2015	7,051	0.9	0.9	0.5	1.4	0.5	1.4	1.0
Senegal	2016	6,843	0.8	0.6	0.3	1.5	0.6	1.5	0.9
Senegal	2017	12,208	0.2	0.2	0.0	0.7	0.1	0.3	0.2
Senegal	2018	6,798	0.1	0.1	0.0	0.2	0.0	0.1	0.1
Senegal	2019	6,243	0.1	0.1	0.0	0.2	0.1	0.1	0.0
Sierra Leone	2013	5,990	2.2	1.4	0.0	20.2	1.0	2.1	1.1
Sierra Leone	2019	5,053	0.2	0.0	0.0	1.4	0.0	0.4	0.4
South Africa	2016	1,525	0.8	0.0	0.0	8.8	0.0	1.0	1.0
Tajikistan	2012	4,968	0.3	0.3	0.0	1.0	0.0	0.4	0.4
Tajikistan	2017	6,118	0.1	0.0	0.0	0.6	0.0	0.1	0.1
Tanzania	2010	7,838	0.1	0.0	0.0	0.5	0.0	0.2	0.2
Tanzania	2015–16	10,423	0.2	0.1	0.0	0.6	0.0	0.2	0.2
Timor-Leste	2016	7,276	0.7	0.5	0.0	2.7	0.3	0.9	0.7
Togo	2013–14	3,596	0.1	0.0	0.0	0.5	0.0	0.0	0.0
Uganda	2011	2,482	0.1	0.0	0.0	0.7	0.0	0.0	0.0
Uganda	2016	5,333	0.1	0.0	0.0	0.6	0.0	0.0	0.0
Yemen	2013	15,142	0.4	0.3	0.0	2.3	0.0	0.6	0.6
Zambia	2013–14	13,085	0.1	0.0	0.0	2.9	0.0	0.2	0.2
Zambia	2018	9,824	0.0	0.0	0.0	0.2	0.0	0.0	0.0
Zimbabwe	2010–11	5,578	0.3	0.1	0.0	2.2	0.0	0.4	0.4
Zimbabwe	2015	6,297	0.2	0.0	0.0	0.6	0.0	0.3	0.3

Note: Weight-for-age *z* scores (WAZ) implausible defined as WAZ below –5 SD or above +6 SD.

3.3 Percent implausible by team

Figure 2a–c and Appendix Table 2 show the number of teams with percent implausible >1% for HAZ, WHZ, and WAZ for each survey. There was variation in the number of teams with implausible values by anthropometric indicator and across surveys:

- For HAZ, across the 90 surveys, 14 surveys (16%) had no teams with implausible values above the 1% threshold. A total of 23 surveys (25%) had between 1–5 teams with implausible values above the 1% threshold; 19 surveys (21%) had between 6–10 teams with implausible values above the 1% threshold; and 34 surveys (38%) had 11 or more teams with implausible values above the 1% threshold.

- For WHZ, across the 90 surveys, 10 surveys (11%) had no teams with implausible values above the 1% threshold. A total of 24 surveys (27%) had between 1–5 teams with implausible values above the 1% threshold; 17 surveys (19%) had between 6–10 teams with implausible values above the 1% threshold; and 39 surveys (43%) had 11 or more teams with implausible values above the 1% threshold.

- Across the 90 surveys, 45 surveys (50%) had no teams with implausible values above the 1% threshold. A total of 30 surveys (33%) had between 1–5 teams with implausible values above the 1% threshold; 8 surveys (9%) had between 6–10 teams with implausible values above the 1% threshold; and 7 surveys (8%) had 11 or more teams with implausible values above the 1% threshold.

Figure 2a Number of teams with percent implausible height-for-age *z* scores (HAZ) above the 1% threshold, by survey

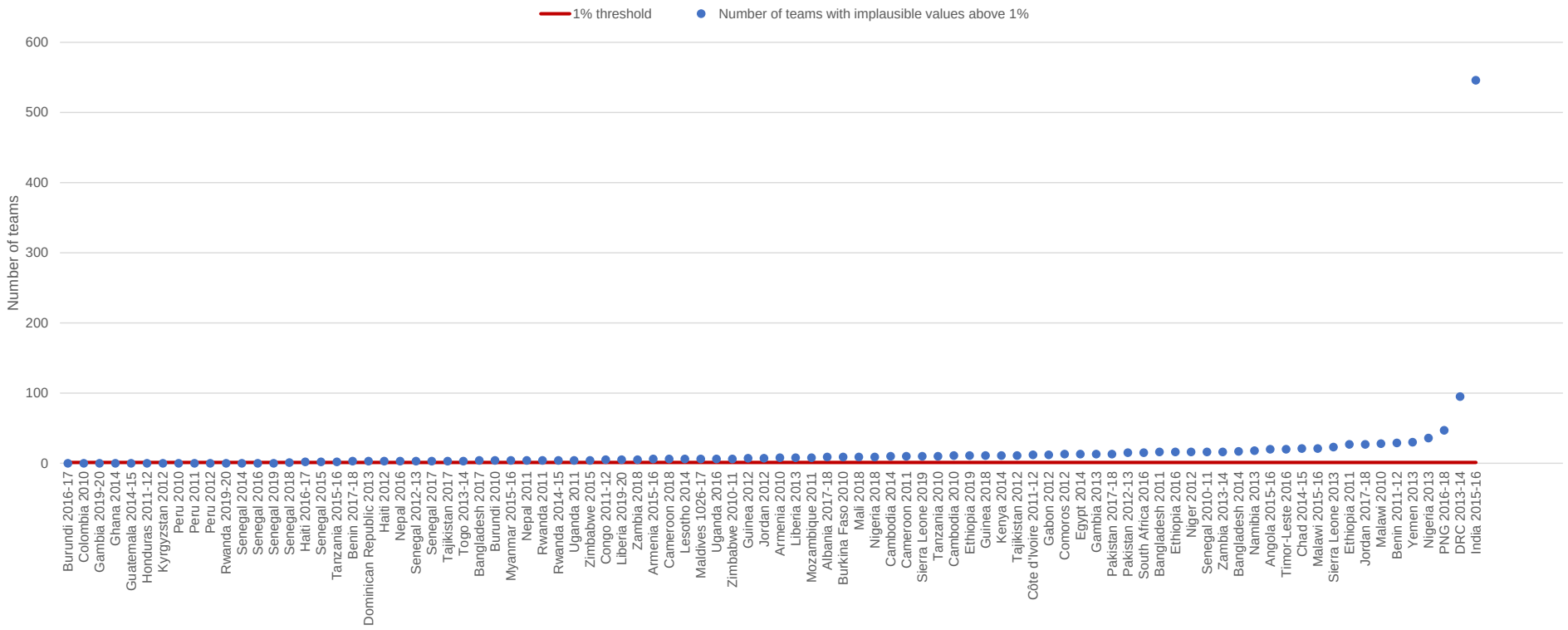


Figure 2b Number of teams with percent implausible weight-for-height *z* scores (WHZ) above the 1% threshold, by survey

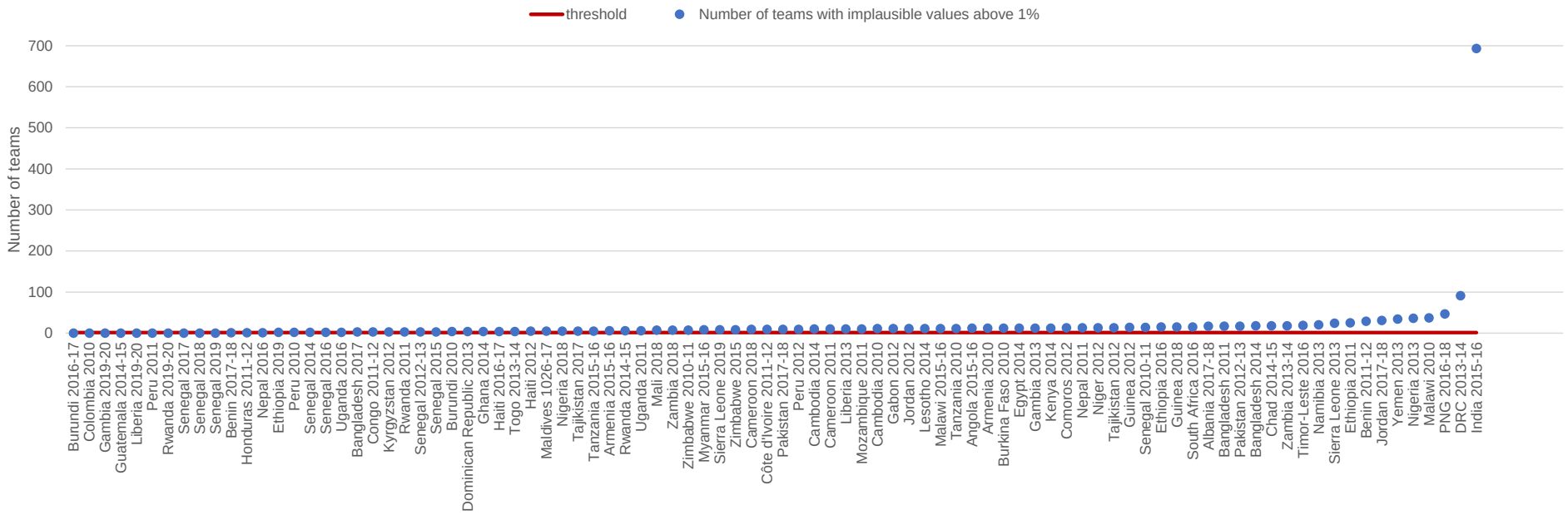
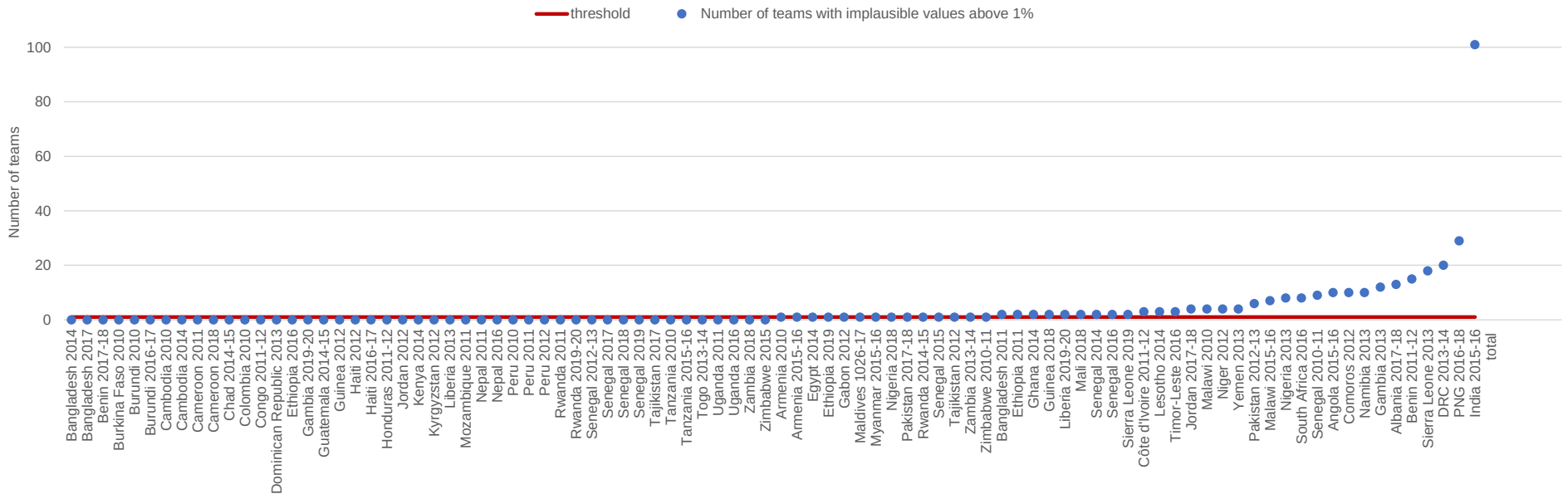


Figure 2c Number of teams with percent implausible weight-for-age *z* scores (WAZ) above the 1% threshold, by survey



Summary of implausible HAZ, WHZ, and WAZ across teams

Figures 3-5 show the descriptive statistics across all surveys and teams for HAZ, WHZ, and WAZ by region. For each indicator, boxplots show the distribution of percent implausible for each region.

Height-for-age

Across all surveys when examining the percentage of teams that are above the 1% HAZ implausible threshold, the median percent of teams greater than 1% was 42%. By survey years, 2010–2014 and 2015–2020, the median percent of teams with implausible above the 1% threshold was lower in more recent surveys, 51.3% versus 32.7% (Appendix Table 3).

Examining the data by region, Figure 3a shows boxplots of teams in each survey grouped by region. Within regions, there was variability of team performance and several teams in NAfr/WAsia/Eur, S/SEA, WAfr and C/SAfr had extremely high percentage of implausible values well above the 1% threshold, with the most located in S/SEA followed by WAfr, where a few teams had a percent implausible near 50% (Figure 3a). In all of these regions except WAfr, the median for teams in the region was above the 1% threshold. There was less variability in team performance in LAC and EAfr, where both regions had fewer teams with an extremely high percentage of implausible values (below 3% and 6% respectively (Figure 3a).

By survey years, team performance generally improved across regions between surveys from 2010–2014 and surveys from 2015–2020 (Figure 3b, 3c, Appendix Table 3). Compared to older surveys, the median in more recent surveys was at or below the 1% threshold in more regions: NAfr/WAsia/Eura, LAC, WAfr, and EAfr. In addition, in more recent surveys (2015–2020), team variability was lower in all regions, except for NAfr/WAsia/Eura and S/SEA which had more teams with an extremely high percentage of implausible values well above the 1% threshold.

Figure 3a Percent implausible height-for-age for each team in a survey, grouped by region 2010–20

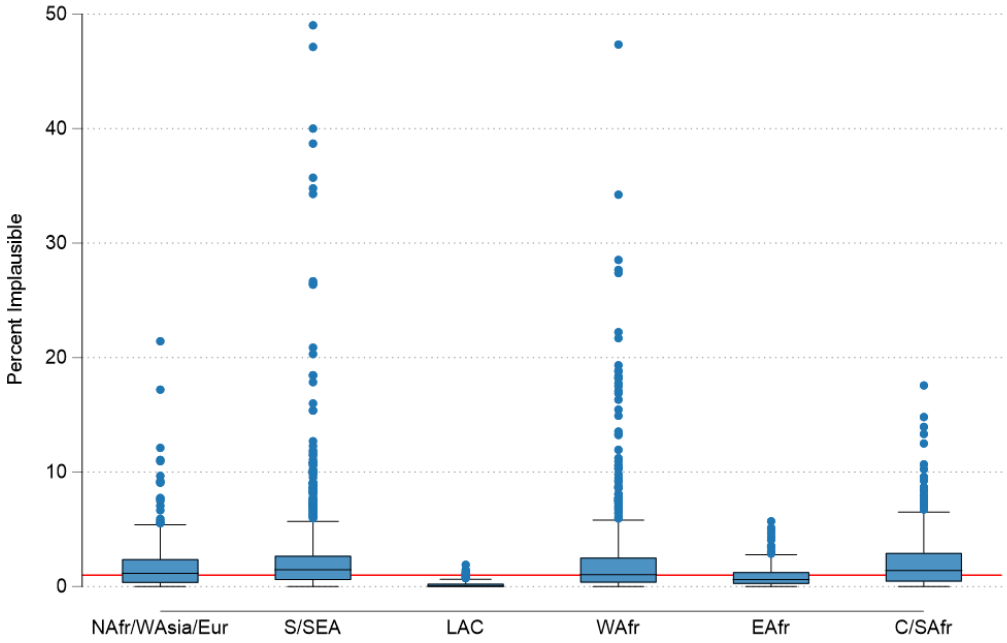


Figure 3b Percent implausible height-for-age for each team in a survey, grouped by region, 2010–14

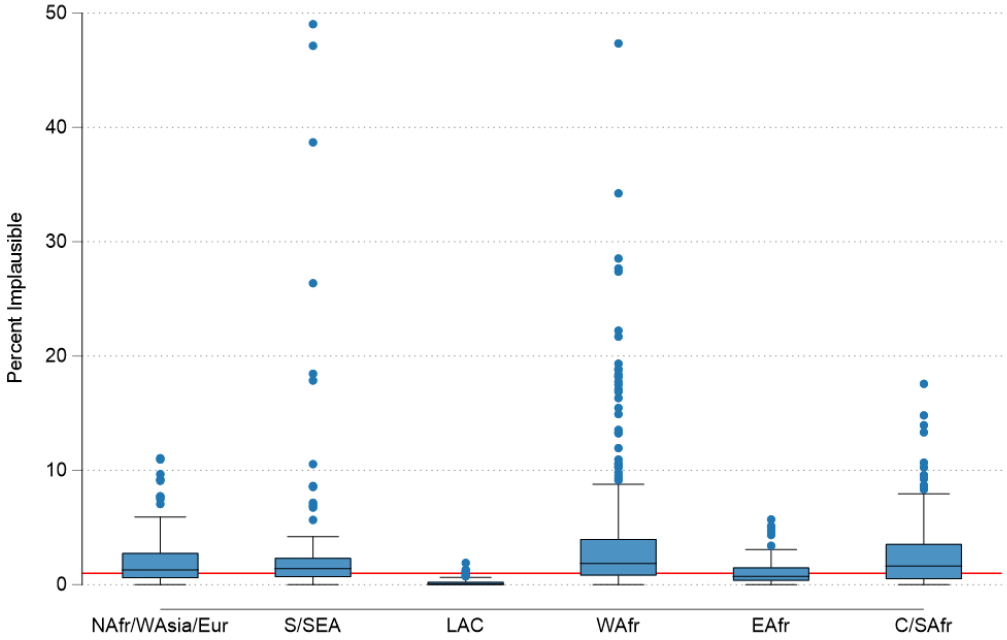
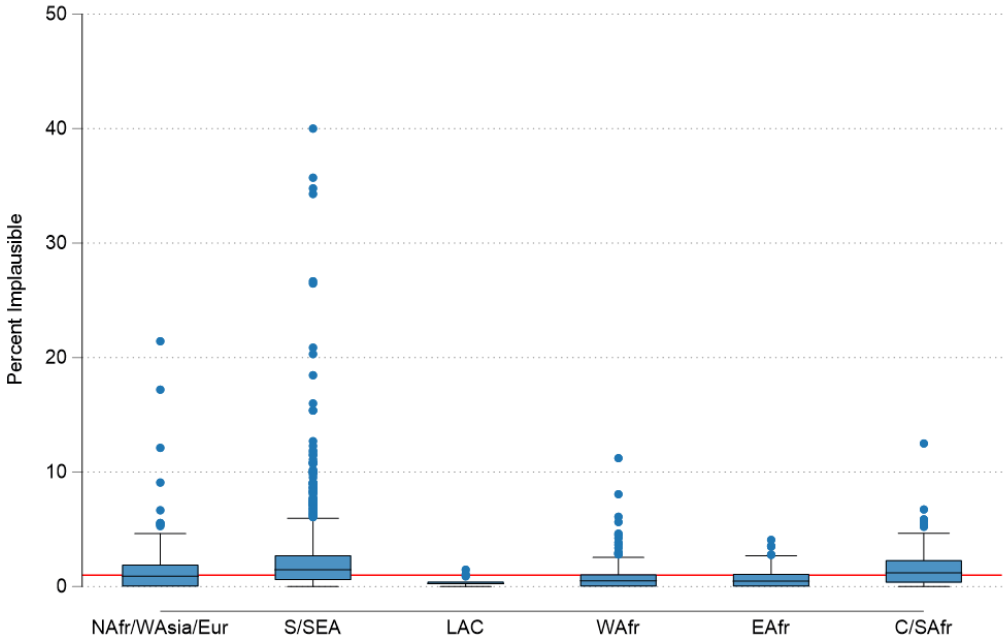


Figure 3c Percent implausible height-for-age for each team in a survey, grouped by region, 2015–20



Weight-for-height

For WHZ, the results were similar to HAZ. Across all surveys, when examining the percentage of teams that are above the 1% WHZ implausible threshold, the median percent of teams greater than 1% was 50%. By survey years, 2010–14 and 2015–20, the median percent of teams with implausible above the 1% threshold was lower in more recent surveys, 65.2% versus 34.5% (Appendix Table 3).

Examining the data by region, Figure 4a shows boxplots of teams in each survey grouped by region. Within regions there was substantial variability of team performance and several teams in NAfr/WAsia/Eur, S/SEA, WAfr and C/SAfr had extremely high percentage of implausible values well above the 1% threshold, with the most located in S/SEA followed by WAfr where a few teams had more than 50% percent implausible (Figure 4a). In NAfr/WAsia/Eur, S/SEA, and CSAfr, the median for teams in the region was above the 1% threshold. There was less variability in team performance in LAC and EAfr, where both regions had fewer teams with extreme values (below 6%) (Figure 4a).

By survey years, team performance generally improved across regions between surveys from 2010–2014 and surveys from 2015–2020 (Figure 4b, 4c, Appendix Table 3). Compared to older surveys, the median in more recent surveys was at or below the 1% threshold in more regions: WAfr, EAfr, C/SAfr and LAC. In more recent surveys (2015–2020), team variability decreased in all regions except for NAfr/WAsia/Eura and S/SEA. In NAfr/WAsia/Eura, team variability was about the same between recent and older surveys. In S/SEA, variability was higher in more recent surveys, although older surveys had some teams with extremely high percentage of implausible values.

Figure 4a Percent implausible weight-for-height for each team in a survey, grouped by region 2010–20

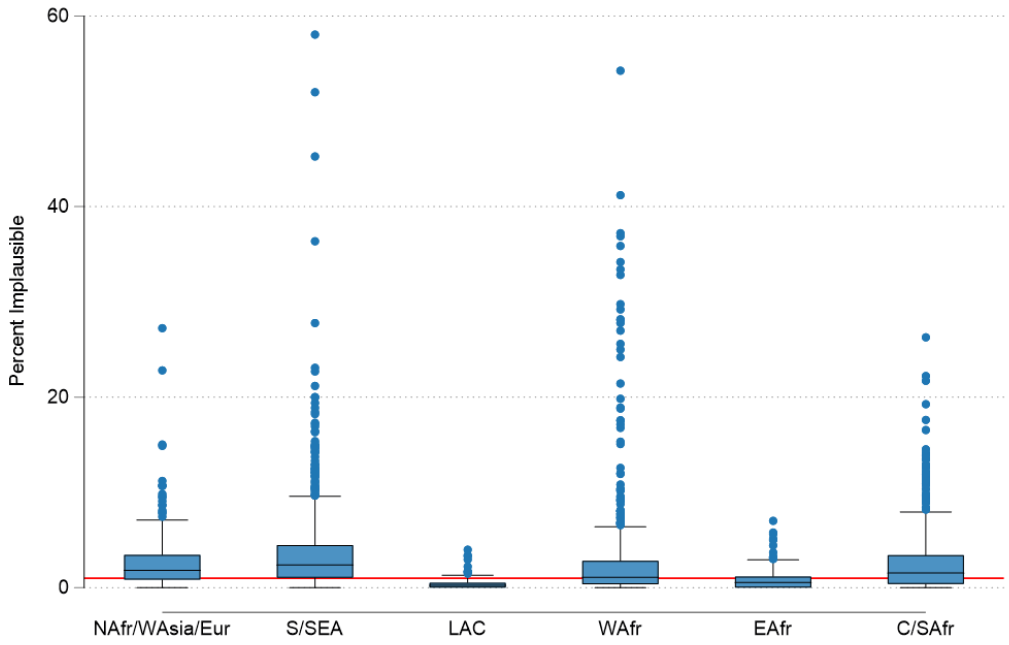


Figure 4b Percent implausible weight-for-height for each team in a survey, grouped by region, 2010–14

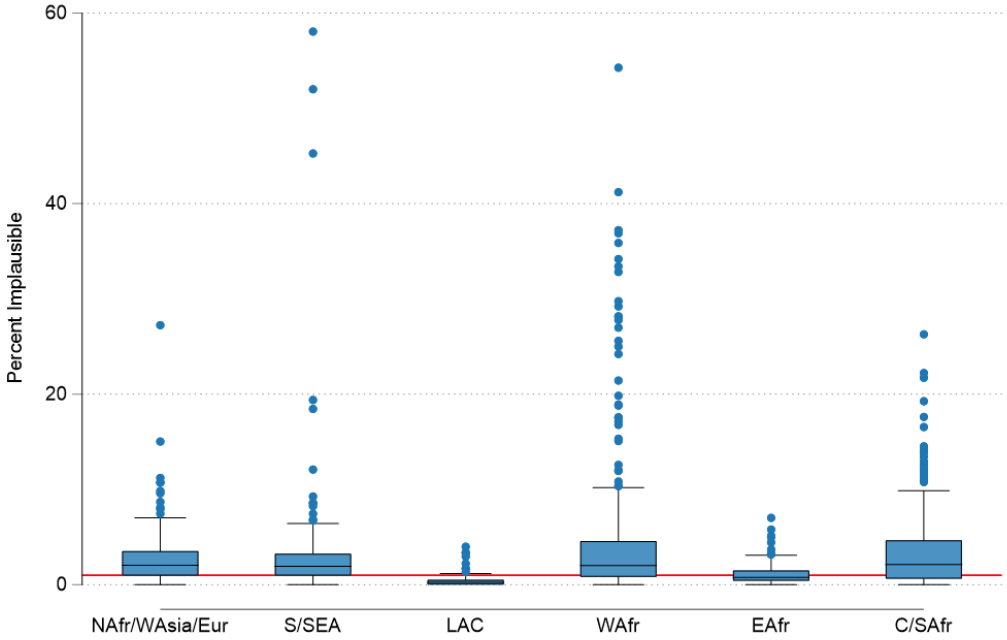
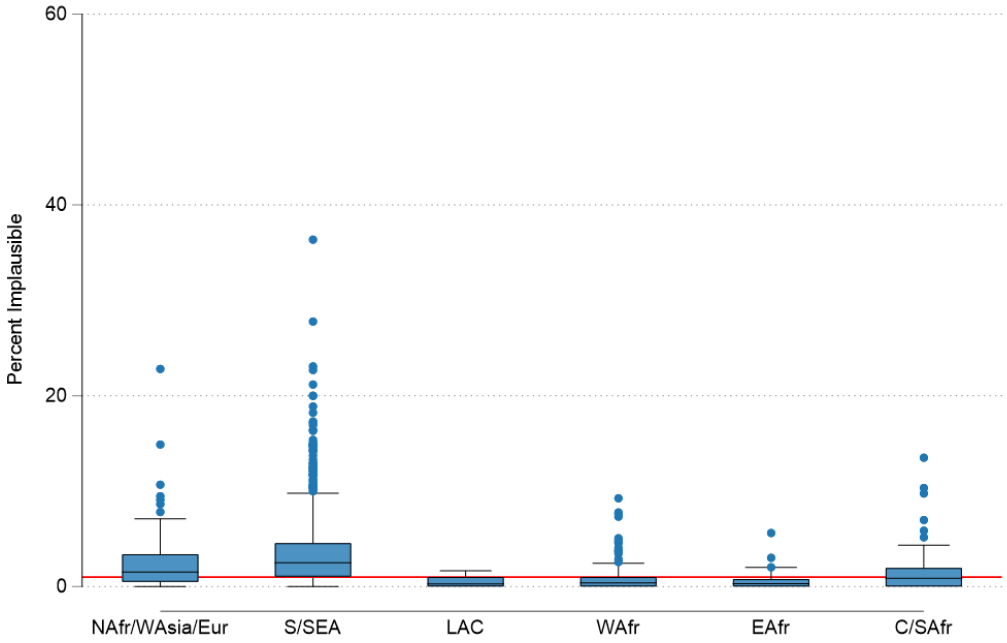


Figure 4c Percent implausible weight-for-height for each team in a survey, grouped by region, 2015–20



Weight-for-age

For WHZ, there were fewer teams with extreme values compared to HAZ and WHZ. Across all surveys when examining the percentage of teams that are above the 1% WAZ implausible threshold, the median percent of teams greater than 1% was 1.4%. By survey years, 2010–14 and 2015–20, the median percent of teams with implausible values above the 1% threshold was higher in more recent surveys, 2.7% versus 0% (Appendix Table 3).

Examining the data by region, Figure 5a shows boxplots of teams in each survey grouped by region. Within regions, there was variability of team performance with several teams in NAfr/WAsia/Eur, S/SEA, WAfr and C/SAfr having an extremely high percentage of implausible values well above the 1% threshold (Figure 5a). In all regions except LAC and EAfr, the median for teams was above the 1% threshold. In LAC and EAfr, there was less variability in team performance and both regions had fewer teams with extreme values (Figure 5a).

By survey years, team performance generally improved across regions between surveys from 2010–14 and surveys from 2015–20 (Figure 5b, 5c; Appendix Table 1). In both older and newer surveys, the median was below the 1% threshold in all regions. In more recent surveys (2015–20), team variability decreased or was similar to older surveys, except for NAfr/WAsia/Eura and S/SEA where team variability was slightly higher newer surveys.

Figure 5a Percent implausible weight-for-age for each team in a survey, grouped by region 2010–20

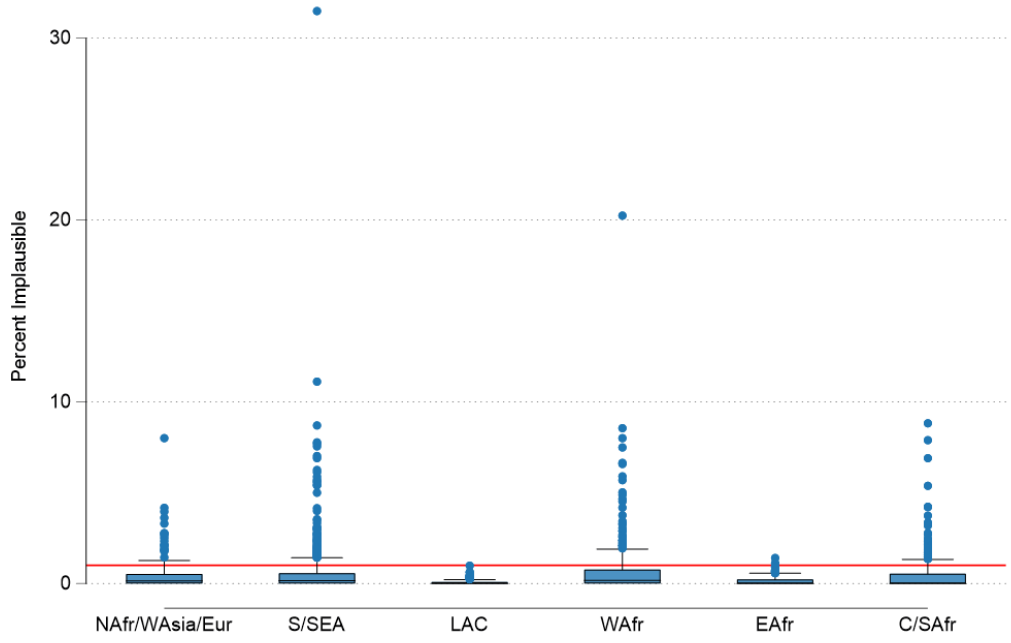


Figure 5b Percent implausible weight-for-age for each team in a survey, grouped by region, 2010–14

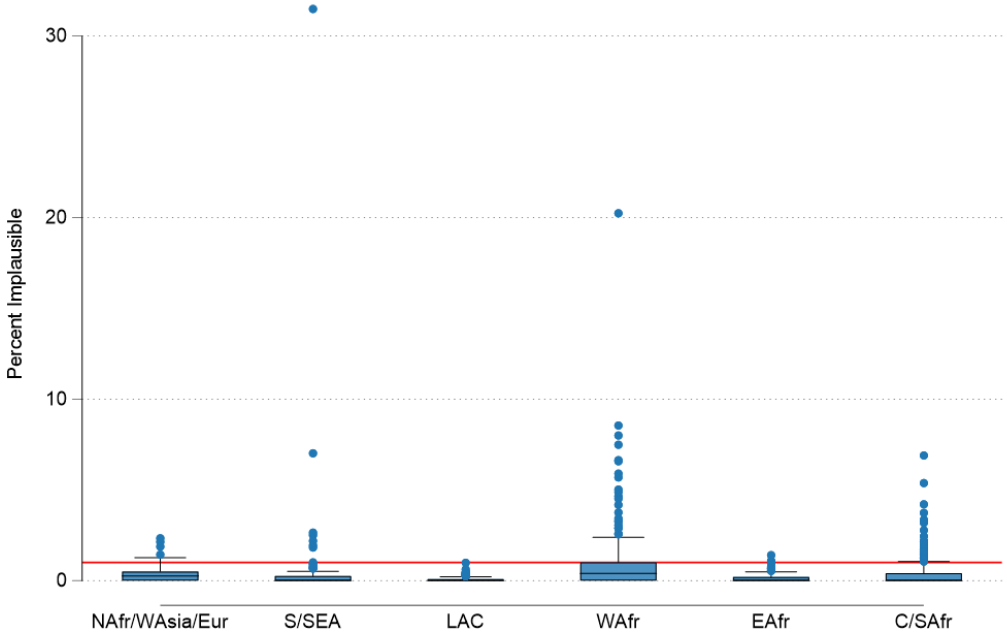
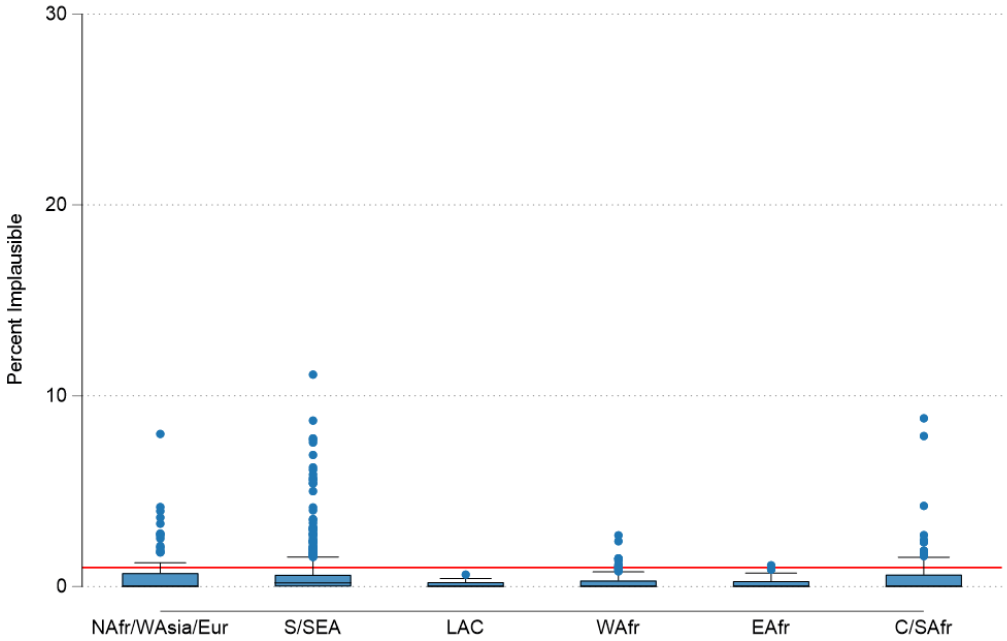


Figure 5c Percent implausible weight-for-age for each team in a survey, grouped by region, 2015–20



3.4 Percent implausible by team for most recent surveys

Figures 6–11 show the percent implausible for HAZ, WHZ, and WAZ by team for the most recent survey in each country. Countries are presented by the world regions described in the methods: North Africa, West Asia and Europe (NAfr/WAsia/Eur); South and Southeast Asia and Oceania (S/SEA); Latin America and the Caribbean (LAC); West Africa (WAfr); East Africa (EAfr); and Central and Southern Africa (C/SAfR). For each region and for each indicator, the range of the percent implausible varies and therefore, the y-axis scales are different across regions.

3.4.1 North Africa, West and Central Asia, and Europe

For HAZ, teams in Egypt, Jordan, and Yemen showed substantial variation in the percent implausible, with many teams well above the 1% threshold (Figure 6a). Teams in Albania, Armenia, and Tajikistan also showed variation in the percent implausible, but with fewer teams above the threshold. In Kyrgyzstan, most teams were below the threshold. The range of percent implausible across countries in the region was large (0–21%) with the highest in Jordan (0–21.4%) and lowest in Kyrgyzstan (0–1%).

For WHZ, there are similar patterns to HAZ. The number of team with percent implausible was high in Egypt, Jordan, and Yemen with many teams well above the 1% threshold (Figure 6b). There was less variation with teams in Albania, Armenia, Tajikistan, and Kyrgyzstan with fewer teams above the 1% threshold. The range of percent implausible across countries in the region was large (0–27%), highest in Egypt (0–27.2%) and lowest in Kyrgyzstan (0.2–1.4%).

For WAZ, there was a different pattern. The range of percent implausible was moderate across countries in the region (0–8%) and highest in Albania (0–8%), with substantial team variation and many teams above the 1% threshold (Figure 6c). In the other countries, there was relatively less variation, and most teams were below the threshold except for a few teams in Armenia, Egypt, and Jordan.

Figure 6a **Percent implausible height-for-age by team, North Africa, West and Central Asia, and Europe**

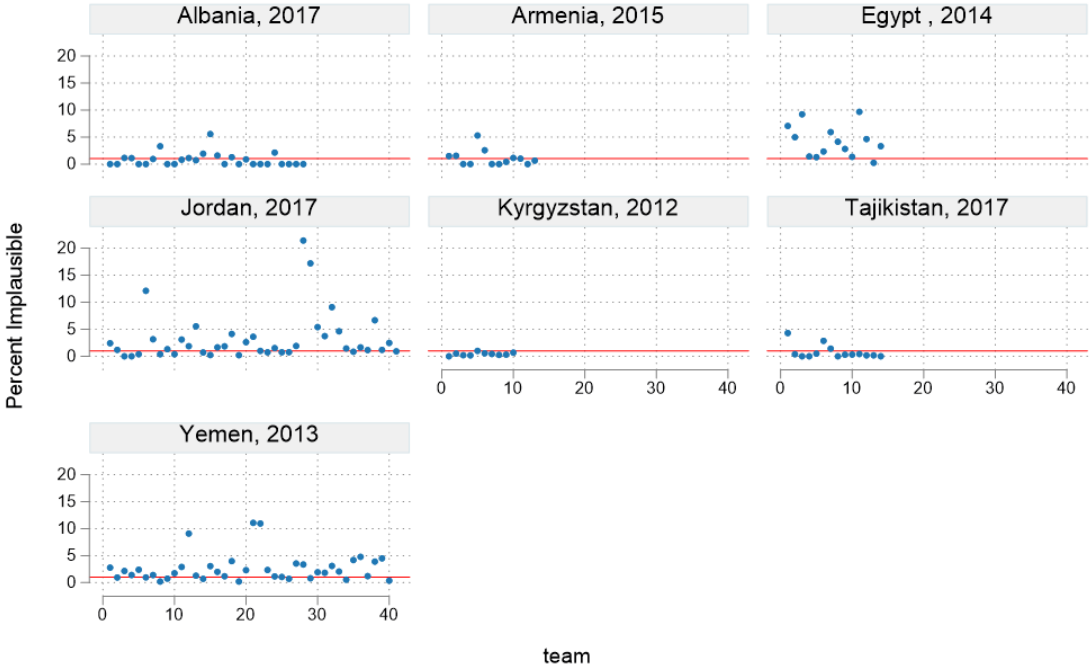


Figure 6b **Percent implausible weight-for-height by team, North Africa, West and Central Asia, and Europe**

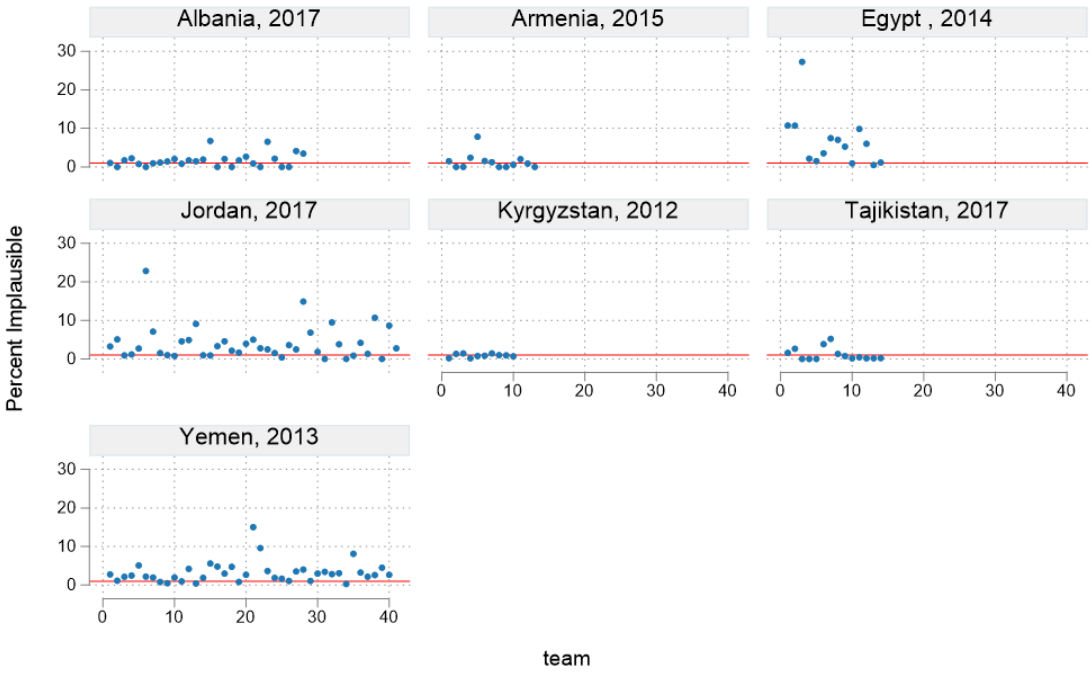
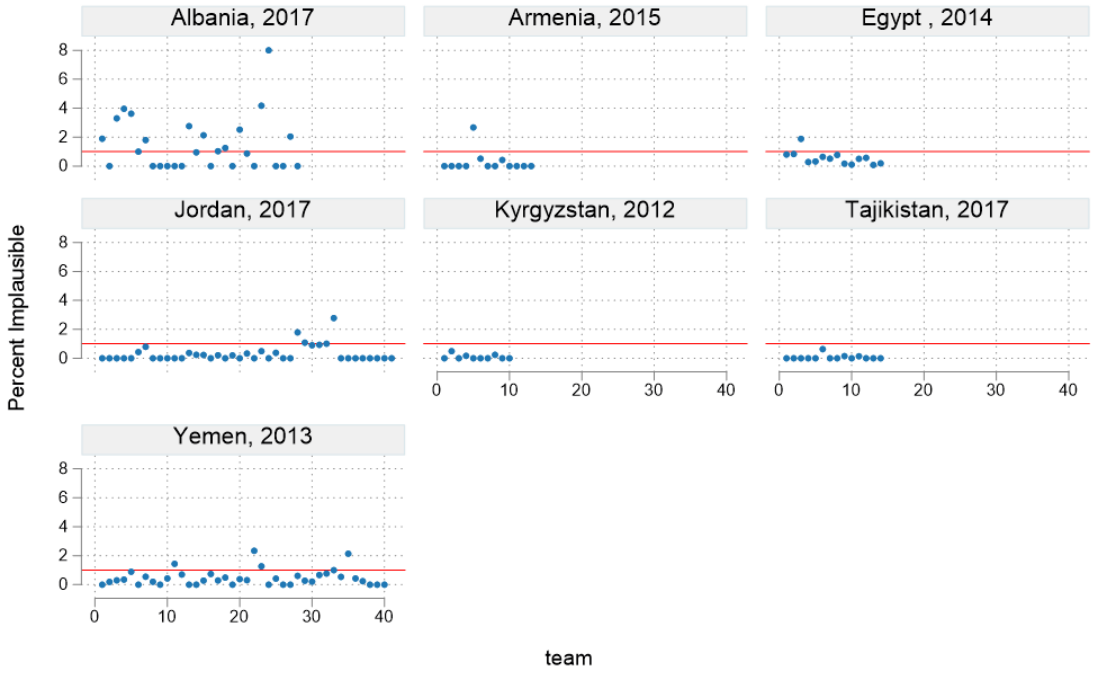


Figure 6c Percent implausible weight-for-age by team, North Africa, West and Central Asia, and Europe



3.4.2 South and Southeast Asia and Oceania

For HAZ, teams in India, Pakistan, Papua New Guinea, and Timor-Leste showed substantial variation in percent implausible, with a large number of teams well above the 1% threshold (Figure 7a). Teams in Bangladesh, Cambodia, Maldives, Myanmar, and Nepal showed low to moderate variation, with several teams above the threshold. The range of percent implausible across countries in the region was large (0–40%)—highest in Papua New Guinea (0–40%), and lowest in Nepal (0–1.7%).

For WHZ, the number of teams with percent implausible was high in India, Papua New Guinea, and Timor-Leste with many teams well above the 1% threshold (Figure 7b). Cambodia and Pakistan had several teams above the threshold, while Bangladesh, Maldives, Myanmar, and Nepal had few teams above the 1% threshold. The range of percent implausible across countries in the region was large (0–36%)—highest in Papua New Guinea (0–36.4%) and lowest in Nepal (0–1.9%) and the Maldives (0.7–2.7%).

For WAZ, there was a different pattern. The range of percent implausible was moderate across countries in the region (0–11%) and highest in Papua New Guinea (0–11%). Both Papua New Guinea and India had substantial team variation with many teams above the 1% threshold (Figure 7c). In the other countries, there was relatively less variation, and most teams were below the threshold except for a few teams in Maldives, Myanmar, Pakistan, and Timor-Leste.

Figure 7a Percent implausible height-for-age by team, South and Southeast Asia and Oceania

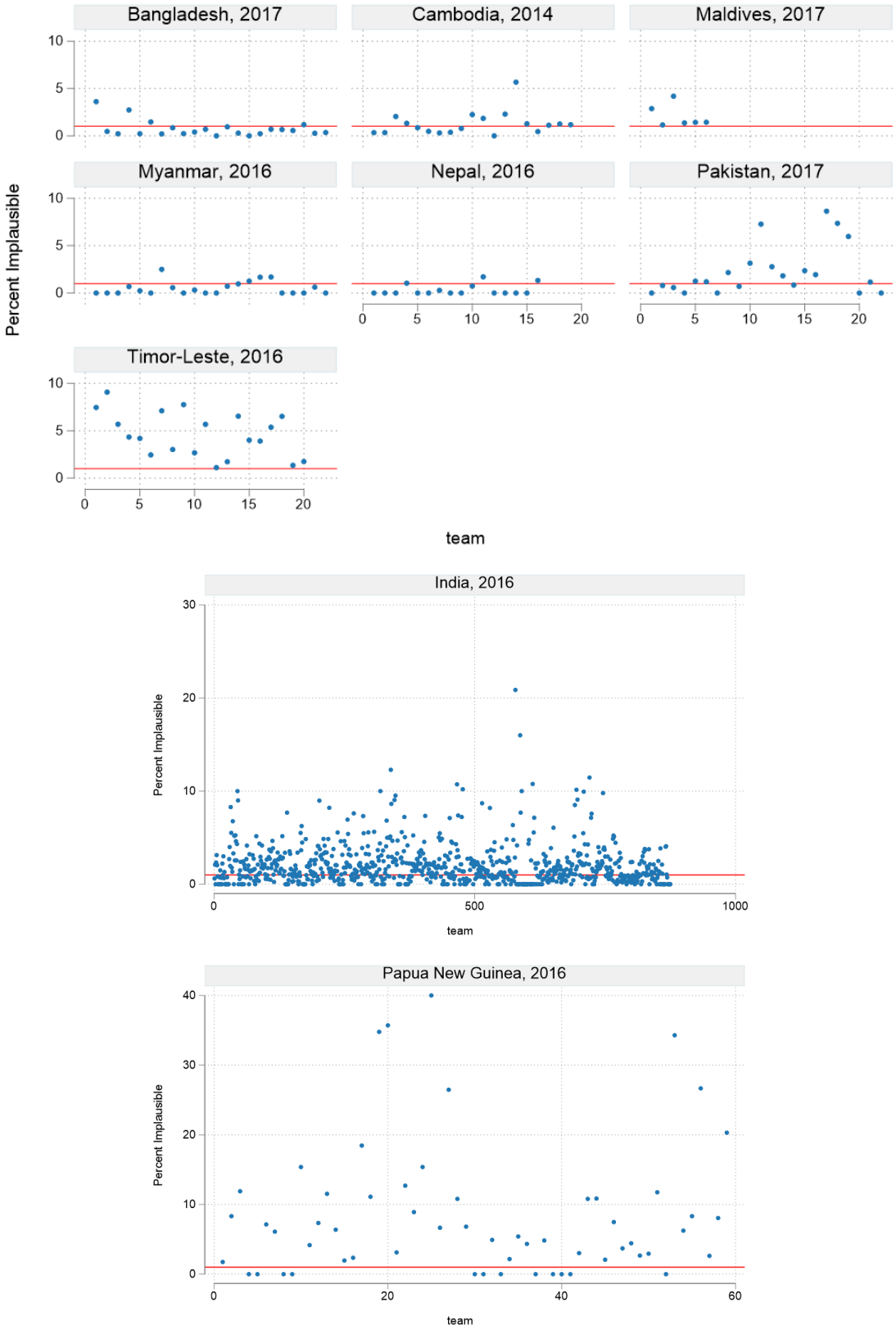


Figure 7b Percent implausible weight-for-height by team, South and Southeast Asia and Oceania

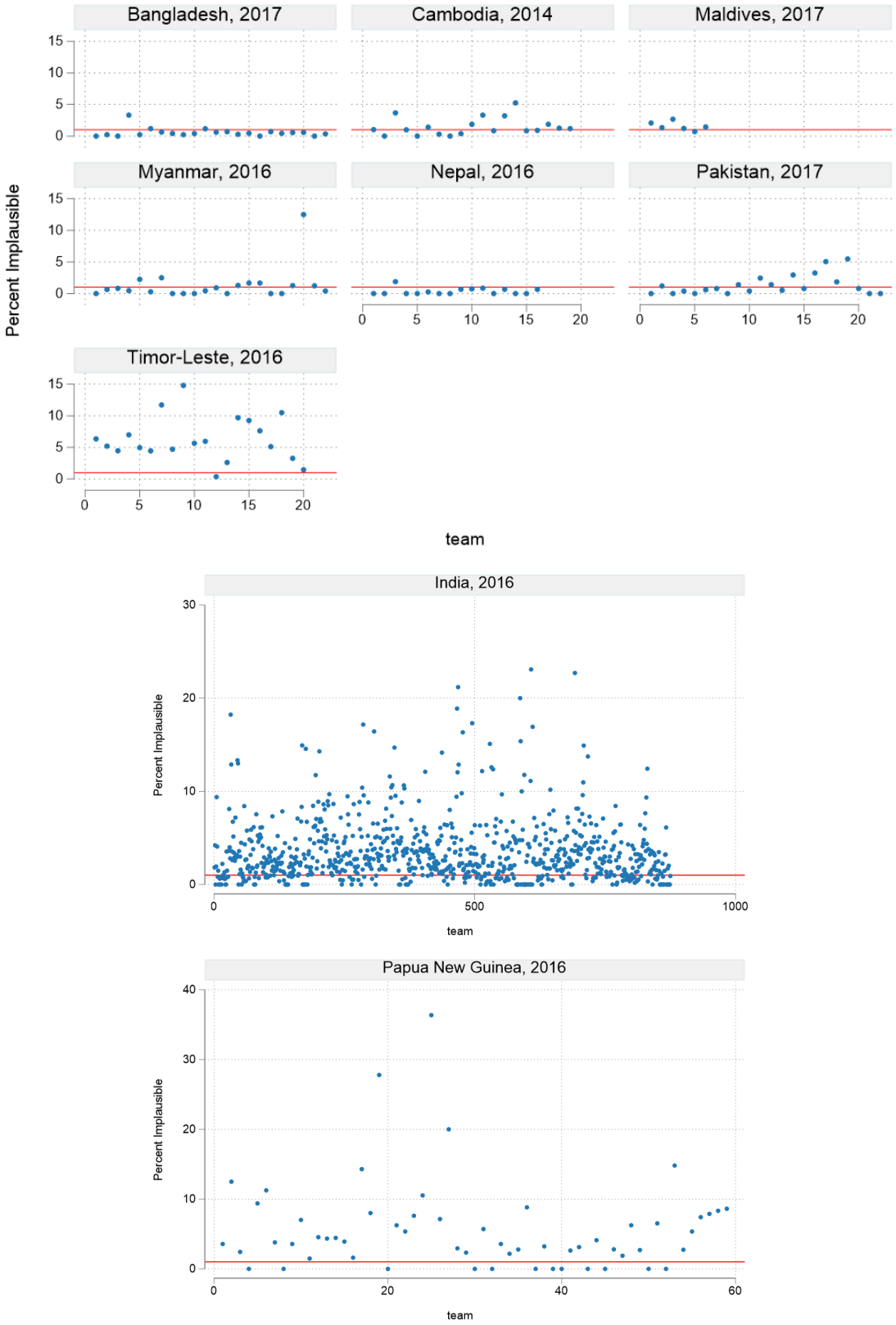
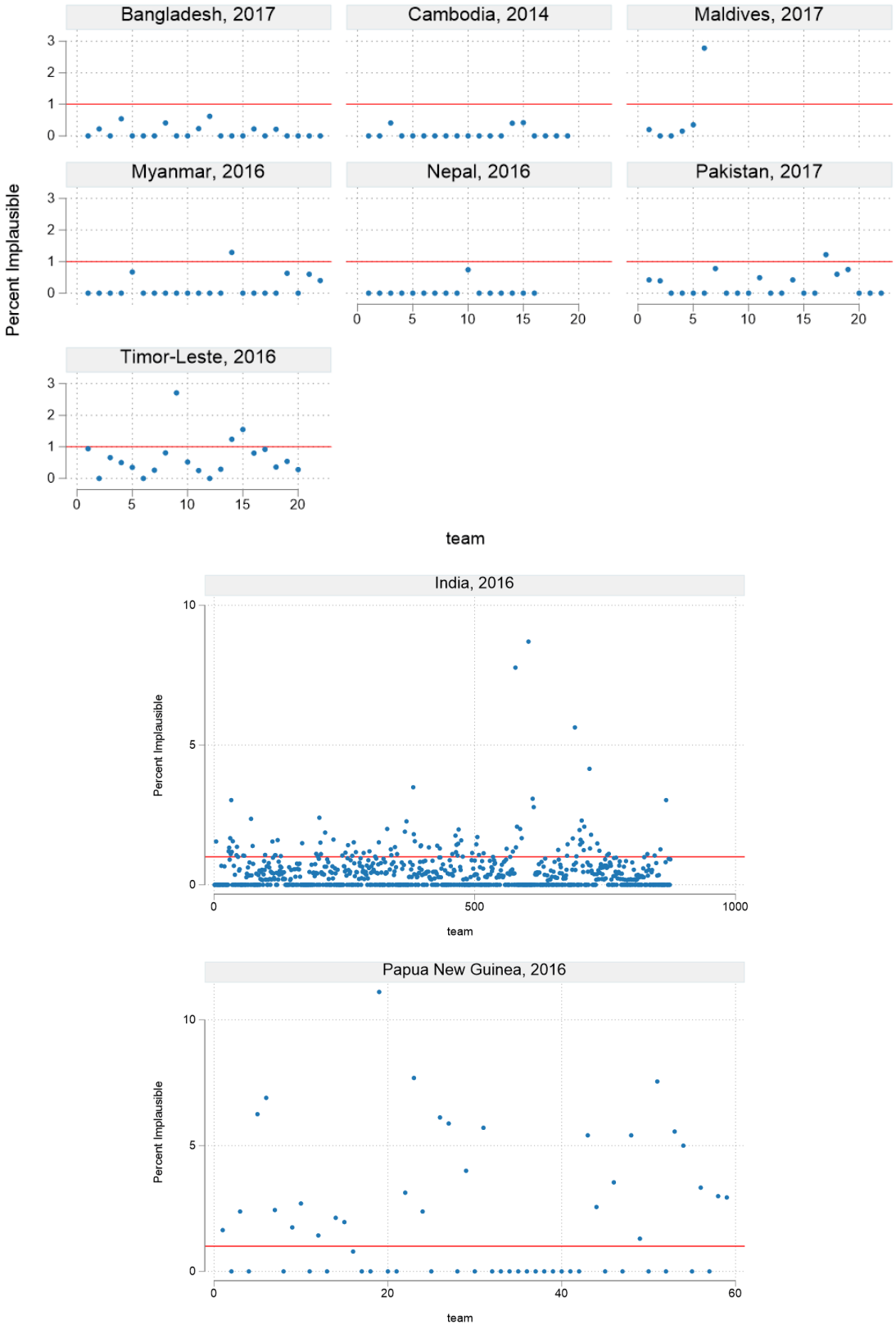


Figure 7c Percent implausible weight-for-age by team, South and Southeast Asia and Oceania



3.4.3 Latin America and the Caribbean

For HAZ, there was low variation in team implausible in all countries. Only a few teams in the Dominican Republic and Haiti were above the 1% threshold, while teams in the other countries were all below the threshold (Figure 8a). The range of percent implausible across countries in the region was very small (0–1.5%), highest in Haiti (0–1.5%), and lowest in Guatemala and Peru (0–0.4%).

For WHZ, there was low variation in team implausible in all countries. There were few teams in the Dominican Republic and Haiti above the threshold, and in Colombia, Guatemala, Honduras, and Peru most teams were below the threshold (Figure 8b). The range of percent implausible across countries in the region was small (0–3%), highest in Dominican Republic (0.3–3.3%), and lowest in Colombia (0–0.5%).

For WAZ, there was low variation in team implausible across countries in the region, and teams in all countries were at or below the 1% threshold (Figure 8c). The range of percent implausible across countries in the region was very small (0–1%), highest in Dominican Republic (0–1%), lowest in Peru (0–0.2%).

Figure 8a Percent implausible height-for-age by team, Latin America and the Caribbean

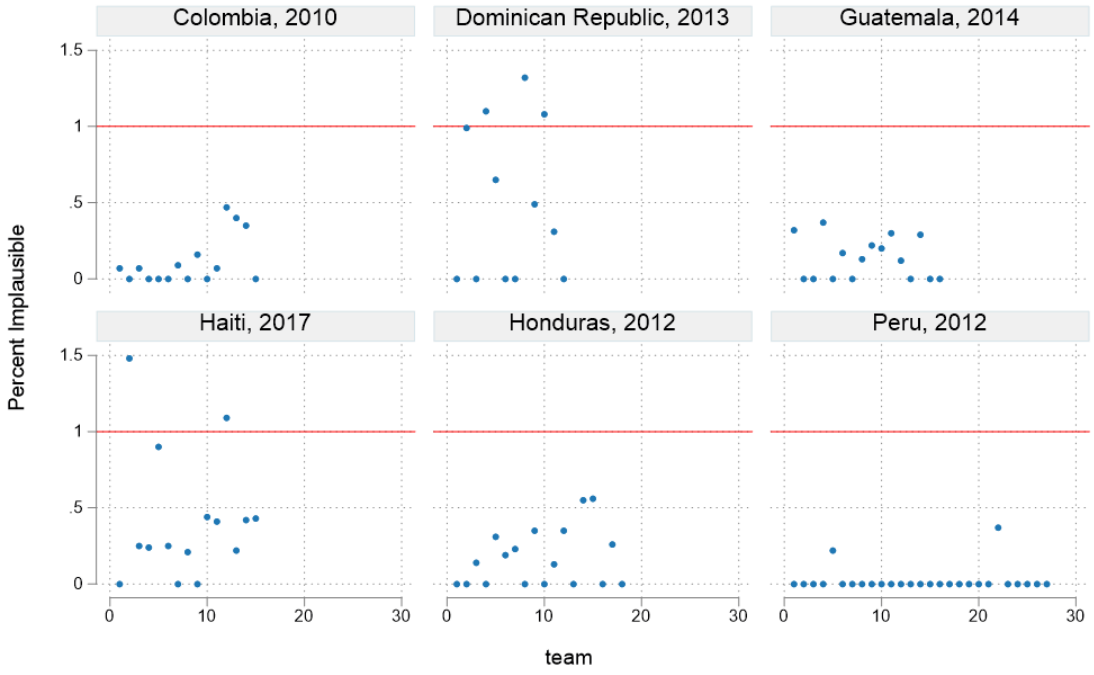


Figure 8b **Percent implausible weight-for-height by team, Latin America and the Caribbean**

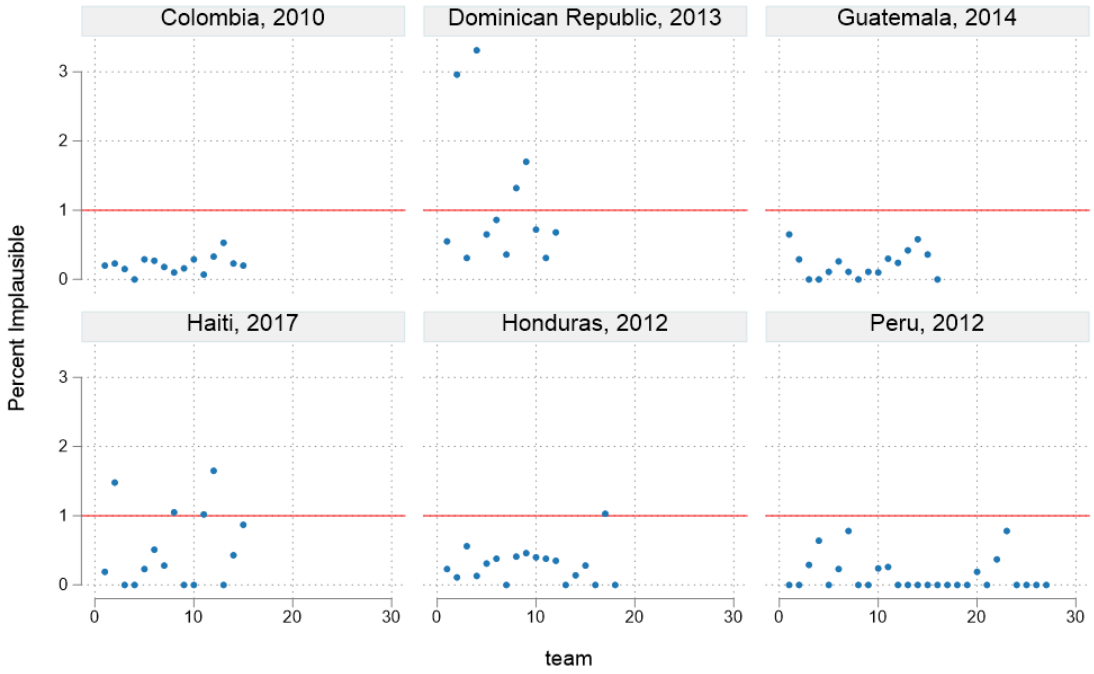
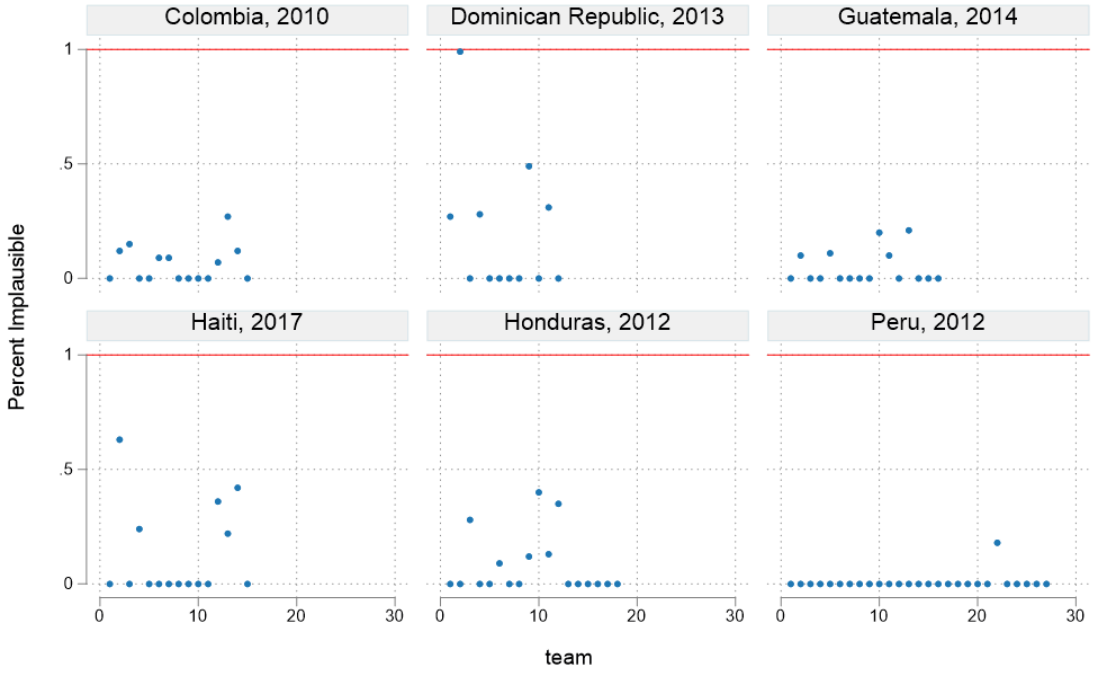


Figure 8c **Percent implausible weight-for-age by team, Latin America and the Caribbean**



3.4.4 West Africa

For HAZ, teams in Niger showed substantial variation in the percent implausible, with many teams above the 1% threshold (Figure 9a). Teams in Benin, Burkina Faso, Cameroon, Côte d'Ivoire, Gabon, Gambia Ghana, Guinea, Liberia, Mali, Nigeria, Senegal, Sierra Leone, and Togo showed low to moderate variation, with several teams above the threshold. The range of percent implausible across countries in the region was large (0–28%), highest in Niger (0–27.7%), and lowest in Gambia (0–0.4%).

For WHZ, there were similar patterns to HAZ. The number of teams with percent implausible was high in Niger with many teams above the 1% threshold (Figure 9b). Teams in Benin, Burkina Faso, Cameroon, Côte d'Ivoire, Gabon, Gambia Ghana, Guinea, Liberia, Mali, Nigeria, Senegal, Sierra Leone, and Togo showed low to moderate variation, with several teams above the threshold. The range of percent implausible across countries in the region was large (0–28%), highest in Niger (0–28.2%), and lowest in Gambia (0–0.2%).

For WAZ, teams show low variation. There were few teams in Cote d'Ivoire, Gabon, Ghana, Guinea, Liberia, Mali, Niger, and Sierra Leone above the 1% threshold, while teams in the other countries were at or below the threshold (Figure 9c). The range of percent implausible across countries in the region was low (0–5%), highest in Niger (0–4.5%), and lowest in Senegal (0–0.2%).

Figure 9a Percent implausible height-for-age by team, West Africa

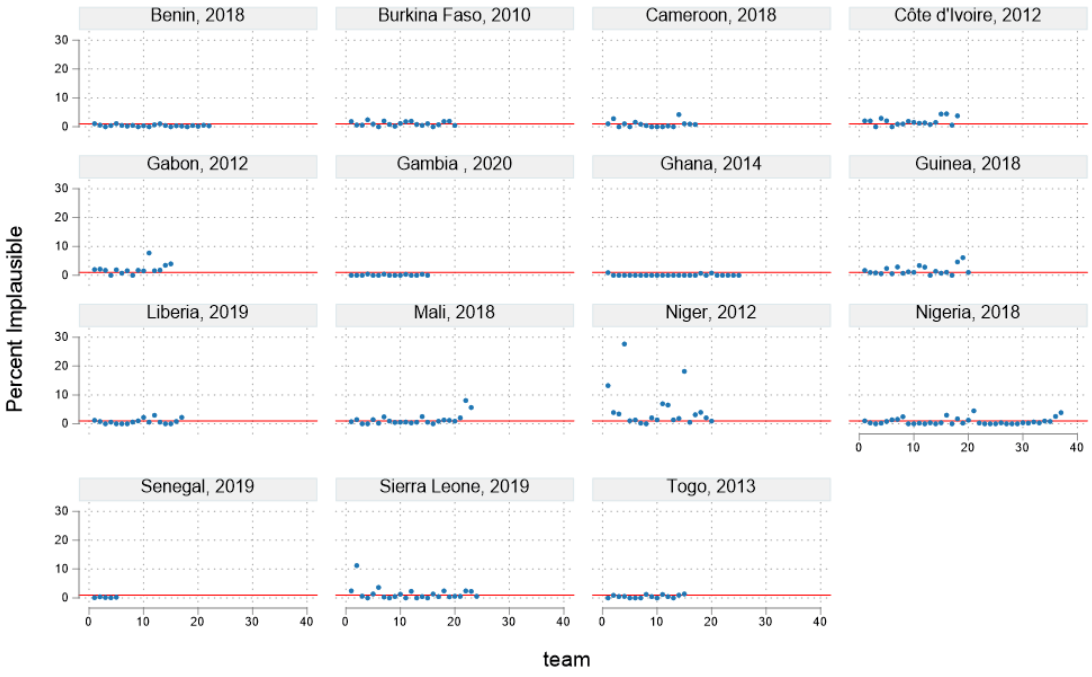


Figure 9b Percent implausible weight-for-height by team, West Africa

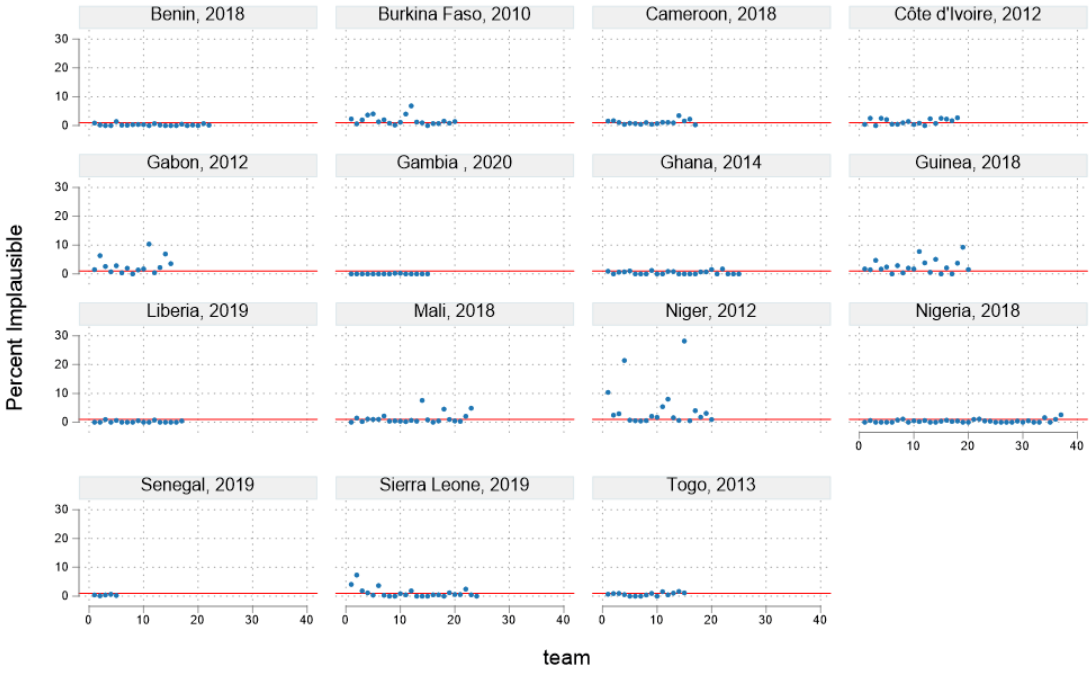
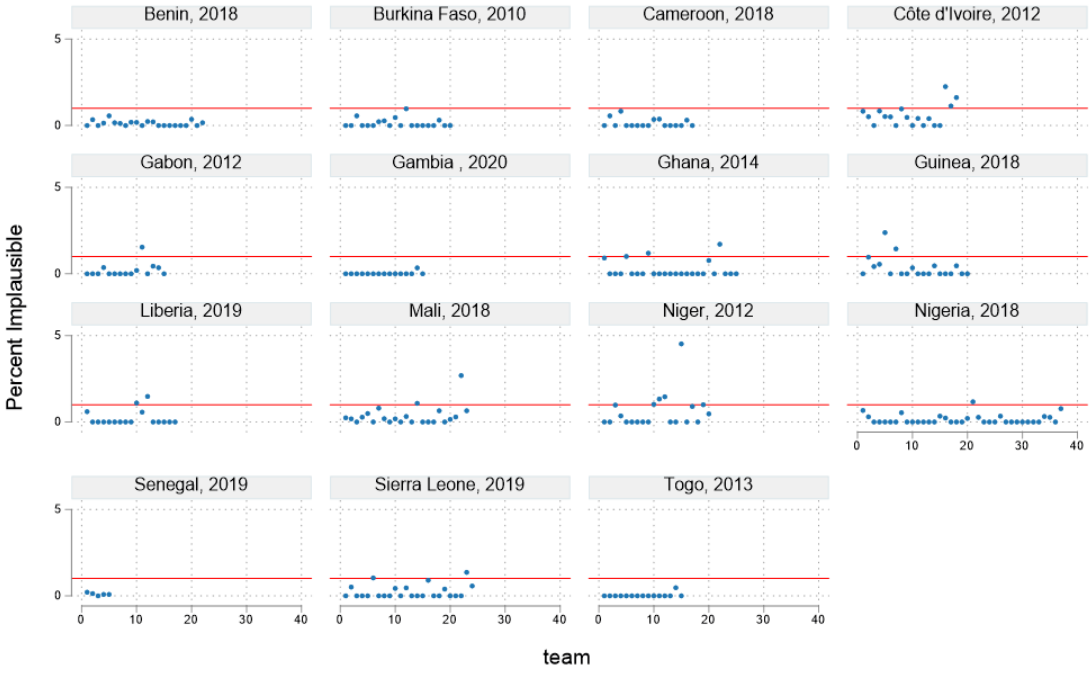


Figure 9c Percent implausible weight-for-age by team, West Africa



3.4.5 East Africa

For HAZ, there was variation in team implausible in most countries. Several teams in Ethiopia and Kenya were slightly above the 1% threshold (Figure 10a). Teams in Rwanda showed low variation and all teams were below the threshold. The range of percent implausible across countries in the region was small (0–3%), highest in Ethiopia (0–2.8%), and lowest in Burundi and Rwanda (0–0.8%).

For WHZ, only Kenya had several teams above the 1% threshold. Other counties had most teams below the threshold (Figure 10a). The range of percent implausible across countries in the region was small (0–6%), highest in Uganda (0–5.6%), and lowest in Burundi (0–0.4%).

For WAZ, there was modest variation in team implausible in Ethiopia and Kenya. Only one team in Ethiopia had a percent implausible above the 1% threshold (Figure 10c). All other countries had low variation, and the teams were below the threshold. The range of percent implausible across countries in the region was very small (0–1%), highest in Ethiopia (0–1.1%), and lowest in Burundi (0–0.4%).

Figure 10a Percent implausible height-for-age by team, East Africa

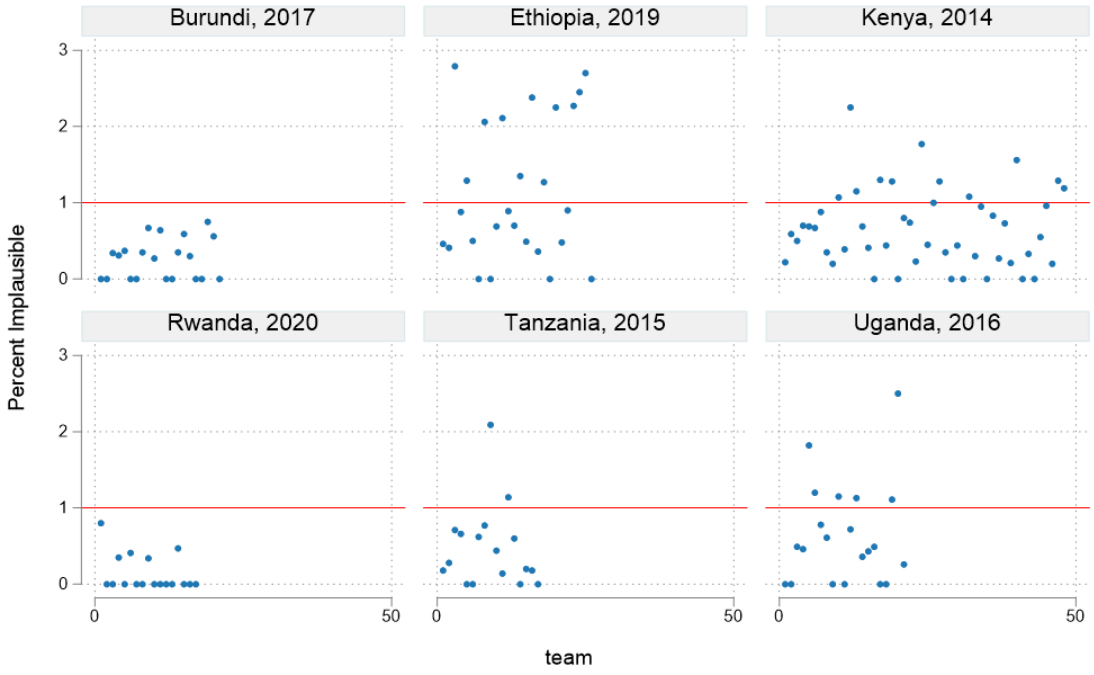


Figure 10b Percent implausible weight-for-height by team, East Africa

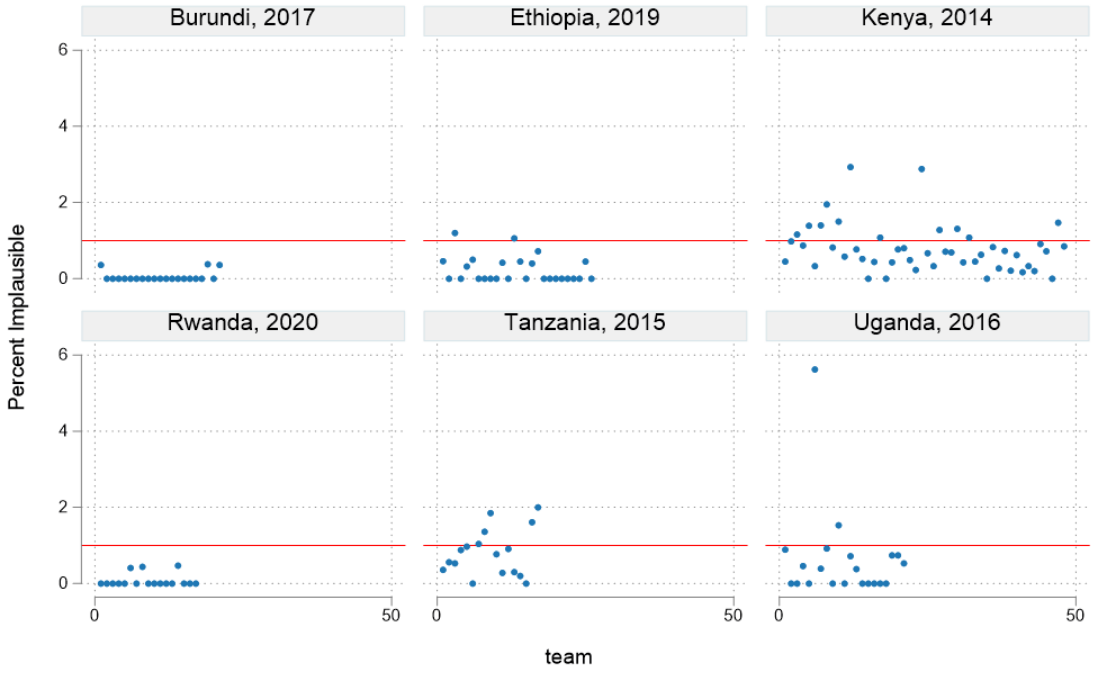
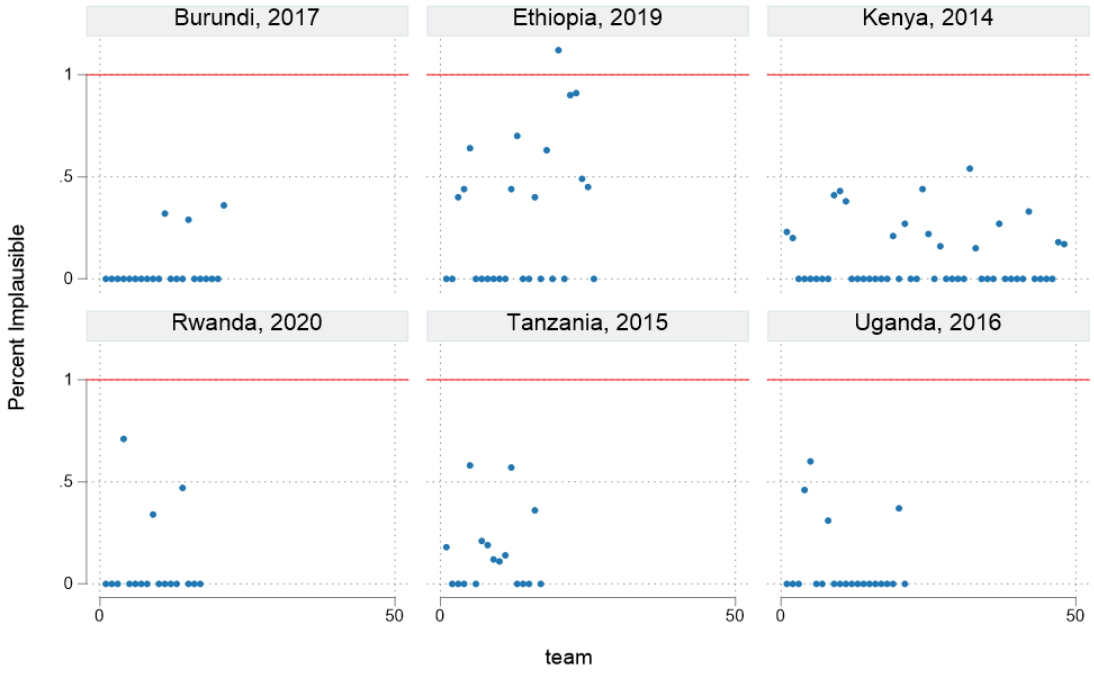


Figure 10c Percent implausible weight-for-age by team, East Africa



3.4.6 Central and Southern Africa

For HAZ, there was substantial variation in team implausible in most countries. Several teams in Angola, Chad, Comoros, Democratic Republic of the Congo, Lesotho, Malawi, Mozambique, Namibia, and South Africa were well above the 1% threshold (Figure 11a). Teams in Congo, Zambia, and Zimbabwe showed low to moderate variation, with a few teams above the threshold. The range of percent implausible across countries in the region was large (0–18%), highest in Comoros (1.7–17.6%), and lowest in Congo (0–2.4%).

For WHZ, there were similar patterns to HAZ. Angola, Chad, Comoros, Democratic Republic of the Congo, Lesotho, Malawi, Mozambique, Namibia, South Africa, Zambia, and Zimbabwe had several teams above the 1% threshold (Figure 11a). In Congo, few teams were above the threshold. The range of percent implausible across countries in the region was large (0–22%), highest in Comoros (2.6–21.7%), and lowest in Congo (0–2.7%).

For WAZ, there was moderate variation in team implausible in Angola, Comoros, Democratic Republic of the Congo, Lesotho, Malawi, Namibia, and South Africa with many teams above the 1% threshold (Figure 11c). In the other countries there was low variation, and most teams were below the threshold. The range of percent implausible across countries in the region was moderate (0–9%), highest in South Africa (0–8.8%), and lowest in Zambia (0–0.2%).

Figure 11a Percent implausible height-for-age by team, Central and Southern Africa

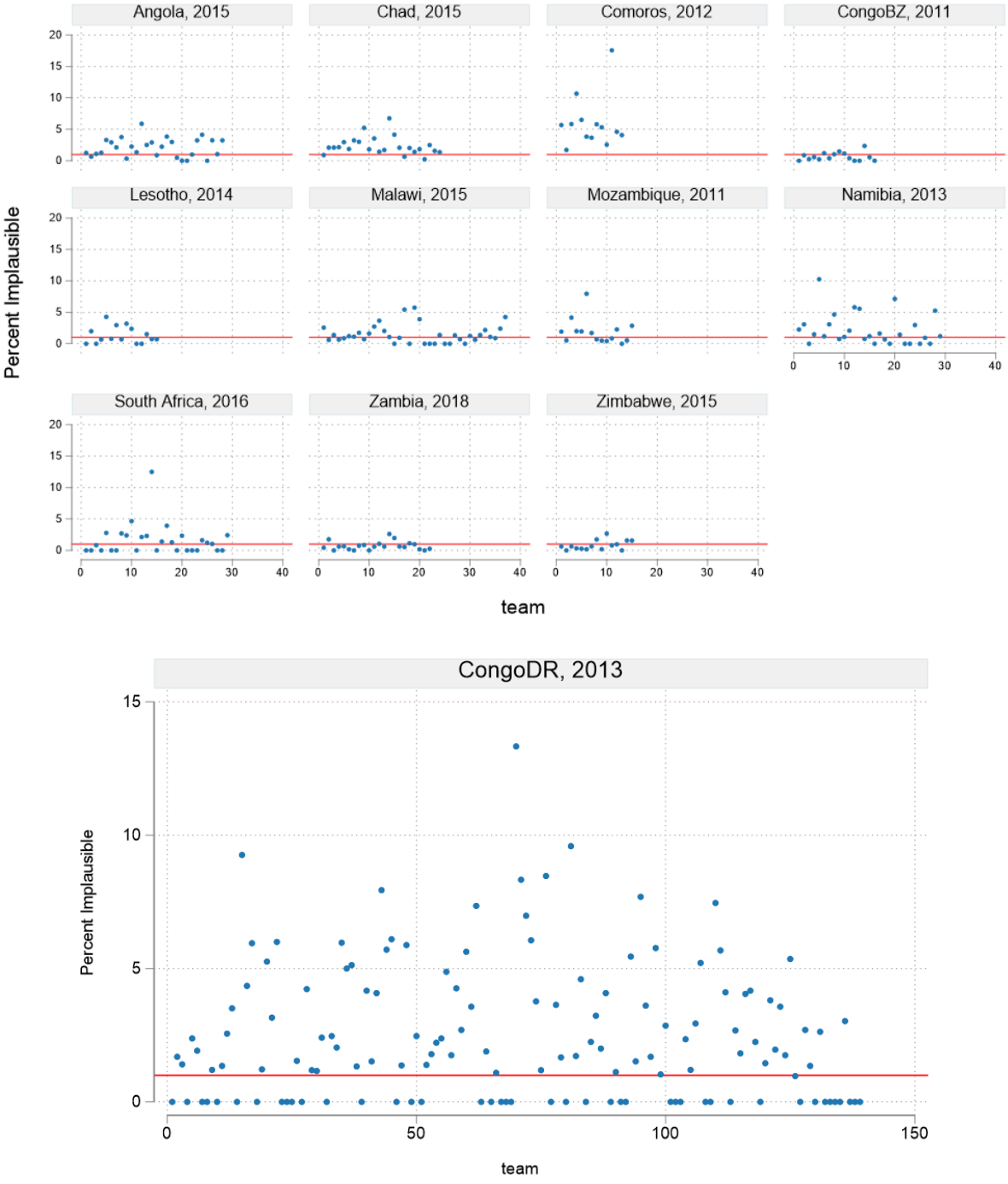
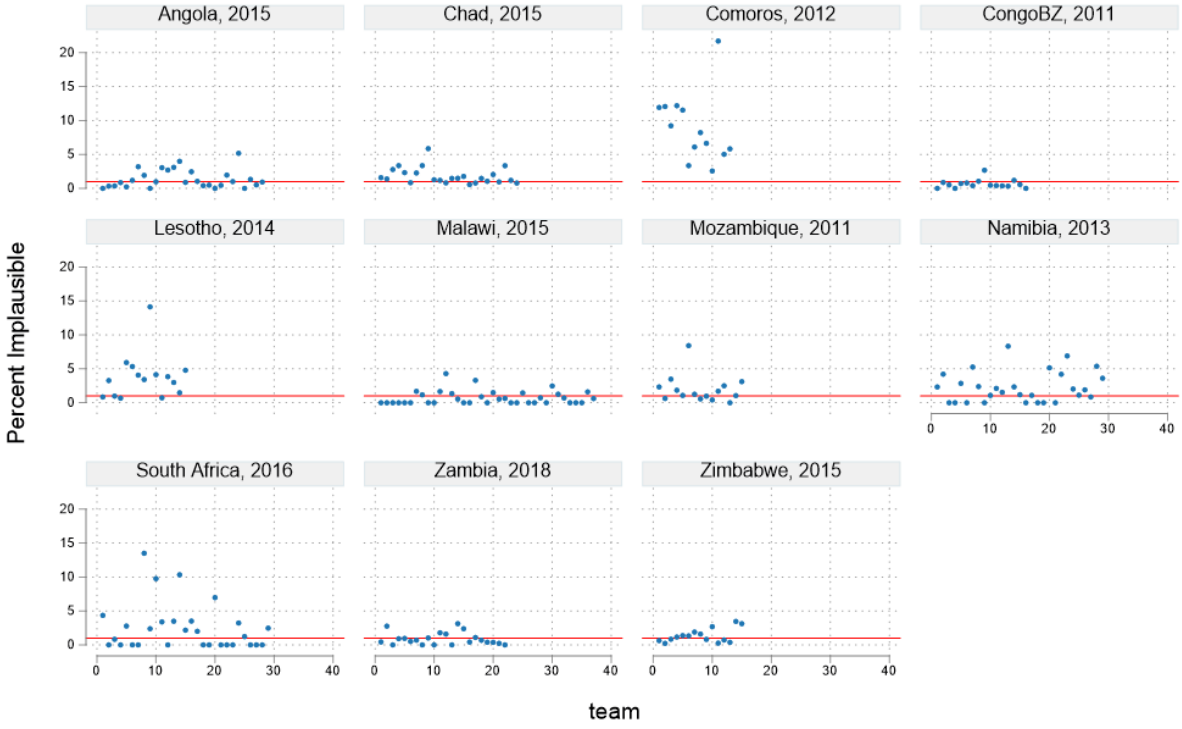


Figure 11b Percent implausible weight-for-height by team, Central and Southern Africa



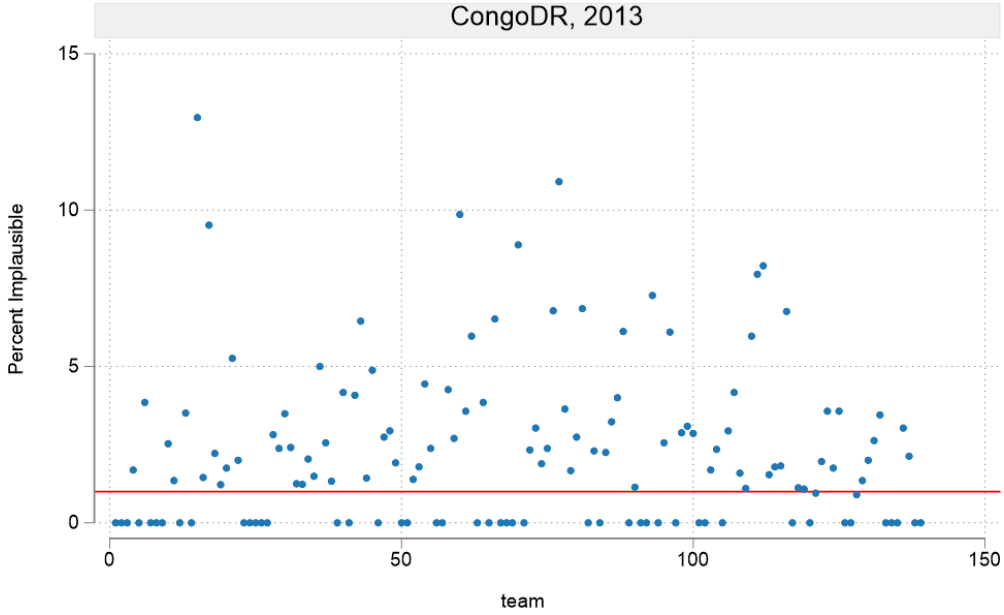
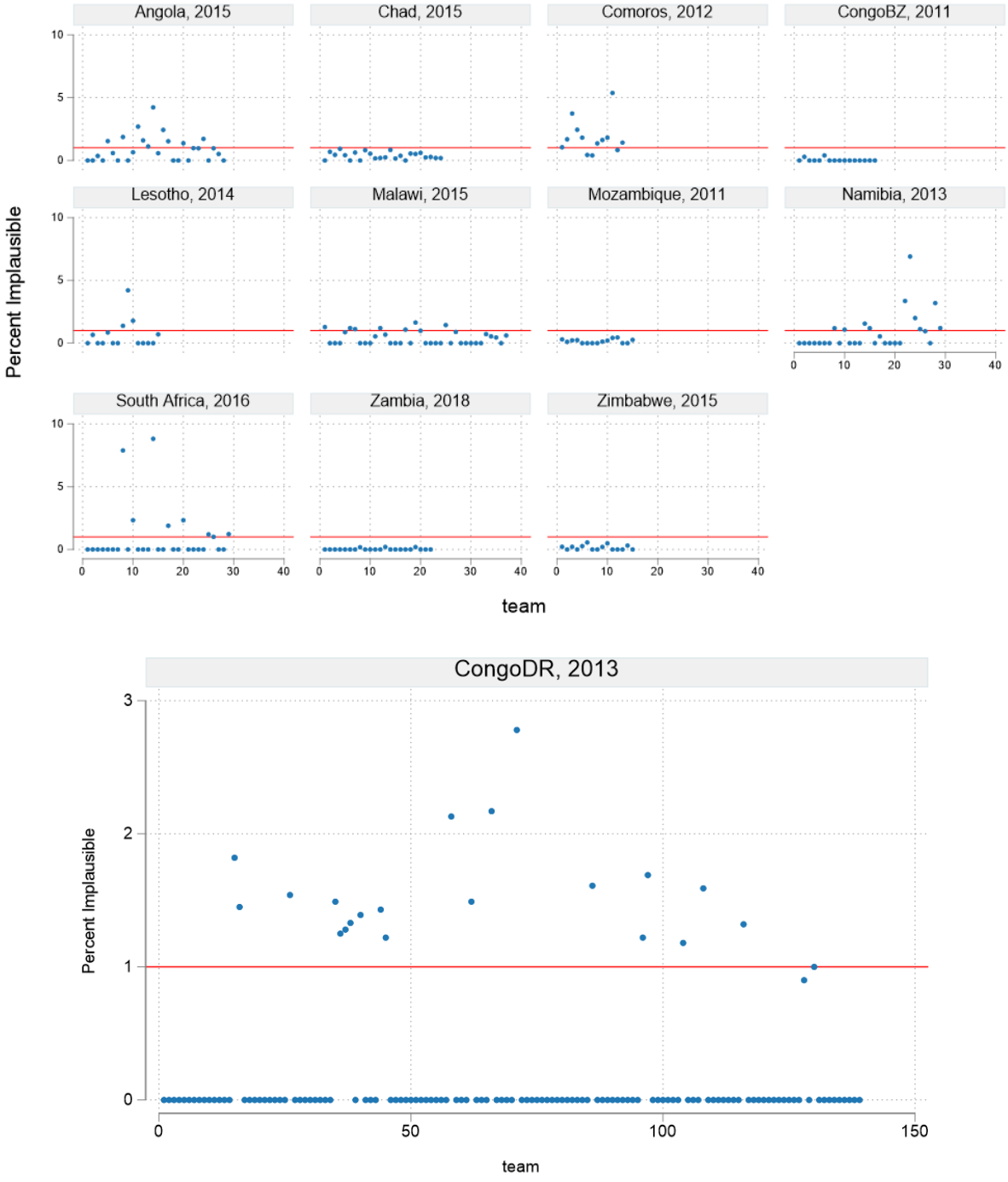


Figure 11c Percent implausible weight-for-age by team, Central and Southern Africa



4 DISCUSSION

Enhancing DHS Program data quality is a continuous process at The DHS Program. To inform this process, this study aimed to characterize implausible anthropometric *z* scores by data collection team across 90 surveys. Nearly half of surveys did not meet the WHO 1% implausible *z* score threshold for at least one of the anthropometric indicators. Across many surveys, there was also variation in team performance. Across regions, Latin America and the Caribbean (LAC) surveys had the lowest total percentage of implausible *z* score values and the least variability in the percent implausible for teams followed by East Africa (EAfr) surveys. Other regions showed more variability in the percent implausible and variation by team. Over time, however, data quality improved in most surveys.

Surveys that were well above the 1% threshold tended to have the majority of teams performing poorly rather than a wide spread of very good and poorly performing teams. For example, among the top three worst performing surveys, almost all teams were above the threshold for HAZ and WHZ in Benin 2011–12 and Sierra Leone 2013, and more than 75% of teams were above the threshold in Pakistan 2012–13. Such cases, as noted by others, indicate an overall issue with the teams' ability to perform measurements that could be related to poor training and/or challenges with field work, such as political instability, difficult terrain, or pressure to complete field work (Perumal et al. 2020).

The variation in the quality of measurements by teams can influence the overall quality of anthropometry in the survey. Many surveys had more than five teams with implausible values above the 1% threshold. Our use of the WHO 1% threshold at the team level is novel, because to date, it has not been used to assess survey quality across teams. However, examining overall survey implausible could mask team variation, which can be a serious issue if the teams' data collection is centered within a specific sub-national region. For example, in India 2015–16, which has the largest number of teams, overall survey implausible was around 2-3% and was considered acceptable by others (Harkare et al. 2021). However, the percentage of teams with implausible HAZ and WHZ above the 1% threshold was 62% and 79%, respectively. Conversely, in Jordan 2017–18, overall survey implausible was also around 2–3%, and the percentage of teams with implausible HAZ and WHZ above the 1% threshold was 66% and 76%.These anthropometry results were not included in the DHS final report due to concerns with data quality. Assaf et al. identified cluster variation as one source of variation in survey data quality, and noted that even among high performing surveys, a large proportion of the variation in *z* scores was explained by the cluster (Assaf, Kothari, and Pullum 2015). Our results support this conclusion and highlight the importance of reducing team variability in measurements.

Many surveys had several teams with implausible values greater than 1%, although many of these were older surveys. The median percent of teams with implausible HAZ and WHZ values above the 1% threshold were between 20% to 30% lower in surveys from 2015–20, as compared to surveys from 2010–14. This is in alignment with findings by others that showed improvements in anthropometric data quality over time (Grellety and Golden 2018).

Our finding that the percentage of implausible values varied by anthropometric indicator is indicative of relative differences in the difficulty collecting height, weight, and age measurements. Height measurements are taken using a measuring board where technicians must correctly position and read the measurement

from the measuring tape. In contrast, weight measurements are taken on a digital scale and are less prone to error. Of 90 surveys, 53 and 56 surveys had more than five teams with implausible HAZ and WHZ values above the 1% threshold, respectively, while only 15 surveys had more than five teams with implausible WAZ values above the threshold. The substantially fewer surveys (<10%) designated as "poor quality" based on implausible WAZ compared to the other anthropometric indicators (>50%) aligns with findings from other studies (Allen et al. 2019; Harkare et al. 2021; Perumal et al. 2020), and suggests that height measurement is a major source of measurement error for data collection teams.

Height measurements are taken for children over age 2 (height is measured standing up) and length is taken for children under age 2 (length is measured lying down). Other studies have shown greater precision and lower percent implausible for all anthropometric indicators among children over age 2 than children under age 2 (Assaf, Kothari, and Pullum 2015; Bilukha et al. 2020; WHO Multicentre Growth Reference Study Group 2006a). Although our analyses did not stratify by age of the child, it is expected that there would be roughly the same number of younger and older children measured by a team. Thus, it is unlikely that differences in poor team performance would be caused by age of the children.

During data collection, some variation in team performance is expected because field conditions differ within a country. In addition, motivation of individual teams and varying levels of fieldwork supervision are also important factors. However, substantial differences in the implausible level between teams is cause for concern because it suggests that there are problems with taking the anthropometric measurements. In 2019, Allen et al. explored using flagging thresholds wider or narrower than the WHO's 1% implausible to identify teams with sub-optimal performance during data collection. However, the study noted the challenges of identifying poorly performing teams early in data collection because of limited cases, and did not find any clear advantages in identifying teams that required remedial action with different anthropometric *z* score thresholds (Allen et al. 2019).

Like all studies, there are several limitations to consider. Our study assessed team variation by one metric of data quality, implausible *z* score values as defined by the WHO. Although other metrics such as a different flagging system (SMART survey—Standardized Monitoring and Assessment of Relief and Transitions—flags), standard deviation, age heaping, and digit preference could have been used to describe team variation, we focused on the WHO implausible values because of its use in DHS field check tables and the existence of a threshold criteria to identify poor quality (Allen et al. 2019; Assaf, Kothari, and Pullum 2015; Pullum and Staveteig 2017; WHO/UNICEF 2019). Another limitation of this work is that a low number of children are measured by each team in some surveys. However, in our analyses, we only considered teams with at least 30 cases to prevent including teams with very few measurements.

In this study, we did not examine the relationship between team variation and regional anthropometric estimates. Future research should examine team variation by region and the extent to which this can affect subnational estimates. For example, data representativeness can be affected if poorly performing teams collect data in one region. We also did not link team variation to anthropometric estimates. It is possible that results could vary by the nutritional profile of a country and this could be further explored. Finally, stratifying team performance by over or under age 2 may yield further insights into team variability and performance.

5 CONCLUSION

Anthropometric data is challenging to collect well. While some variation in team performance is expected in surveys, very high levels within a survey may be a sign of increased measurement error within certain teams. The impact of a high percentage of implausible *z* scores by team is clear at the national level because about half the surveys had poor quality HAZ and WHZ results. However, future research is needed to examine variation in team performance at the regional level to explore the impact of data quality on the interpretation of anthropometric estimates.

The reasons for poor overall survey quality may be due to all teams performing poorly or a mixture of some teams performing well and others poorly. Understanding whether the root cause of poor data quality is the team as a whole or variation in team performance is useful for identifying strategies to address data quality in surveys. For example, if survey data quality is a greater issue across teams, actions need to be taken to improve overall procedures such as training. However, when it is an issue with specific teams, better supervision in the field would be the most effective remedy.

Many of the new or updated procedures at The DHS Program are useful in improving both overall and individual team quality (The DHS Program 2019). The inclusion of anthropometric data quality assurance methods in the budgeting and planning for training and fieldwork is essential. For example, the inclusion of standardization exercises as part of training allows for the assessment of whether teams can produce precise and accurate measurements before going into the field. During data collection, use of enhanced technical supervision tools for monitoring data collection and reviewing field check tables to identify teams with high percentages of implausible data and other measures of data quality can be used to provide targeted feedback to poorly performing teams. In addition, remeasurement of height and weights reduces incorrect anthropometric values in the dataset and provides important insights into the quality of data by providing information on teams' ability to take precise measurements. Such data quality measures during the planning, training, and implementation of surveys will continue to enhance the quality of anthropometric data in surveys.

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APPENDIX

Appendix Table 1 Summary statistics of the median percentage of implausible height-for-age *z* scores (HAZ), weight-for-height *z* scores (WHZ), and weight-for-age *z* scores (WAZ) by team across all surveys, surveys between 2010–14, and surveys between 2015–20

Indicator	Median of mean	Median of Min	Median of Max	Median of Median	Median of 25th Quartile	Median of 75th Quartile	Median of Interquartile Range
All surveys 2010–2020							
HAZ	1.4	0.0	4.0	0.8	0.4	1.6	1.1
WHZ	1.3	0.0	4.2	1.0	0.5	1.8	1.3
WAZ	0.2	0.0	1.0	0.0	0.0	0.3	0.3
Surveys 2010–2014							
HAZ	1.4	0.0	4.1	1.1	0.7	1.9	1.1
WHZ	1.6	0.0	4.8	1.4	0.6	2.3	1.5
WAZ	0.2	0.0	1.0	0.0	0.0	0.3	0.3
Surveys 2015–2020							
HAZ	0.9	0.0	3.8	0.6	0.2	1.1	1.0
WHZ	0.9	0.0	3.4	0.5	0.2	1.2	0.9
WAZ	0.2	0.0	1.1	0.0	0.0	0.3	0.3

Note: The summary statistics are first calculated for each survey and then the median of the summary statistics across all surveys are calculated.

HAZ implausible defined as height-for-age *z* scores (HAZ) below –6 SD or above +6 SD.
WHZ implausible defined as weight-for-height *z* scores below –5 SD or above +5 SD.
WAZ implausible defined as weight-for-age *z* scores below –6 SD or above +5 SD.

Appendix Table 2 **Number and percentage of teams with percent implausible height-for-age *z* scores (HAZ), weight-for-height *z* scores (WHZ), and weight-for-age *z* scores (WAZ) above 1% according to survey**

Country	Survey Year	Number of teams	Number of teams with implausible values above 1%			Percentage of teams with implausible above 1%		
			HAZ	WHZ	WAZ	HAZ	WHZ	WAZ
Albania	2017–18	28	9	17	13	32.1	60.7	46.4
Angola	2015–16	28	20	12	10	71.4	42.9	35.7
Armenia	2010	13	8	12	1	61.5	92.3	7.7
Armenia	2015–16	13	6	6	1	46.2	46.2	7.7
Bangladesh	2011	20	16	17	2	80.0	85.0	10.0
Bangladesh	2014	22	17	18	0	77.3	81.8	0.0
Bangladesh	2017	22	4	3	0	18.2	13.6	0.0
Benin	2011–12	29	29	29	15	100.0	100.0	51.7
Benin	2017–18	22	3	1	0	13.6	4.5	0.0
Burkina Faso	2010	20	9	12	0	45.0	60.0	0.0
Burundi	2010	18	4	4	0	22.2	22.2	0.0
Burundi	2016–17	21	0	0	0	0.0	0.0	0.0
Cambodia	2010	19	11	11	0	57.9	57.9	0.0
Cambodia	2014	19	10	10	0	52.6	52.6	0.0
Cameroon	2011	20	10	10	0	50.0	50.0	0.0
Cameroon	2018	17	6	9	0	35.3	52.9	0.0
Chad	2014–15	24	21	18	0	87.5	75.0	0.0
Colombia	2010	15	0	0	0	0.0	0.0	0.0
Comoros	2012	13	13	13	10	100.0	100.0	76.9
Congo	2011–12	16	5	3	0	31.3	18.8	0.0
Congo Democratic Republic	2013–14	139	95	91	20	68.3	65.5	14.4
Côte d'Ivoire	2011–12	18	12	9	3	66.7	50.0	16.7
Dominican Republic	2013	12	3	4	0	25.0	33.3	0.0
Egypt	2014	14	13	12	1	92.9	85.7	7.1
Ethiopia	2011	35	27	25	2	77.1	71.4	5.7
Ethiopia	2016	33	16	15	0	48.5	45.5	0.0
Ethiopia	2019	26	11	2	1	42.3	7.7	3.8
Gabon	2012	15	12	11	1	80.0	73.3	6.7
Gambia	2013	14	13	12	12	92.9	85.7	85.7
Gambia	2019–20	15	0	0	0	0.0	0.0	0.0
Ghana	2014	25	0	4	2	0.0	16.0	8.0
Guatemala	2014–15	16	0	0	0	0.0	0.0	0.0
Guinea	2012	15	7	14	0	46.7	93.3	0.0
Guinea	2018	20	11	15	2	55.0	75.0	10.0
Haiti	2012	15	3	5	0	20.0	33.3	0.0
Haiti	2016–17	15	2	4	0	13.3	26.7	0.0
Honduras	2011–12	18	0	1	0	0.0	5.6	0.0
India	2015–16	875	546	693	101	62.4	79.2	11.5
Jordan	2012	26	7	11	0	26.9	42.3	0.0
Jordan	2017–18	41	27	31	4	65.9	75.6	9.8
Kenya	2014	48	11	12	0	22.9	25.0	0.0
Kyrgyzstan	2012	10	0	3	0	0.0	30.0	0.0
Lesotho	2014	15	6	11	3	40.0	73.3	20.0
Liberia	2013	16	8	10	0	50.0	62.5	0.0
Liberia	2019–20	17	5	0	2	29.4	0.0	11.8
Malawi	2010	37	28	37	4	75.7	100.0	10.8
Malawi	2015–16	37	21	11	7	56.8	29.7	18.9
Maldives	2016–17	6	6	5	1	100.0	83.3	16.7
Mali	2018	23	9	7	2	39.1	30.4	8.7
Mozambique	2011	15	8	10	0	53.3	66.7	0.0
Myanmar	2015–16	22	4	8	1	18.2	36.4	4.5
Namibia	2013	29	18	20	10	62.1	69.0	34.5
Nepal	2011	16	4	13	0	25.0	81.3	0.0
Nepal	2016	16	3	1	0	18.8	6.3	0.0
Niger	2012	20	16	13	4	80.0	65.0	20.0
Nigeria	2013	37	36	36	8	97.3	97.3	21.6
Nigeria	2018	37	9	5	1	24.3	13.5	2.7

Continued…

Appendix Table 2—*Continued*

Country	Survey Year	Number of teams	Number of teams with implausible values above 1%			Percentage of teams with implausible above 1%		
			HAZ	WHZ	WAZ	HAZ	WHZ	WAZ
Pakistan	2012–13	20	15	17	6	75.0	85.0	30.0
Pakistan	2017–18	22	13	9	1	59.1	40.9	4.5
Papua New Guinea	2016–18	59	47	47	29	79.7	79.7	49.2
Peru	2010	26	0	2	0	0.0	7.7	0.0
Peru	2011	26	0	0	0	0.0	0.0	0.0
Peru	2012	27	0	9	0	0.0	33.3	0.0
Rwanda	2011	15	4	3	0	26.7	20.0	0.0
Rwanda	2014–15	17	4	6	1	23.5	35.3	5.9
Rwanda	2019–20	17	0	0	0	0.0	0.0	0.0
Senegal	2010–11	16	16	14	9	100.0	87.5	56.3
Senegal	2012–13	3	3	3	0	100.0	100.0	0.0
Senegal	2014	4	0	2	2	0.0	50.0	50.0
Senegal	2015	4	2	3	1	50.0	75.0	25.0
Senegal	2016	4	0	2	2	0.0	50.0	50.0
Senegal	2017	9	3	0	0	33.3	0.0	0.0
Senegal	2018	5	1	0	0	20.0	0.0	0.0
Senegal	2019	5	0	0	0	0.0	0.0	0.0
Sierra Leone	2013	24	23	24	18	95.8	100.0	75.0
Sierra Leone	2019	24	10	8	2	41.7	33.3	8.3
South Africa	2016	29	15	15	8	51.7	51.7	27.6
Tajikistan	2012	14	11	13	1	78.6	92.9	7.1
Tajikistan	2017	14	3	5	0	21.4	35.7	0.0
Tanzania	2010	14	10	11	0	71.4	78.6	0.0
Tanzania	2015–16	17	2	5	0	11.8	29.4	0.0
Timor-Leste	2016	20	20	19	3	100.0	95.0	15.0
Togo	2013–14	15	3	4	0	20.0	26.7	0.0
Uganda	2011	16	4	6	0	25.0	37.5	0.0
Uganda	2016	21	6	2	0	28.6	9.5	0.0
Yemen	2013	40	30	34	4	75.0	85.0	10.0
Zambia	2013–14	24	16	18	1	66.7	75.0	4.2
Zambia	2018	22	5	7	0	22.7	31.8	0.0
Zimbabwe	2010–11	15	6	7	1	40.0	46.7	6.7
Zimbabwe	2015	15	4	8	0	26.7	53.3	0.0

Note: Height-for-age *z* scores (HAZ) implausible defined as HAZ below –6 SD or above +6 SD.
Weight-for-height *z* scores (WHZ) implausible defined as WHZ below –5 SD or above +5 SD.
Weight-for-age *z* scores (WAZ) implausible defined as WAZ below –5 SD or above +6 SD.

Appendix Table 3 **Median percentage of teams above the 1% implausible threshold for height-for-age *z* scores (HAZ), weight-for-height *z* scores (WHZ), and weight-for-age *z* scores (WAZ) across all surveys, surveys between 2010–14, and surveys between 2015–20**

Indicator	Median percent of teams with implausible >1%
All surveys 2010–2020	
HAZ	42.0
WHZ	50.0
WAZ	1.4
Surveys 2010–2014	
HAZ	51.3
WHZ	63.8
WAZ	0.0
Surveys 2015–2020	
HAZ	32.7
WHZ	34.5
WAZ	2.7

Note: The percentage of teams with implausible values above the 1% threshold calculated for each survey and then the median value across all surveys are calculated.

HAZ implausible defined as height-for-age *z* scores (HAZ) below –6 SD or above +6 SD.

WHZ implausible defined as weight-for-height *z* scores below –5 SD or above +5 SD.

WAZ implausible defined as weight-for-age *z* scores below –6 SD or above +5 SD.