World Health Organization

WHO Anthro Survey Analyser

Quick guide

Caution note on data privacy:

The user should upload de-identified data to be analysed with the WHO Anthro Survey Analyser; ownership resides with the principal investigator (PI) or researcher. To protect the data, https will be used for the data transfer and the data will not be saved once the session has been closed. However, as it will be temporarily stored in a cloud server, a disclaimer and terms of use must be accepted for the use of the application.

Disclaimer:

The WHO Anthro Survey Analyser runs in its own protected environment and its access is SSL encrypted; uploaded data is not saved once you close the session. However, the data will be temporarily stored in the cloud hosting the application and thus users are advised to ensure data is de-identifiable.

All reasonable precautions have been taken by WHO to verify the calculations performed by this application. However, the application is being distributed without warranty of any kind, either express or implied. The responsibility for the use and interpretation of the application's output lies with the user. In no event shall the World Health Organization be liable for damages arising from its use.

Note on usage of the online tool

This online tool sits in the shinyapp.io platform, where the WHO Department of Nutrition for Health and Development opened an account, which is payable based on the number of hours used per month (fixed). As such, users should be mindful to not leave the application open without using it. To avoid unnecessary time spent, the application is set to close after 15 minutes of idleness. After its closure, the user has to re-upload the file and re-map their variables for the analyses.

The maximum file size that can be uploaded is 50MB.

The link to the WHO Anthro Survey Analyser

https://whonutrition.shinyapps.io/anthro

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Acknowledgements:

The WHO Anthro Survey Analyser was built up from the WHO R macro developed by Elaine Borghi, from the Growth Monitoring and Assessment Unit (GRS), Department of Nutrition for Health and Development, WHO, Geneva. Monika Blössner and Elaine Borghi worked on the conceptualization, design and content of the application, under the supervision of Mercedes de Onis (GRS). The tool extends the concepts featured in the Nutrition Survey module of the Anthro Software. Epidemos LTD (Jonathan Polonsky as focal point) improved the R macro efficiency and developed the first prototype of the online application based on R and the Shiny R package; and Dirk Schumacher included additional data entry validation checks and implemented user-friendless enhancements.

We are grateful for the work on the testing phase by the Paola Alejandra Castillo Rojas (WHO intern), Monica Crissel Flores-Urrutia and Elisa Dominguez (WHO staff), and Chitra Maharani Saraswati (consultant). We also thank the International Centre for Equity in Health, who worked closely with WHO on the application of standard methodology for complex survey sample analyses with financial support from the World Bank. We are also indebted to our colleague Richard Kumapley from UNICEF for his help with testing the WHO Anthro Survey Analyser results against those obtained with UNICEF's Stata macro developed following the same methodology. Special thanks to the Working Group on Anthropometric Data Quality under the WHO-UNICEF Technical Advisory Expert Group on Nutrition Monitoring (TEAM) for their review of the tool, but in special their valuable contributions to the data quality assessment module in special.

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TABLE OF CONTENTS

THE WHO ANTHRO SURVEY ANALYSER

The Anthro Survey Analyser is an online tool developed by the Department of Nutrition for Health and Development of the World Health Organization (WHO) which allows users to perform comprehensive analysis of anthropometric survey data for children under five years of age based on weight and height. The analyses are based on the WHO Child Growth Standards.[1] This version of the tool provides results for four of the anthropometric indexes: height-for-age, weight-for-age, weight-for-height, and body-mass-index-for-age.

This online tool is designed to build country capacity on data analysis and reporting on child malnutrition outcomes. It aims to enhance good practice in survey data collection, survey analysis, and reporting results.

Users should read this manual before entering their data as it contains directions on data preparation for effective analyses.

What are its differences from the Anthro Software?

The tool incorporates standard methodology as in the WHO Anthro Software[2] - Nutrition Survey module to calculate z-scores, prevalence estimates, and z-score summary statistics.

In terms of output, there are some additions:

- Outputs are provided in an "**expanded format**" with the following measures included:
  - The WHO Anthro Software included results disaggregated by age, sex, type of residence, and sub-regions/districts, if available. The WHO Anthro Survey Analyser adds to those stratifications according to wealth quintiles, mother's education, and any other country-specific relevant factor.
  - Calculations of confidence intervals and standard errors around the estimates accounts for complex sample designs methodology[3] whenever necessary.
  - The Anthro Software provides child malnutrition estimates for the most common cut-offs (e.g. stunting, which uses the indicator height-for-age below -2SD; or wasting, using the indicator weight-for-height below -2SD, and others). The tool provides cut-offs for all four indexes at -3SD, -2SD, -1SD, +1SD, +2SD, and +3SD.
  - For each index, weighted and unweighted sample sizes are provided.

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[1] WHO Multicentre Growth Reference Study Group. WHO child growth standards. Length, height for-age, weight-for-age, weight-for-length and body mass index-for age. Methods and development. Geneva: World Health Organization; 2006. Available at http://www.who.int/childgrowth/standards/Technical_report.pdf (Accessed 07 December 2017).
[2] World Health Organization. WHO Anthro (version 3.2.2, January 2011). Available at http://www.who.int/childgrowth/software (Accessed 07 December 2017).
[3] R package Survey. Available at https://cran.r-project.org/web/packages/survey/survey.pdf. By Thomas Lumley. 2015. (Accessed 07 February 2018).

- A section on data quality assessment allows users to evaluate data quality based on recommended checks that can help to identify potential data issues that can bias prevalence estimates.[4] Most of the data quality assessment checks are provided by survey team and geographical region whenever available.
- In addition to the online graphics and tables that can be easily downloaded, the tool provides two report templates: 1) a data quality assessment report template and 2) a summary report template. These reports include main findings and key outputs for data quality assessment based on the existing best practices for reporting.

What are the outputs of the Anthro Survey Analyser?

- A **z-score** file based on the WHO Child Growth Standards: individual data, including calculated z-scores, and its corresponding flags based on the WHO flagging system for identifying implausible values.
- A **prevalence** file based on the WHO recommended standard analysis[5]: includes prevalence estimates with corresponding standard errors and confidence intervals; and z-score summary statistics (mean and standard deviation) with all cut-offs describing the full index distribution (-3, -2, -1, +1, +2, +3). All results are provided at overall and disaggregated levels for all available stratification variables (age, sex, type of residence, geographical regions, wealth quintiles, mother education and one additional factor the user is interested in for which data are available).
- A **data quality report template** in Word format. This template lays out the minimum required details to ensure high standards in the survey data quality. The WHO Anthro Survey Analyser includes most of the data quality checks recommended by the Working Group on Anthropometry Data Quality.[4] Checks are presented by survey teams, whenever available, in addition to geographical regions. Some checks can also be conducted by other stratifications.
- **A survey report template** in Word format. This template lays out the minimum required details to follow the existing guidelines for good practice in reporting.[4] The main findings are also included in the form of graphics and tables which depicts prevalence estimates and z-score distributions. These measures are further stratified by different group variables for the five main indicators—namely stunting, wasting, severe wasting, overweight, and underweight—as well as data quality assessment statistics and displays. This template aims to provide useful inputs of key findings and data quality assessment for a full survey report.
- **Graphics and figures:** all graphics included in the application are in grayscale to allow for black and white printing. They can be downloaded whenever they are displayed.

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[4] Working Group (WG) on Anthropometry Data Quality, for the WHO/UNICEF Technical Expert Advisory Group on Nutrition Monitoring (TEAM). Recommendations for improving the quality of anthropometric data collection, analysis and reporting. 2019. Available at https://www.who.int/nutrition/publications/anthropometry-data-quality-report.

[5] Please refer to Appendix C: Key considerations for data standardisation.

Who will benefit from using the Anthro Survey Analyser?

The Anthro Survey Analyser is intended to be a useful tool for individuals in National Statistics Offices, data collection specialised agencies or programs, research centres, and any other institutions responsible for the analysis of anthropometric child indicators. It can be especially useful for users who do not have access to standard statistical software to analyse surveys.

STEPS TO ANALYZE SURVEYS

This tool is based on R code and utilises the shiny package.[6] As such, there are some basic rules that will ensure its efficient use. Moreover, the standard analyses of anthropometric survey data require many of the input variables to be defined according to a specific format. The steps described in the following sections will facilitate effective use of the tool.

1. Data preparation for Anthro Survey Analyser

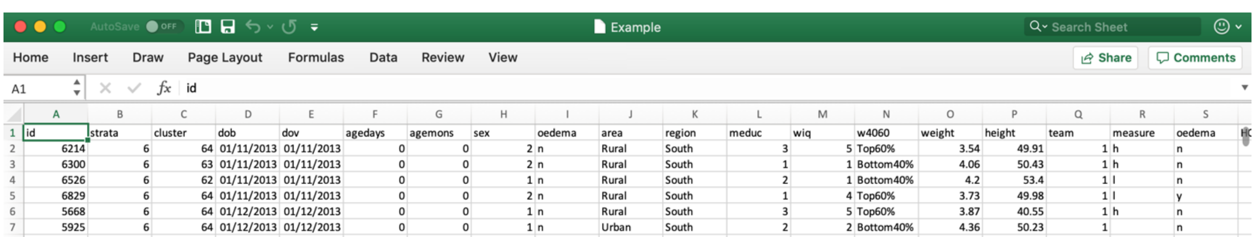
The standard analysis of survey anthropometric data, as recommended by WHO, comprises of the calculation of z-scores for each child based on the WHO Child Growth Standards, the creation of flagging variables to exclude implausible data according to the WHO flagging system, and the calculation of prevalence estimates and z-score summary statistics. To have the best accuracy for the output estimates, the user should know what the compulsory variables are as well as the recommended format for each of the mapped (input) variables.

The Anthro Survey Analyser does include validation checks for each mapped input variable used for the analysis and provides user-friendly messages to guide the user in detecting potential mismatches. However, the user is strongly encouraged to perform **data preparation prior** to importing the file into the Anthro Survey Analyser. **However, it is imperative that original variables are kept in the datafile for proper data quality assessment and transparency in reporting.** Table 1 provides guidance on accepted values for each of the variables to be mapped as input to the analysis and information on whether the variable is compulsory.

File preparation

The data file to be imported should be in a **comma delimited format (.csv).** The file can be created in any spreadsheet software used for the organization, analysis, and storage of data in tabular form such as Microsoft Excel. Once the data is properly organised it can be saved as or transferred to a ".csv" format.

Attention: This application is based on R code. Therefore, any variable label can only contain characters, numbers, "_", and "-". It **should not** include spaces or symbols. This also applies to the file name to be imported. For example, names such as "country survey.csv" or "survey2013&2014" **are not accepted**.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	id	strata	cluster	dob	dov	agedays	agemons	sex	oedema	area	region	meduc	wiq	w4060	weight	height	team	measure	oedema
2	6214	6	64	01/11/2013	01/11/2013	0	0	2	n	Rural	South	3	5	Top60%	3.54	49.91	1	h	n
3	6300	6	63	01/11/2013	01/11/2013	0	0	2	n	Rural	South	1	1	Bottom40%	4.06	50.43	1	h	n
4	6526	6	62	01/11/2013	01/11/2013	0	0	1	n	Rural	South	2	1	Bottom40%	4.2	53.4	1	l	n
5	6829	6	64	01/11/2013	01/11/2013	0	0	2	n	Rural	South	1	4	Top60%	3.73	49.98	1	l	y
6	5668	6	64	01/12/2013	01/12/2013	0	0	1	n	Rural	South	3	5	Top60%	3.87	40.55	1	h	n
7	5925	6	64	01/12/2013	01/12/2013	0	0	1	n	Urban	South	2	2	Bottom40%	4.36	50.23	1		n

Figure 1. File preparation.

[6] shiny: Web Application Framework for R. https://cran.r-project.org/web/packages/shiny.

Table 1. Data preparation: compulsory variables and accepted values/formats.

Variable	Compulsory or Optional?	Accepted values and other details
Age related variables: Date of birth & Date of visit (recommended) or Age (in days or in months)	Compulsory	Date of birth AND Date of visit: DD/MM/YYYY or MM/DD/YYYY. Both variables, date of birth and date of visit, should be provided to calculate age in days (date of visit minus date of birth). This is the recommended best practice approach. If DAY is missing for the date of birth, a new variable should be created by imputing the missing day by 15 in the analysis file before importing the dataset (e.g. ??/05/2014 should be set as 15/05/2014). In turn, if month or year is missing, the date value should be set to missing/blank. When date of birth and date of visit are missing in the analysis dataset for any reason, the software allows for the analysis to be performed based on a variable that contains age (in days or months). However, this is not the best practice, as data of birth that were used to calculate age should be retained in the dataset and used. Age: numeric - <u>in days:</u> calculated as date of visit minus date of birth (integer value). - <u>in months:</u> calculated as age in days divided by 30.4375 (float value). Decimals should always be provided for more accurate calculation of z-scores. **Notes:** - Invalid date of birth or date of visit or a negative value resulting from date of visit minus (-) date of birth entails a missing age. - If Date of birth and Date of visit are provided, the mapping of the variable Age will not be available to the user. - For all cases where age is missing, only results for weight-for-height will be computed and children will be accounted for the total sample size (0 to 5 years), but not classified in the age groups.
Sex	Compulsory	Numeric or text. For male (1/"M"/"m") and for female (2/"F"/"f") If missing, z-scores will not be calculated for any index because the WHO Child Growth Standards are sex-specific.
Weight	Optional	Numeric, float value (in kilograms). Limited between 0.9-58.0kg. It is recommended that weight is provided with at least one decimal.

		If missing, estimates for weight-related indices will not be calculated.
Length or height	Optional	Numeric, float value (in centimetres). Limited between 38.0-150.0cm. It is recommended that length or height measurements are provided with at least one decimal. If missing, estimates for length- or height-related indices will not be calculated.
LH measure (Standing or Recumbent position for height or length measurement)	Optional	Character. Recumbent length ("L" or "l") or standing height ("H" or "h"). It is recommended that recumbent length is used for children aged less than 731 days and standing height for those aged 731 or more days. Depending on information provided about the measurement position, the tool automatically adjusts the length/height of each child when calculating z-scores by adding 0.7cm if standing height is measured for children aged < 24 months and subtracting 0.7cm if recumbent (lying) length is measured for children aged ≥24 months. If this information is missing, the tool applies the values of "L" or "H" according to this recommendation above. If this information is missing and the child's age also missing, the code will assume that the measurement was recumbent length if the length/height value is below 87 cm (mean value from the Multicentre Growth Reference Study sample[7]in boys and girls, for height-for-age and length-for-age at 24 months) and otherwise assume that the measurement was standing height. For children under 9 months of age, data which suggests that the infant was "standing" rather than the expected "lying" should be disregarded in the analysis, i.e. set to missing, since this is deemed to be an error. This is done to avoid the wrong automatic adjustment in such cases (adding 0.7 cm), which would result in an overestimation of wasting and underestimation of stunting.
Oedema	Optional	Character. For no oedema ("N", "n", or "2") and for oedema cases ("Y", "y", or "1"). Oedema measurement is only appropriate in surveys where local experts, specifically clinicians or individuals from the Ministry of

[7] World Health Organization. WHO Anthro (version 3.2.2, January 2011). Available at http://www.who.int/childgrowth/software (Accessed 07 December 2017).

		Health working at a local level, can clearly indicate if they have seen recent cases where nutritional oedema was present.[4] If information on oedema is collected following the above recommendation: - children with oedema are automatically be classified with "severe acute malnutrition" (<-3SD for weight-related indexes) to calculate prevalence estimates; - cases with missing values are treated as no oedema; - weight-related indices z-scores will not be calculated for children with oedema (i.e. set to missing); - the summary report includes the number of children with bilateral oedema. - the number of cases of oedema should be included in the survey report. Note: It is recommended as best practice to report prevalence levels based on analyses both including and excluding oedema-related data.
Sampling weight	Optional	Numeric float A sampling weight must be assigned to everyone in the sample to compensate for unequal probabilities of case selection in a sample, usually owing to the design. All individuals not assigned a sampling weight should be excluded from analyses for generating malnutrition estimates but remain in the data set for reporting purposes. If sampling weights are not provided, the sample will be assumed to be self-weighted, i.e. the sampling weight equals one (unweighted analyses will be carried out). - All individuals not assigned a sampling weight are excluded from analyses for generating malnutrition estimates but remain in the data set for reporting purposes.
Team	Optional	Numeric integer Whenever provided, this variable is used for performing data quality assessment stratified to help interpretation.
Strata and Cluster (Primary Sampling Unit – PSU)	Optional	Numeric integer Each child/household should be assigned to a strata and cluster; these design-related variables are considered by the analyses to boost the stability of estimated variance. If not provided, it will be assumed that all children belong to the same unique strata/cluster.

		- All children with missing cluster data will be excluded from the analysis sample. **Notes:** - The calculation of prevalence estimates requires cluster labels to be nested within each stratum; i.e. cluster labels are unique for each stratum (usually sequentially). In instances of non-nested clusters, the tool will require the user to confirm that this was done on purpose and prevalence estimates will be calculated regardless.
Residence type	Optional	Numeric integer or character. Recommended values: “Rural” or “Urban” Any values are accepted. The recommended labels however are preferable for output interpretation.
Geographical region	Optional	Numeric integer or character
Wealth quintiles	Optional	Ordinal numeric integer or character. Accepted values are 1, 2, 3, 4, 5; or Q1, Q2, Q3, Q4, Q5; whereby 1=poorest and 5=richest, in ascending order.
Mother’s education	Optional	Numeric integer or character. Recommended values: “None”, “Primary” and “Secondary” - Any number of categories or values are accepted for the analysis, provided sample sizes are sufficiently large in all categories. However, the common, standard recommended categories are no education, primary school, and secondary school or higher (“None”, “Primary” and “Secondary”). **Note:** Mother’s education refers to the highest level of schooling attained by the mother.
Other grouping variable	Optional	Numeric or character Any variable that is of interest for obtaining results from stratified analysis.
Filter variable(s)	Optional	Numeric or character Binary variables (0/1 or Yes /No) are preferable to facilitate the selection of included records by the applied filter.
*Missing data recoding		Blank/empty cell In case of missing value codes such as 9999, 9998, etc., missing values should be recoded by creating a new variable. The original variables should always be retained since their presence in the file guarantees data reproducibility and transparency.

2. Uploading the file

1. Enter the following URL in the browser of your preference (e.g. Google Chrome, Mozilla Firefox).

   https://whonutrition.shinyapps.io/anthro

   The website displayed should be as shown in Figure 2. Accepting the terms stated in the disclaimer is required to use the tool.

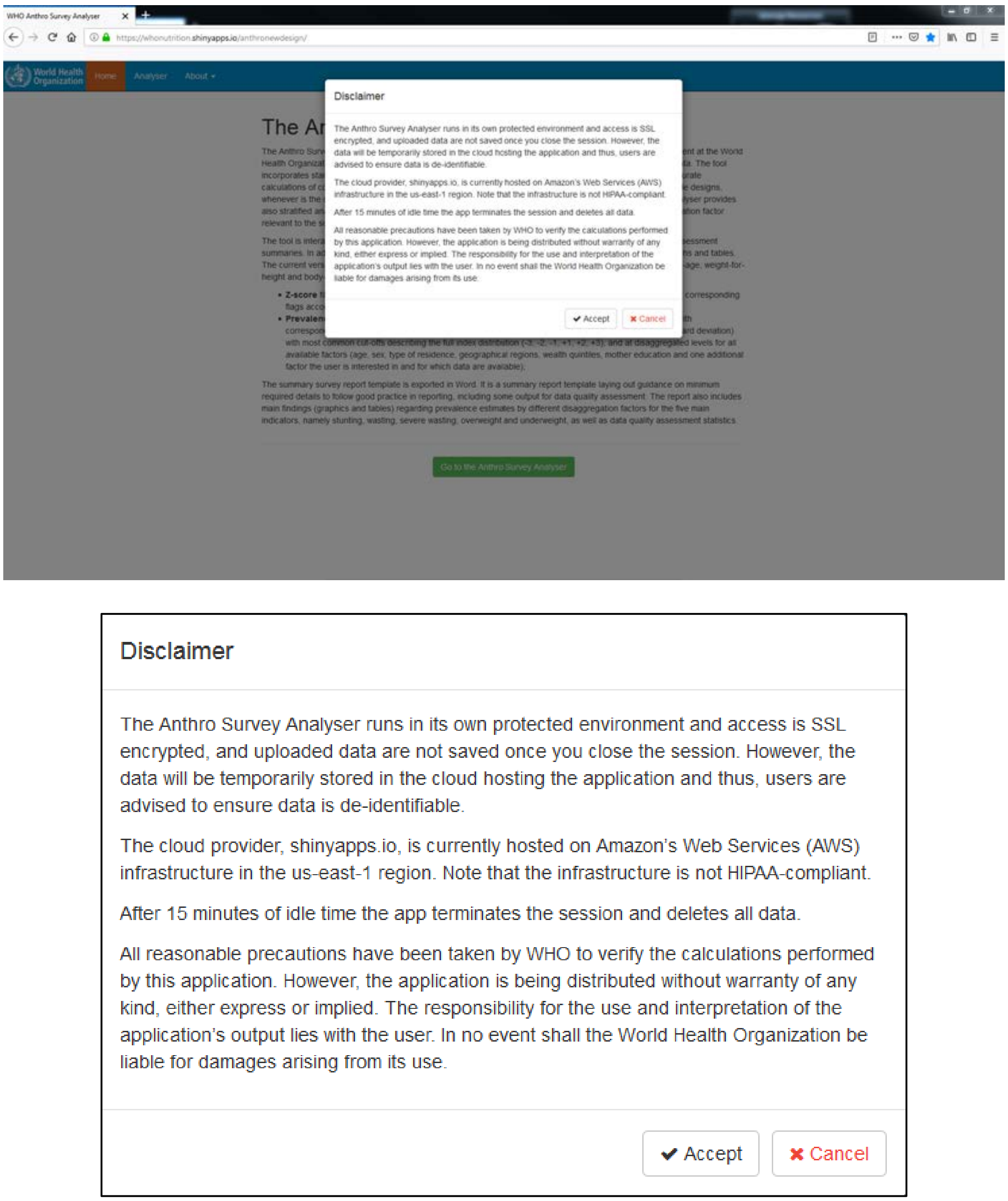


Figure 2. Disclaimer.

2. Once "Upload data" is activated, click on "Browse" and select the file that contains the dataset to be analysed. Refer to Figure 3. Keep in mind that the uploaded files are required to be in a csv format.

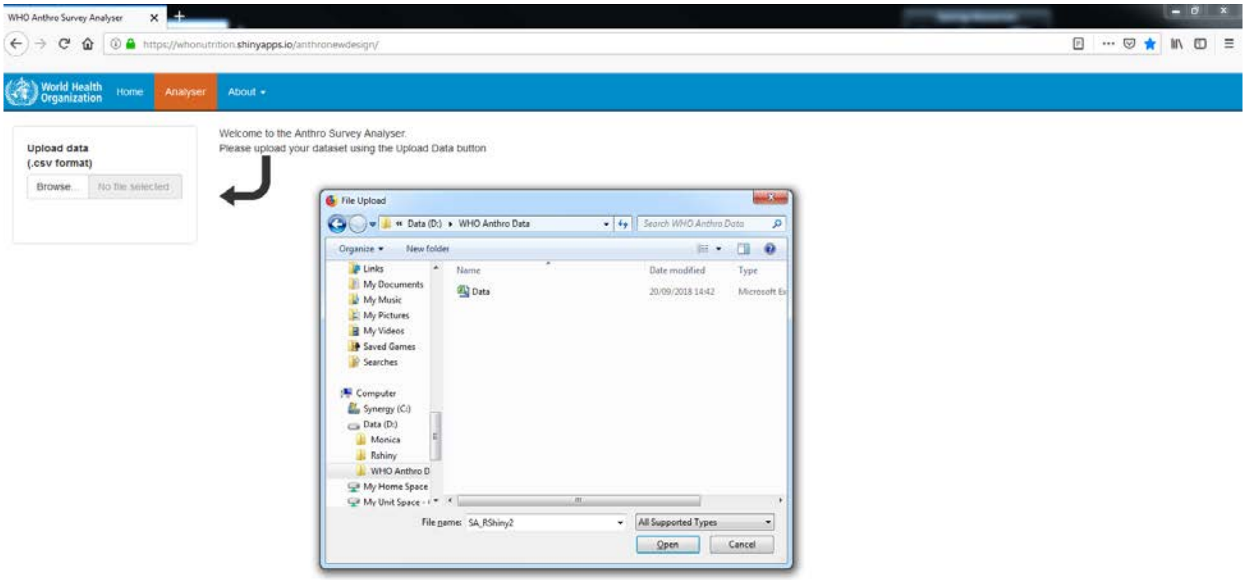


Figure 3. Analysis dataset file upload.

3. Variable mapping

Variable mapping requires the user to manually select the variables from the dataset that corresponds to the variables used for analysis. As a part of the data validation, only the formats specified in Table 1 is possible for each variable selection, as seen in Figure 4.

The tool can recognise the correct format for each variable. In the instance that no variable-specific format is found in any of the available variables in the dataset, a pop-up message as shown in Figure 5 will be seen.

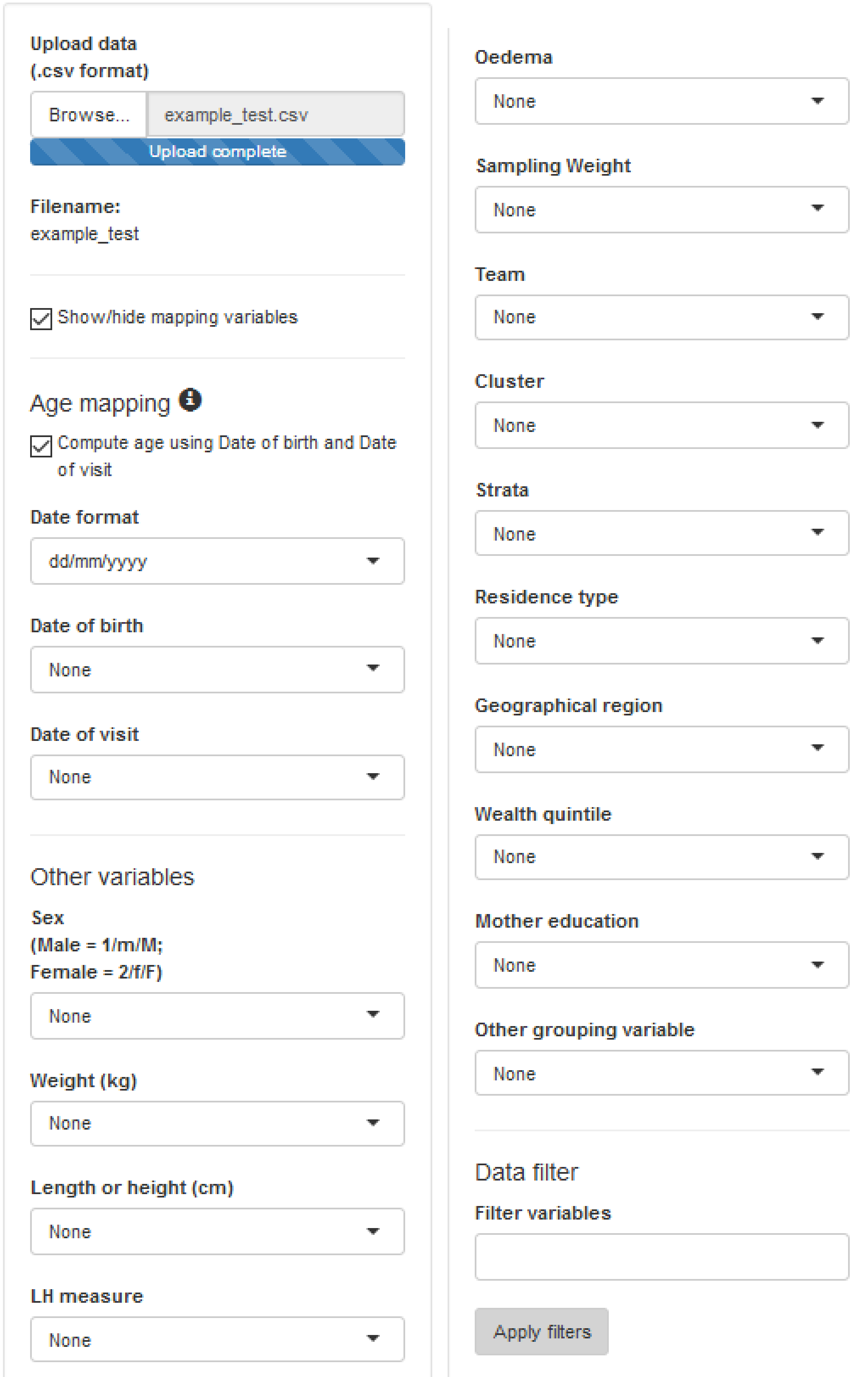


Figure 4. Variable mapping.

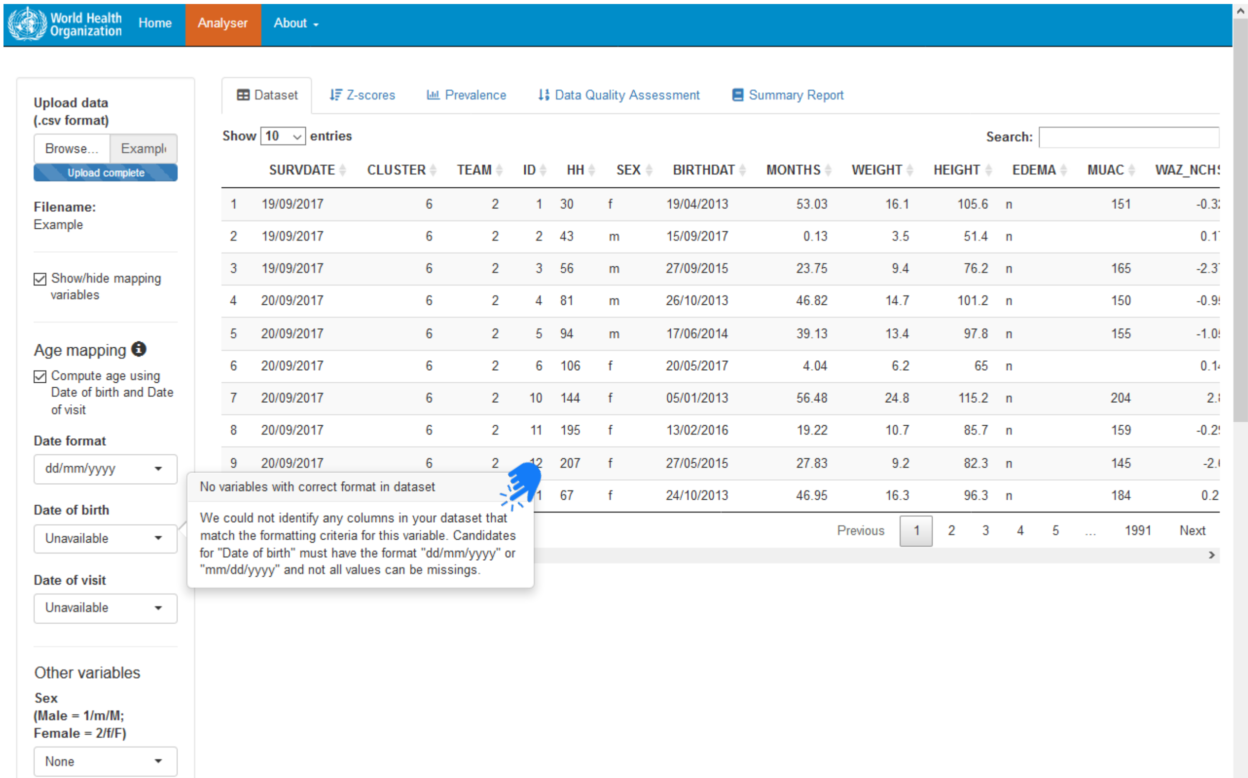


Figure 5. Variable mapping pop-up message when no variable available in the dataset matches the required format.

Age mapping

Age calculation based on date of birth and date of visit variables is the **default and recommended approach**. In this instance, the checkbox “Compute age using Date of birth and Date of visit” is checked. Users may also select the date format to be either DD-MM-YYYY or MM-DD-YYYY using the dropdown, DD-MM-YYYY being the default. Refer to Figure 6 for these features.

If for any reason this is not the approach desired to calculate age, the user must **uncheck** that box for the mapping of the “Age” field to become available (Figure 7). If the age variable is to be mapped, the user should indicate the unit for Age.

Note: if age is provided in months, its values should contain decimals for accurate calculation of the age-based indicators’ z-scores, such as stunting and underweight. Age in days is therefore preferable to age in months. The user also needs to check the checkbox for “Age unit in months” if the age variable is indeed mapped in months.

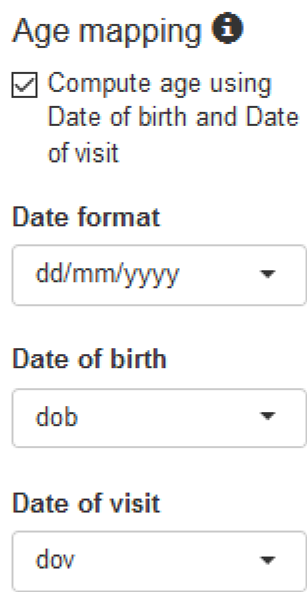


Figure 6. Default age mapping.

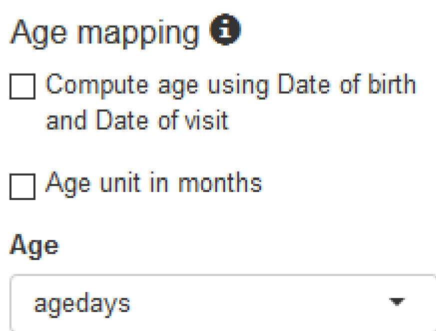


Figure 7. Age mapping when user selects existing age variable.

Dataset display

The complete uploaded spreadsheet, including unmapped variables, will appear under the “Dataset”tab. The final dataset is displayed on the right side of the mapping (based on the filter selection, if any).

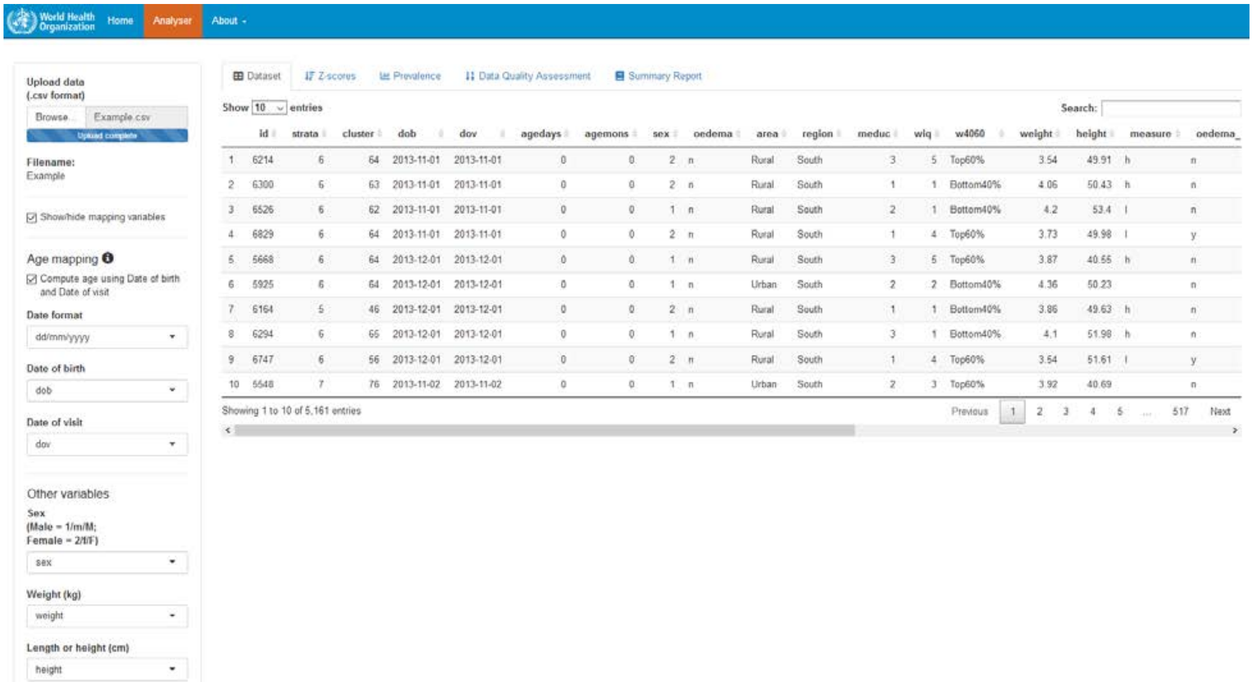


Figure 8. Dataset display

4. Z-score calculations

The “Z-scores” tab contains functionalities to calculate z-scores for each observation and subsequently download a csv file containing the original dataset as well as the calculated z-scores and z-score flags. Figure 9 shows the steps to follow. **Note:** Prevalence estimates will not be calculated before the z-scores are calculated.

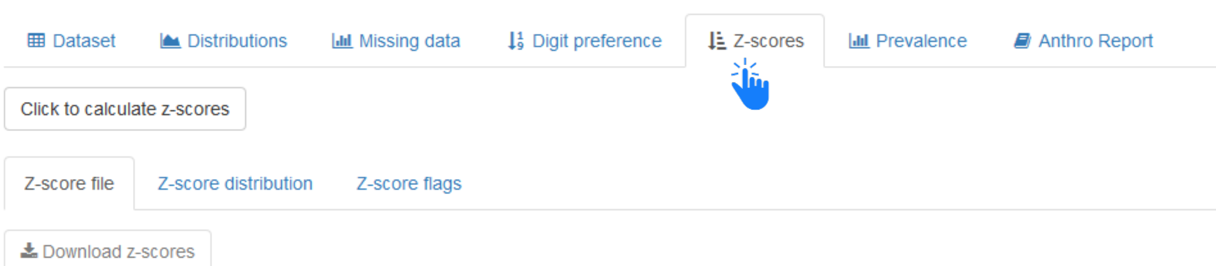
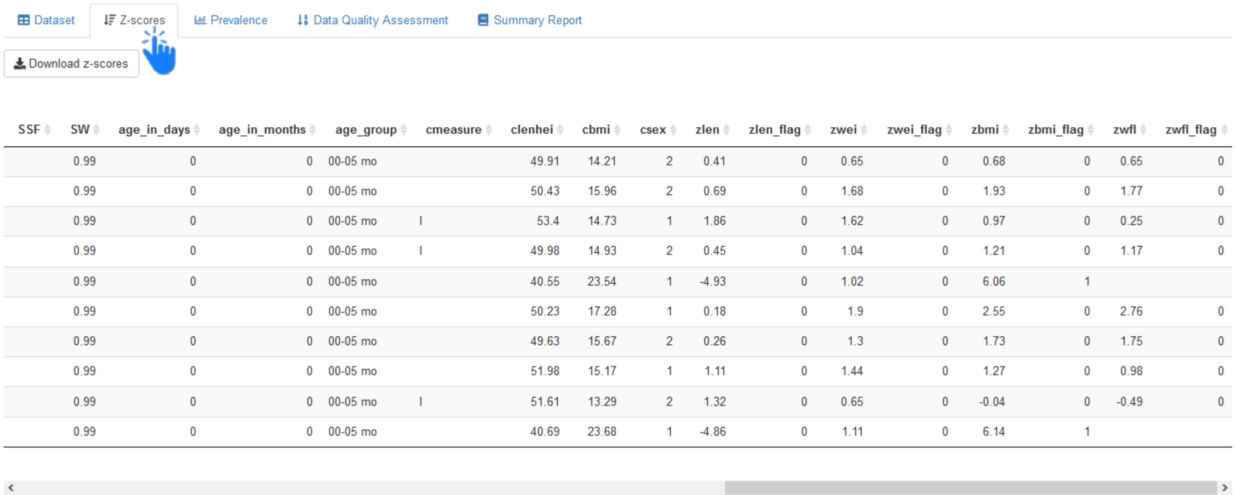


Figure 9. Z-score calculation and visualization features.

Z-scores are automatically calculated once you navigate to the “Z-scores” tab. You can then download a csv file containing the calculated z-scores by clicking on the “Download z-scores” button. The file will contain all rows in the original file uploaded (including the rows excluded by any filter applied), with a column indicating whether the child was selected for the final sample. Table 2 specifies the contents of the added columns.



SSF	SW	age_in_days	age_in_months	age_group	cmeasure	clenhei	cbmi	csex	zlen	zlen_flag	zwei	zwei_flag	zbmi	zbmi_flag	zwfl	zwfl_flag
	0.99	0	0	00-05 mo		49.91	14.21	2	0.41	0	0.65	0	0.68	0	0.65	0
	0.99	0	0	00-05 mo		50.43	15.96	2	0.69	0	1.68	0	1.93	0	1.77	0
	0.99	0	0	00-05 mo	l	53.4	14.73	1	1.86	0	1.62	0	0.97	0	0.25	0
	0.99	0	0	00-05 mo	l	49.98	14.93	2	0.45	0	1.04	0	1.21	0	1.17	0
	0.99	0	0	00-05 mo		40.55	23.54	1	-4.93	0	1.02	0	6.06	1		
	0.99	0	0	00-05 mo		50.23	17.28	1	0.18	0	1.9	0	2.55	0	2.76	0
	0.99	0	0	00-05 mo		49.63	15.67	2	0.26	0	1.3	0	1.73	0	1.75	0
	0.99	0	0	00-05 mo		51.98	15.17	1	1.11	0	1.44	0	1.27	0	0.98	0
	0.99	0	0	00-05 mo	l	51.61	13.29	2	1.32	0	0.65	0	-0.04	0	-0.49	0
	0.99	0	0	00-05 mo		40.69	23.68	1	-4.86	0	1.11	0	6.14	1		

Figure 10. Z-scores display.

Table 2. Calculated variables added to the z-score output.

Variable	**Description**
included	Indicates whether the child was included in the final sample ("TRUE"/"FALSE")
age_group	Age group
age_in_days	Age in days for deriving z-score
cmeasure#	Adjusted measurement position based on child age: set to missing for children < 9 months old with measure value equals to "h" or "H" (measured standing).
clenhei*	Converted length/height based on information whether the child was measure standing (h or H) or laying down (l or L)
cbmi	BMI value based on weight and clenhei
csex	Sex for deriving z-score
zlen	Length/height-for-age z-score
zlen_flag	Flag for zlen < -6 or zlen > 6
zwei	Weight-for-age z-score
zwei_flag	Flag for zwei < -6 or zwei > 5
zbmi	BMI-for-age z-score
zbmi_flag	Flag for zbmi < -5 or zbmi > 5
zwfl	Weight-for-length/ height z-score
zwfl_flag	Flag for zwfl < -5 or zwfl > 5

#Notes on 'cmeasure':

- It is recommended that recumbent length is used for children aged <731 days (<24 months) and standing height for those aged ≥731 days (24+ months). If data on the measurement position are missing, the tool automatically assumes the measure based on these recommendations.
- For children under 9 months of age, data which suggests that the infant was "standing" rather than the expected "lying" are disregarded in the analysis, i.e. set to missing, since this is deemed to be an error. This is done to avoid the wrong automatic adjustment in such cases (adding 0.7 cm), which would result in an overestimation of wasting and underestimation of stunting.

***Notes on 'clenhei':**

- For instances of mismatches, automatic adjustments are made by the tool when calculating z-scores, adding 0.7cm if the standing height was measured for children aged <24 months and subtracting 0.7cm if the recumbent (lying) length was measured for children aged 24+ months.

5. Calculation of prevalence estimates

The Anthro Survey Analyser calculates the prevalence estimates with the corresponding standard errors and confidence intervals in a format called the "**expanded format**". An expanded format includes z-score summary statistics, of mean and standard deviation, with cut-offs describing the full index distribution (at -3, -2, -1, +1, +2, +3) and at disaggregated levels for all available factors (such as age, sex, type of residence, survey team, geographical regions, wealth quintiles, mother education and one additional factor the user is interested in and for which data are available).

Each of the indexes, when associated with the specific recommended cut-offs, results in indicators. The most commonly used indicators in assessing child nutrition status for national surveys are shown in Table 3. Assessment based on mid-arm upper circumference assessment, even though used in many situations, is not included in this version of this application.

Table 3. Most common anthropometric indicators to assess child nutrition status in national nutrition surveys.

Indicators	Definitions
Stunting	Height-for-age < -2SD
Severe wasting	Weight for Height < -3 SD
Wasting	Weight for Height < -2 SD
Overweight	Weight for Height > +2 SD
Underweight	Weight-for-age < -2SD

Oedema

For each of the indicators, prevalence calculations are based on all valid z-scores. When information on oedema is provided, children with oedema are classified as having severe malnutrition. This means their z-scores for the indexes of weight-for-height, weight-for-age, and BMI-for-age are below the -3SD cut-off and are accounted for as such in the prevalence calculation. However, as their weights are invalid, their z-scores are set to missing; as a result, their z-scores are not accounted for in the calculations for mean z-score or z-score standard deviation for these indexes. Therefore, z-scores for all weight-related indices will be set to "missing" when oedema is present. The report includes the number of children with bilateral oedema.

All the calculations for the standard errors and confidence intervals are based on the approaches for complex sampling designs (R package 'survey'[8]).

[8] T. Lumley (2018) "survey: analysis of complex survey samples". R package version 3.35.

Calculating prevalence

Calculating the prevalence estimates must be done after the z-score calculations have been completed. To calculate the prevalence estimates, click on the tab “Prevalence” and then “Click to calculate prevalence estimates” (Figure 11).

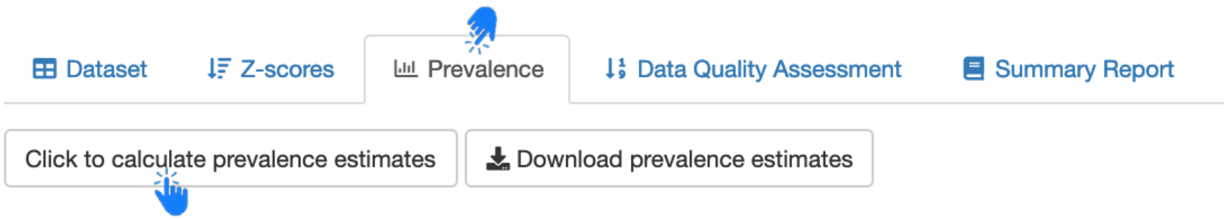
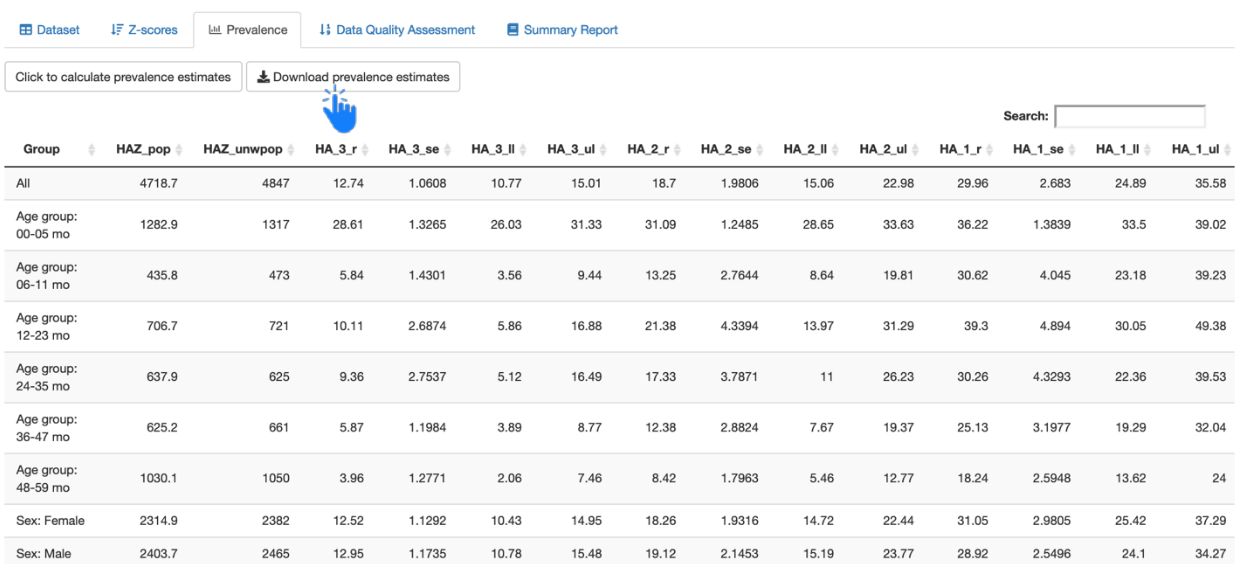


Figure 11. Functionality for calculating prevalence estimates.

Once prevalence estimates are calculated, the original dataset with the expanded output will appear in the window, as shown in Figure 12.



Group	HAZ_pop	HAZ_unwpop	HA_3_r	HA_3_se	HA_3_ll	HA_3_ul	HA_2_r	HA_2_se	HA_2_ll	HA_2_ul	HA_1_r	HA_1_se	HA_1_ll	HA_1_ul
All	4718.7	4847	12.74	1.0608	10.77	15.01	18.7	1.9806	15.06	22.98	29.96	2.683	24.89	35.58
Age group: 00-05 mo	1282.9	1317	28.61	1.3265	26.03	31.33	31.09	1.2485	28.65	33.63	36.22	1.3839	33.5	39.02
Age group: 06-11 mo	435.8	473	5.84	1.4301	3.56	9.44	13.25	2.7644	8.64	19.81	30.62	4.045	23.18	39.23
Age group: 12-23 mo	706.7	721	10.11	2.6874	5.86	16.88	21.38	4.3394	13.97	31.29	39.3	4.894	30.05	49.38
Age group: 24-35 mo	637.9	625	9.36	2.7537	5.12	16.49	17.33	3.7871	11	26.23	30.26	4.3293	22.36	39.53
Age group: 36-47 mo	625.2	661	5.87	1.1984	3.89	8.77	12.38	2.8824	7.67	19.37	25.13	3.1977	19.29	32.04
Age group: 48-59 mo	1030.1	1050	3.96	1.2771	2.06	7.46	8.42	1.7963	5.46	12.77	18.24	2.5948	13.62	24
Sex: Female	2314.9	2382	12.52	1.1292	10.43	14.95	18.26	1.9316	14.72	22.44	31.05	2.9805	25.42	37.29
Sex: Male	2403.7	2465	12.95	1.1735	10.78	15.48	19.12	2.1453	15.19	23.77	28.92	2.5496	24.1	34.27

Figure 12. Prevalence estimates and z-score summary statistics in the expanded format.

For stratification groups whereby all their proportions are missing, point estimates are calculated but their confidence intervals cannot be calculated and are therefore set to missing (NA).

You can also download a csv file which includes all of the prevalence estimates by clicking on”Download prevalence estimates”, as indicated in Figure 12. The downloaded file would also include accuracy measures for all indexes and cut-offs. Table 4 provides variable labels for the columns in the downloaded file.

Table 4. Labels for variables in the output file with prevalence estimates and other summary statistics.

Index		Cut-offs		Suffix	
HA	Height-for-age	*_3*	Prevalence corresponding to <-3SD	*_pop*	Weighted sample size
WA	Weight-for-age	*_2*	Prevalence corresponding to <-2SD	*_unwpop*	Unweighted sample size
BMI	Body-mass-index-for-age	*_1*	Prevalence corresponding to <-1SD	*_r*	Mean/prevalence
WH	Weight-for-height	*1*	Prevalence corresponding to >+1SD	*_ll*	95% confidence interval lower limit
HA_WH	Combined indicator based on height-for-age and weight-for-height (stunted & overweight)	*2*	Prevalence corresponding to >+2SD	*_ul*	95% confidence interval upper limit
		3	Prevalence corresponding to >+3SD	*_stdev*	Standard Deviation
				_se	Standard error
Examples:					
WHZ_pop		weight-for-height weighted sample size			
HA_r		height-for-age z-score mean			
WA_stdev		weight-for-age z-score standard deviation			
WH2_r		prevalence of weight-for-height >+2 SD (overweight)			
WH_r		Mean weight-for-height z-score			
BMI_2_se		Prevalence of BMI-for-age <-2 SD standard error			
BMI_3_ll		Prevalence of BMI-for-age <-3 SD 95% confidence interval, lower limit			
HA_2_WH_2_ul		Prevalence of children Height-for-age and weight-for-height combined (stunted & wasted) lower 95% confidence interval limit			

6. Data quality assessment

The Data Quality Assessment tab provides several visualisation tools for data quality assessment based on the existing guidelines for best practice reporting.

Frequency distributions

The tool provides frequency distributions of the input variables age group, weight, and height, which can be found by clicking the “Distributions” tab. The option to visualize the distribution by different stratifications is offered for the group variables mapped. For example, it might be useful to look at the age distribution by sex, or by any other of the stratification factors, to look at potential sampling patterns that indicate biases.

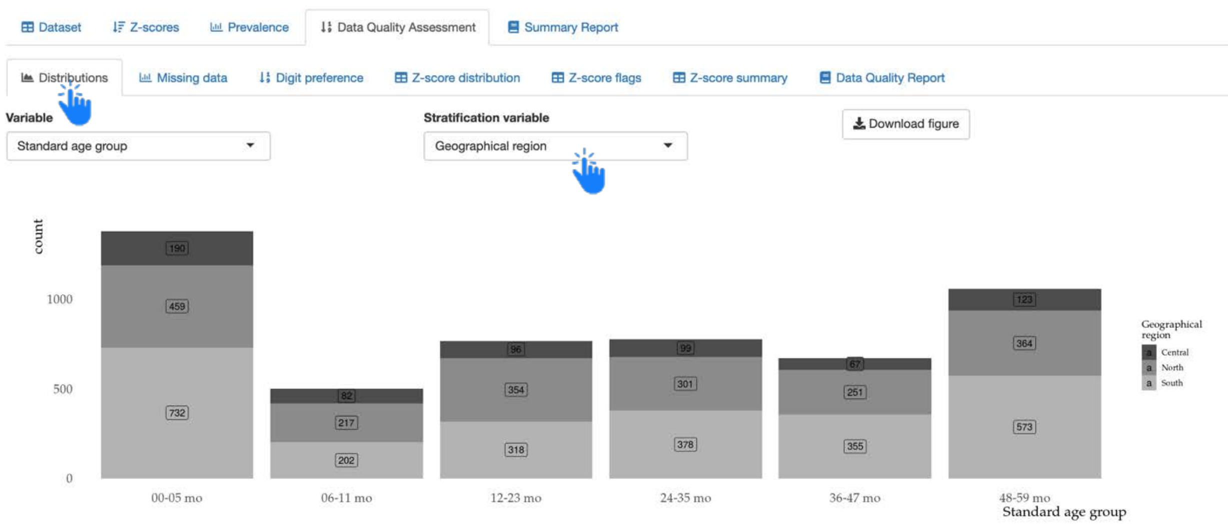


Figure 13. Frequency distribution by age and geographical region.

Missing data

Under the “Missing data” tab, the proportion of missing data is visualised for each of the mapped variables. Further stratification of the missing data will give an output in table form. Refer to Figure 14 and Figure 15 for examples.

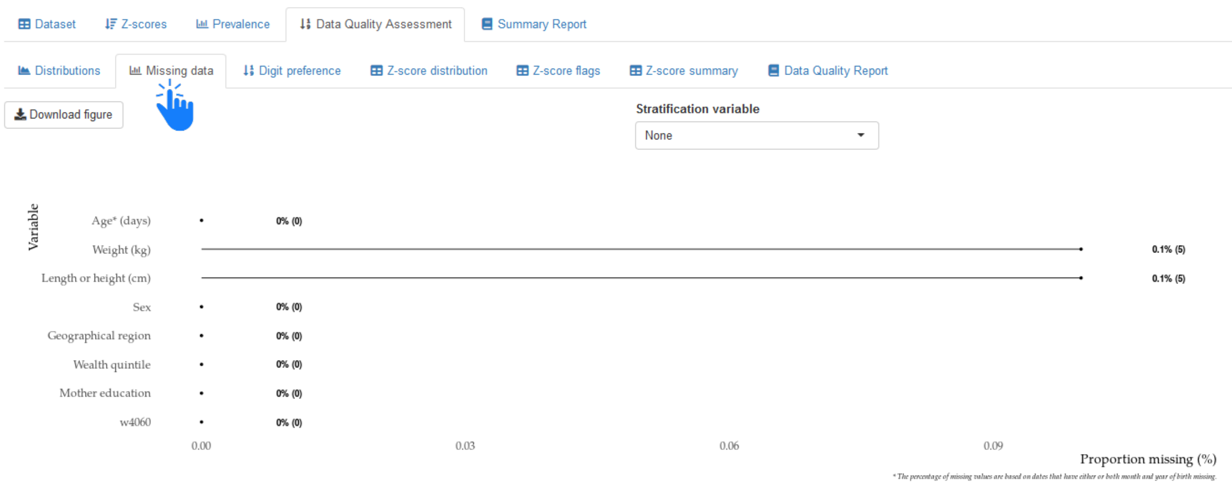
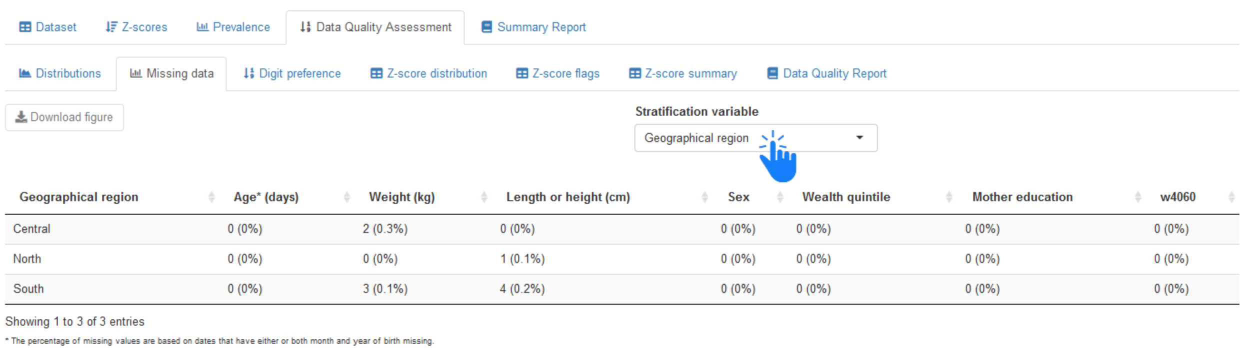


Figure 14. Missing data for data quality assessment.



Geographical region	Age* (days)	Weight (kg)	Length or height (cm)	Sex	Wealth quintile	Mother education	w4060
Central	0 (0%)	2 (0.3%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
North	0 (0%)	0 (0%)	1 (0.1%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
South	0 (0%)	3 (0.1%)	4 (0.2%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)

Showing 1 to 3 of 3 entries

* The percentage of missing values are based on dates that have either or both month and year of birth missing.

Figure 15. Missing data stratified by geographical region.

Digit preference

The tab "Digit preference" provides visualisations for decimals' digit preference for weight(kg) and length or height (cm) at one-decimal precision (Figure 16). This can be stratified on the variables Team or Geographical region for further analysis, as seen in Figure 17.

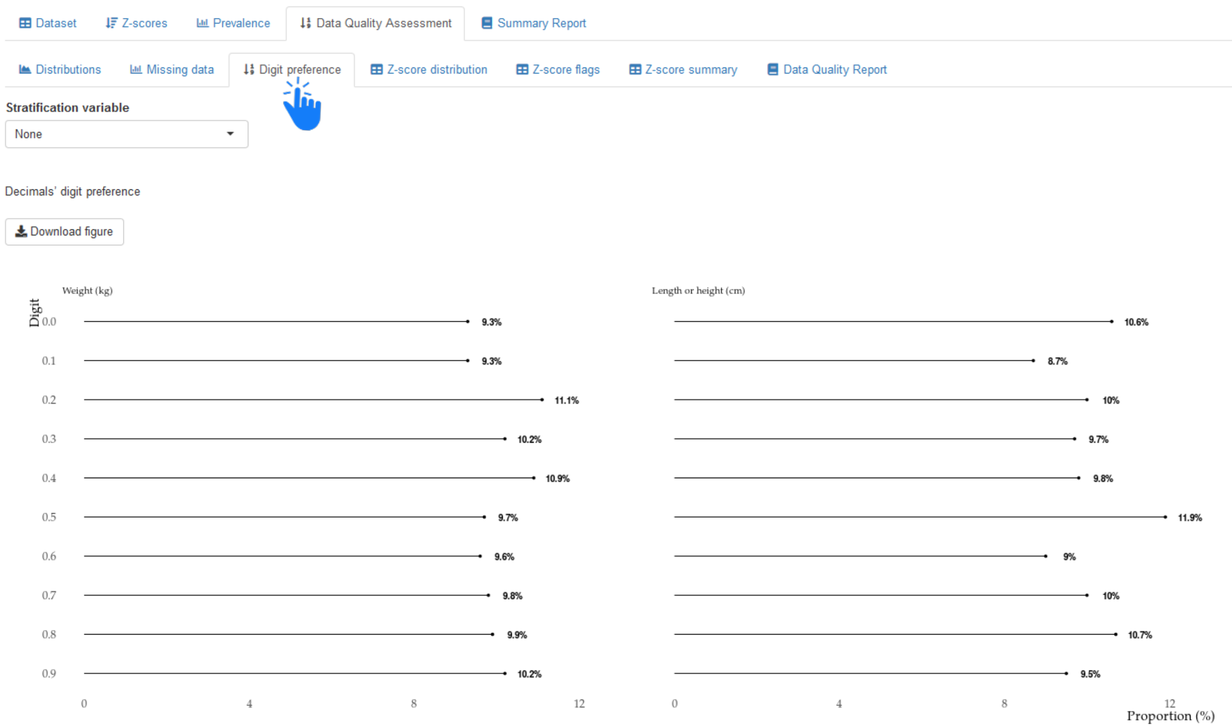


Figure 16. Digit preference visualisation at one-decimal precision.

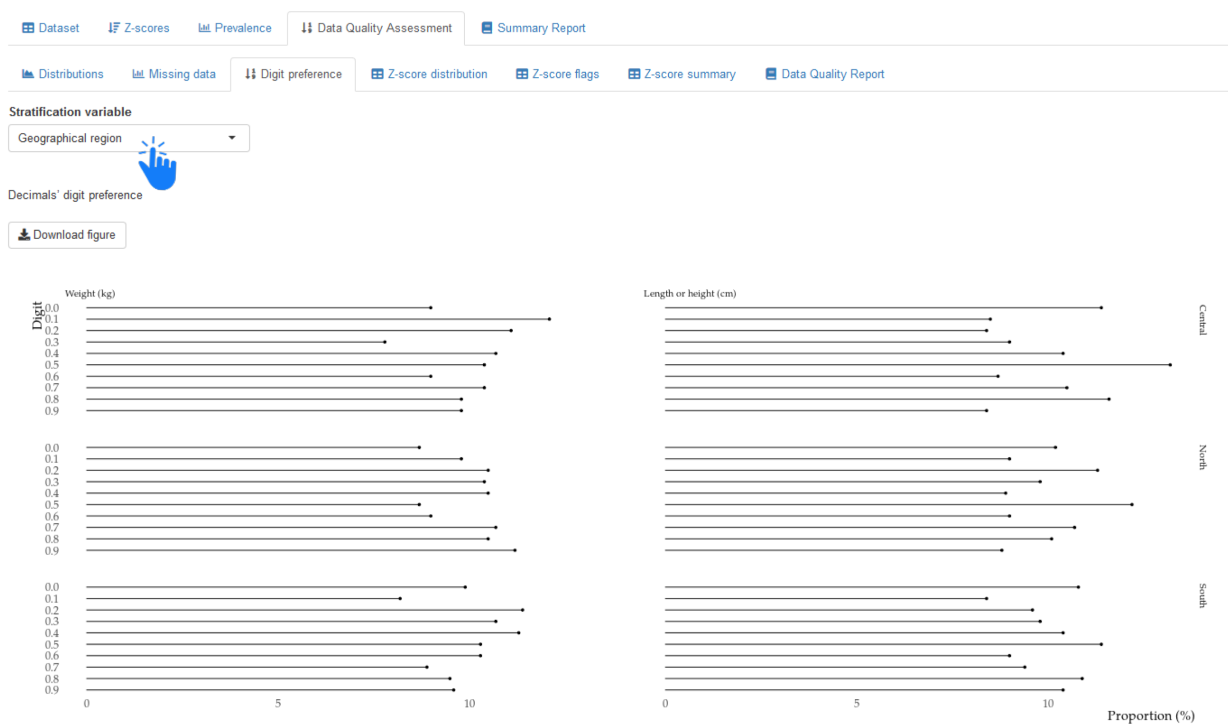


Figure 17. Decimals' digit preference visualisation stratified by Geographical region.

Visualisation for integer digit preference is also given in the form of a histogram for overall weight (kg) and length or height (cm) (Figure 18).

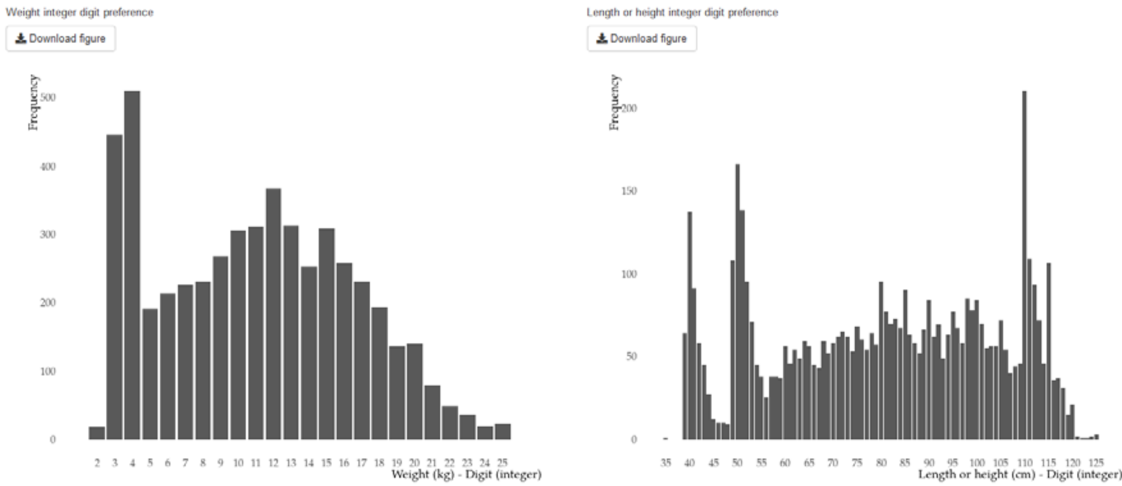


Figure 18. Integer digit preference visualisation.

Z-score distributions

Smoothed emprical density distributions are displayed for each of the anthropometric indexes, as well as by any of the stratification factors. The standard normal density distribution curve is also overlaid as a dashed-and-dotted line to provide a visual reference (refer to Figure 19).

Figure 19. Z-score distribution by mother's education.

Z-score flags

The recommended flags for z-score values follows the WHO flagging system[9] and is provided in Table 5 below.

Table 5. WHO flagging system.

Indexes	Lower SD	Upper SD
Weight-for-age	<-6	>+5
Length/height-for-age	<-6	>+6
Weight-for-length/height	<-5	>+5
Body mass index-for-age	<-5	>+5

A graphical display of the proportions of flagged z-scores for each of the indices, based on the WHO flagging system, is given under the tab "Z-score flags" (Figure 20).

Figure 20. Z-score flags for each index.

Z-score summary

A z-score summary table is also provided for comparison of z-scores between the stratified groups; you may also download the table by clicking on the "Download Z-score summary" button, as displayed in Figure 21.

---

[9] Source: WHO Anthro 2005. WHO Anthro for Personal Computers Manual. Software for assessing growth and development of the world's children. Geneva: WHO, 2006 (http://www.who.int/childgrowth/software/WHOAnthro2005_PC_Manual.pdf).

Group	Unweighted N	Mean (zlen)	Standard deviation (zlen)	Skewness (zlen)	Kurtosis (zlen)	Mean (zwei)	Standard deviation (zwei)	Skewness (zwei)	Kurtosis (zwei)	Mean (zbmi)	Standard deviation (zbmi)	Skewness (zbmi)	Kurtosis (zbmi)	Mean (zwfl)
All	5161	-0.28	2.13	-0.42	3.23	0.37	1.48	-0.54	4.40	0.47	1.69	-0.15	3.40	0.35
Age group: 00-05 mo	1381	-1.06	2.44	-0.56	2.05	0.78	1.26	-0.63	4.30	1.14	1.64	0.04	3.18	0.81
Age group: 06-11 mo	501	-0.23	1.80	-0.07	4.08	0.34	1.51	-0.29	3.68	0.55	1.52	-0.49	3.57	0.68
Age group: 12-23 mo	768	-0.57	1.79	0.03	3.65	0.32	1.56	-0.15	3.21	0.51	1.47	-0.49	4.12	0.55
Age group: 24-35 mo	778	-0.11	2.11	0.28	3.19	-0.10	1.84	-0.79	4.47	0.36	1.85	-0.01	3.01	0.09
Age group: 36-47 mo	673	0.26	2.07	0.05	2.87	0.23	1.38	-0.05	3.90	0.02	1.65	-0.23	3.30	0.04
Age group: 48-59 mo	1060	0.44	1.69	-0.59	3.64	0.29	1.35	-0.21	3.93	0.04	1.64	-0.16	3.34	-0.02
Sex: Male	2639	-0.26	2.14	-0.48	3.23	0.38	1.54	-0.51	4.34	0.42	1.73	-0.17	3.27	0.33
Sex: Female	2522	-0.29	2.11	-0.36	3.25	0.36	1.43	-0.56	4.43	0.52	1.63	-0.11	3.53	0.38
Team: 1	1132	-0.84	2.41	-0.64	2.27	0.67	1.31	-0.63	4.48	0.89	1.69	-0.07	3.35	0.59
Team: 2	2309	-0.31	1.97	0.13	3.46	0.14	1.62	-0.44	4.16	0.39	1.61	-0.23	3.58	0.32
Team: 3	1720	0.14	2.02	-0.64	3.62	0.48	1.36	-0.41	4.35	0.33	1.74	-0.12	3.18	0.26
Area: Rural	4171	-0.24	2.12	-0.41	3.24	0.37	1.48	-0.55	4.53	0.46	1.68	-0.17	3.42	0.35

Figure 21. Z-score summary table.

Data Quality Assessment Report

The Data Quality Assessment Report is a word document compiling main summary statistics and visualisations previously mentioned under the Data Quality Assessment tab of the tool. To download this, click on “Generate & download data quality report” under the “Data Quality Assessment” > “Data Quality Report” tabs, as shown in Figure 22. It might take several minutes for the report to be generated for downloading.

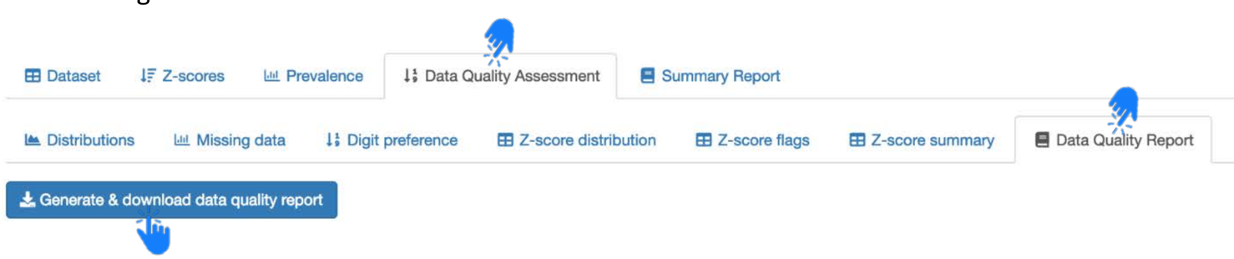


Figure 22. Generating the data quality assessment report for a survey dataset.

An example of the Data Quality Assessment report follows in Appendix A.

SUMMARY REPORT

This function allows the user to export a summary report template in Word, laying out guidance on the requirements needed to follow good practice in reporting. The sections on details of survey design, measure instruments, description of the sample, and other information are to be completed by the user. This is important to enhance transparency and survey design, coverage, and data quality evaluation.

The report also includes main findings (graphics and tables) regarding prevalence estimates by different disaggregation factors for the five main indicators, namely: stunting, wasting, severe wasting, overweight, and underweight. It also includes main data quality assessment statistics, as proportion of missing age, weight, or height, digit preference for length and weight, proportion of flagged z-scores, and z-score distributions by the various stratification factors available.

Click on the "Generate & download report" button located in the "Anthro Report" tab. It might take several minutes for the report to be prepared for downloading. Refer to Figure 23.

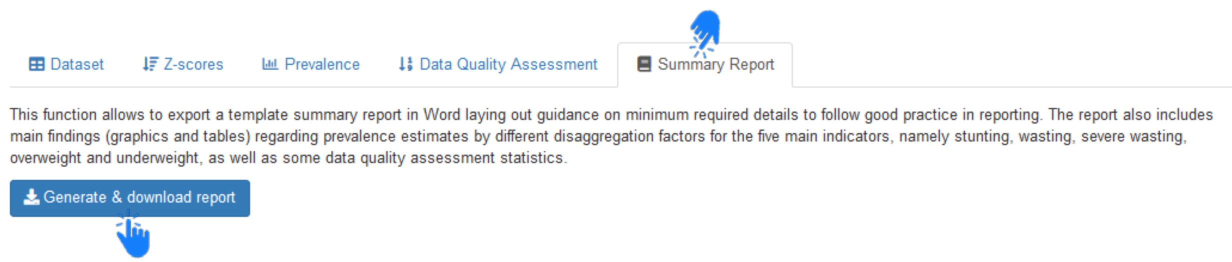


Figure 23. Generating the summary report template for a survey dataset.

An example of the summary report template follows in Appendix B.

APPENDIX A: EXAMPLE OF DATA QUALITY ASSESSMENT REPORT

DATA QUALITY REPORT

ADD SURVEY DETAILS - field work period, context Information, Information on training, limitations on access to selected households, etc.

AUTHOR

Table of Contents

Recommended citation:

Data quality assessment report template with results from WHO Anthro Survey Analyser

Analysis date: 2019-03-14 16:40:14

Link: https://whonutrition.shinyapps.io/anthro/

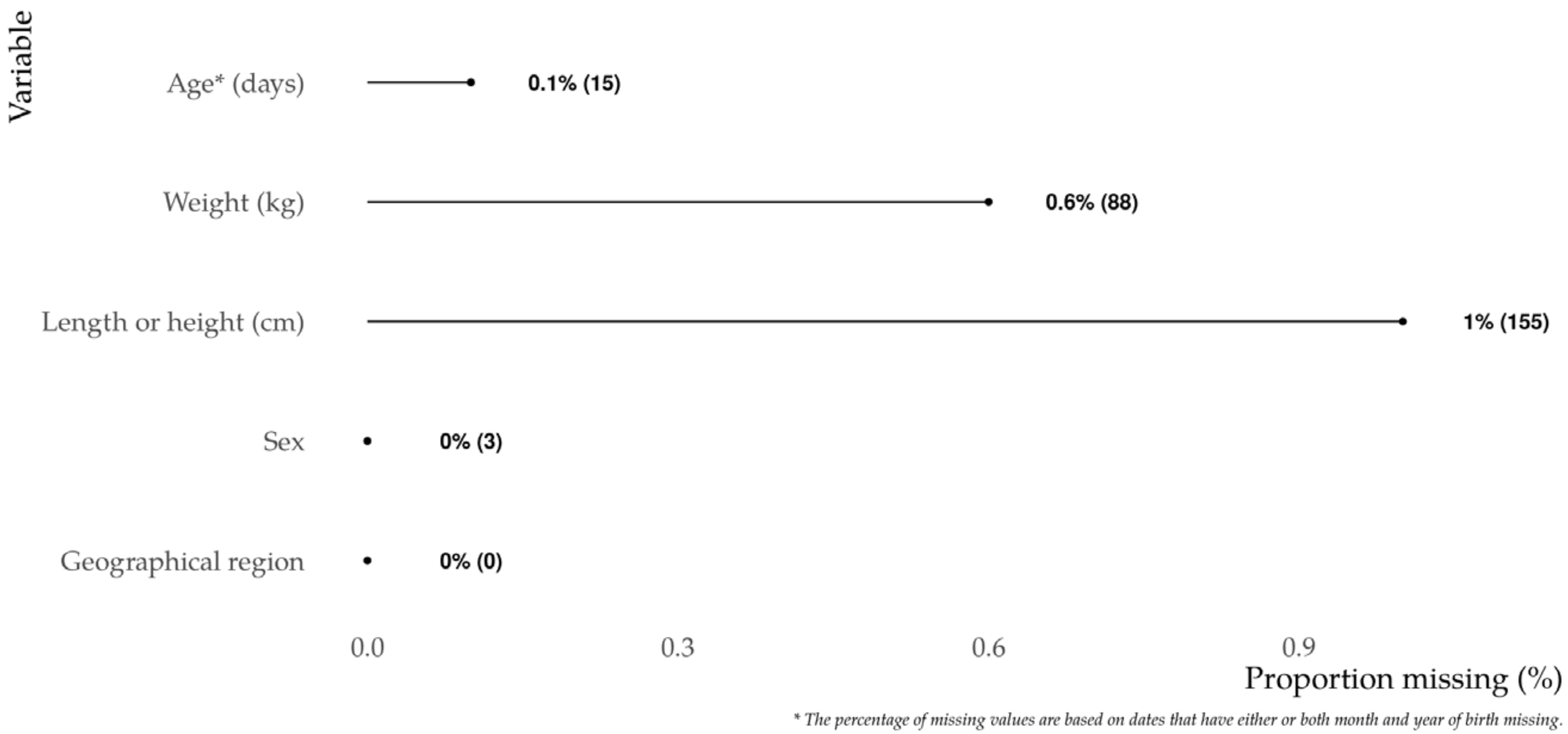
This report is a template that includes key data quality checks that can help to identify issues with the data and considerations when interpreting results. Other outputs that can be relevant to your analyses can be saved directly from the tool interactive dashboards and added to the report.

For guidance on how to interpret the results, user should refer to the document "Recommendations for improving the quality of anthropometric data and its analysis and reporting" by the Working Group on Anthropometric Data Quality, for the WHO-UNICEF Technical Expert Advisory Group on Nutrition Monitoring (TEAM). The document is available at www.who.int/nutrition/team, under "Technical reports and papers".

Missing data

Percentage (number of cases) of children missing information on variables used in the analysis

Total number of children: 15735.



Missing data by Geographical Region

Geographical region	N	Age* (days)	Weight (kg)	Length or height (cm)	Sex
1	812	4 (0.5%)	5 (0.6%)	5 (0.6%)	3 (0.4%)
2	918	4 (0.4%)	25 (2.7%)	34 (3.7%)	0 (0%)
3	946	1 (0.1%)	8 (0.8%)	16 (1.7%)	0 (0%)
4	950	0 (0%)	3 (0.3%)	5 (0.5%)	0 (0%)
5	974	0 (0%)	0 (0%)	0 (0%)	0 (0%)
6	933	0 (0%)	5 (0.5%)	5 (0.5%)	0 (0%)
7	1091	0 (0%)	0 (0%)	0 (0%)	0 (0%)
8	1296	2 (0.2%)	4 (0.3%)	14 (1.1%)	0 (0%)
9	983	1 (0.1%)	0 (0%)	1 (0.1%)	0 (0%)
10	1073	0 (0%)	0 (0%)	1 (0.1%)	0 (0%)
11	657	0 (0%)	3 (0.5%)	5 (0.8%)	0 (0%)
12	891	2 (0.2%)	8 (0.9%)	9 (1%)	0 (0%)
13	797	0 (0%)	14 (1.8%)	20 (2.5%)	0 (0%)
14	824	0 (0%)	7 (0.8%)	19 (2.3%)	0 (0%)
15	997	1 (0.1%)	1 (0.1%)	13 (1.3%)	0 (0%)
16	1083	0 (0%)	0 (0%)	0 (0%)	0 (0%)
17	510	0 (0%)	5 (1%)	8 (1.6%)	0 (0%)

The percentage of missing values for age are based on dates that have either or both month and year of birth missing.

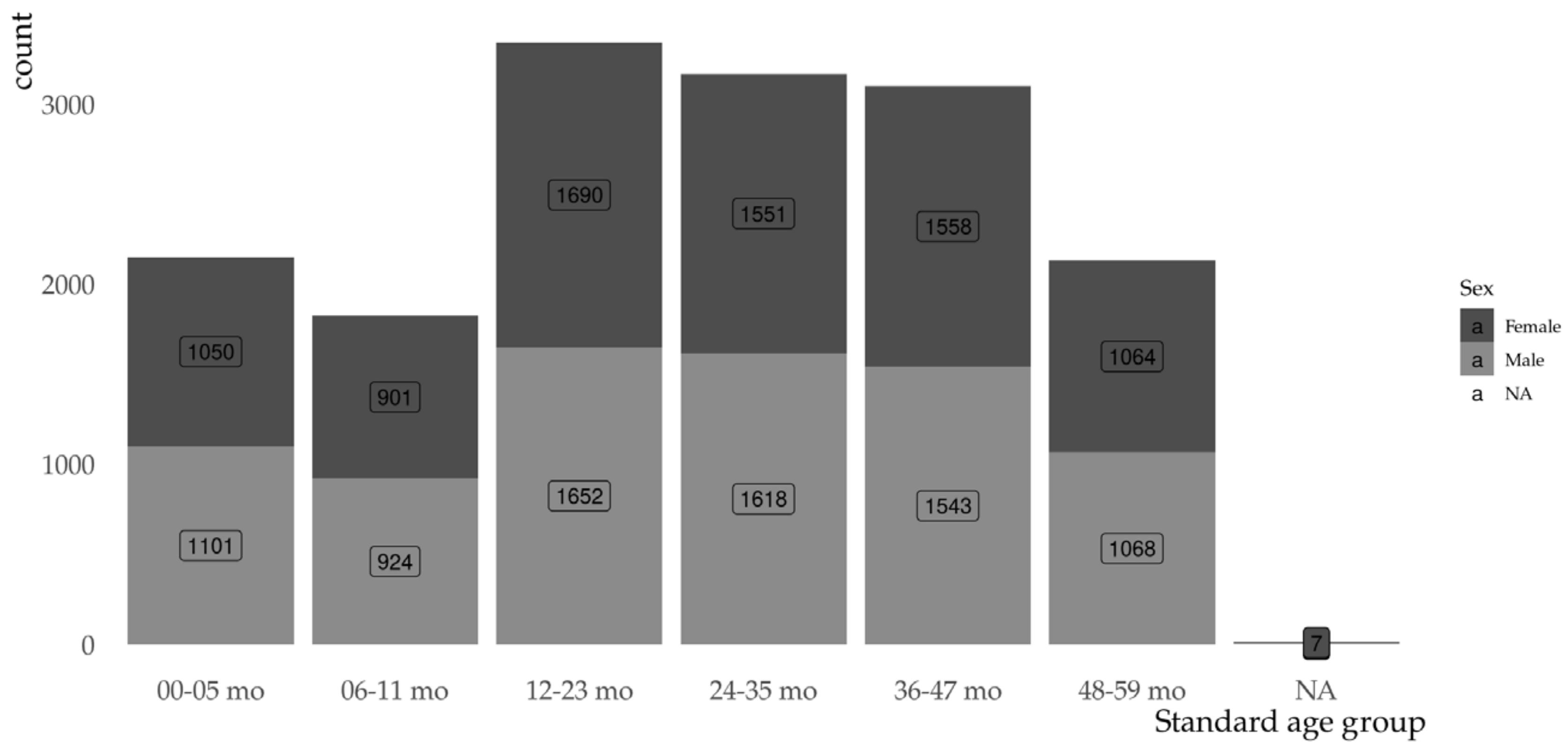
Missing data by Team

Team	N	Age* (days)	Weight (kg)	Length or height (cm)	Sex	Geographical region
1	1059	4 (0.4%)	5 (0.5%)	5 (0.5%)	3 (0.3%)	0 (0%)
2	919	0 (0%)	0 (0%)	1 (0.1%)	0 (0%)	0 (0%)
3	1060	0 (0%)	3 (0.3%)	16 (1.5%)	0 (0%)	0 (0%)
4	887	1 (0.1%)	9 (1%)	20 (2.3%)	0 (0%)	0 (0%)
5	1016	2 (0.2%)	1 (0.1%)	8 (0.8%)	0 (0%)	0 (0%)
6	1052	0 (0%)	8 (0.8%)	15 (1.4%)	0 (0%)	0 (0%)
7	1181	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
8	1075	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
9	943	2 (0.2%)	8 (0.8%)	12 (1.3%)	0 (0%)	0 (0%)
10	1009	0 (0%)	9 (0.9%)	9 (0.9%)	0 (0%)	0 (0%)
11	999	1 (0.1%)	8 (0.8%)	16 (1.6%)	0 (0%)	0 (0%)
12	706	1 (0.1%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
13	743	4 (0.5%)	7 (0.9%)	11 (1.5%)	0 (0%)	0 (0%)
14	840	0 (0%)	16 (1.9%)	22 (2.6%)	0 (0%)	0 (0%)
15	806	0 (0%)	5 (0.6%)	6 (0.7%)	0 (0%)	0 (0%)
16	774	0 (0%)	6 (0.8%)	10 (1.3%)	0 (0%)	0 (0%)
17	666	0 (0%)	3 (0.5%)	4 (0.6%)	0 (0%)	0 (0%)

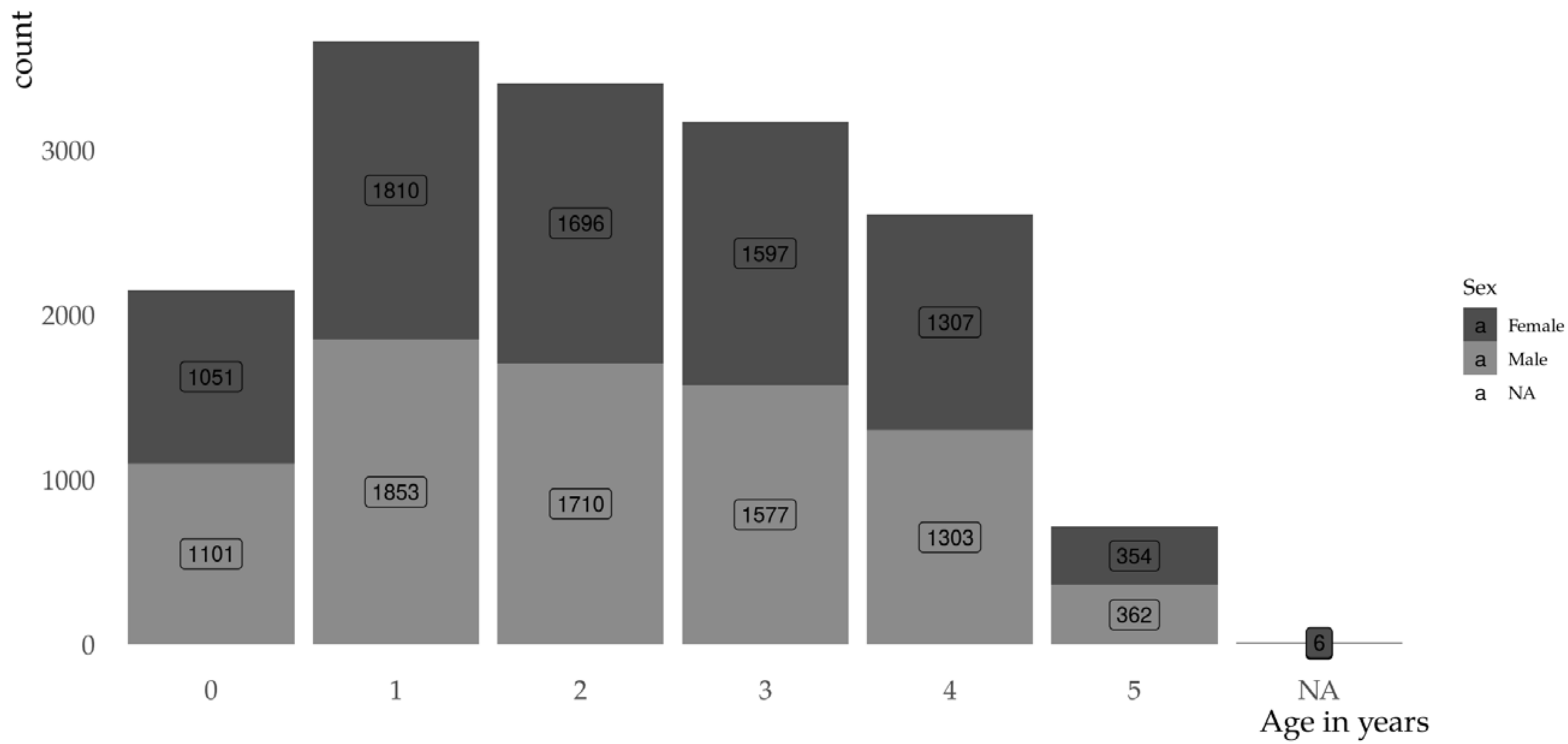
The percentage of missing values for age are based on dates that have either or both month and year of birth missing.

Data Distribution

Distribution by standard age grouping and sex



Distribution by age in years and sex



Number of cases and proportions of mismatches between length/height measurement position and recommended position, by age group.

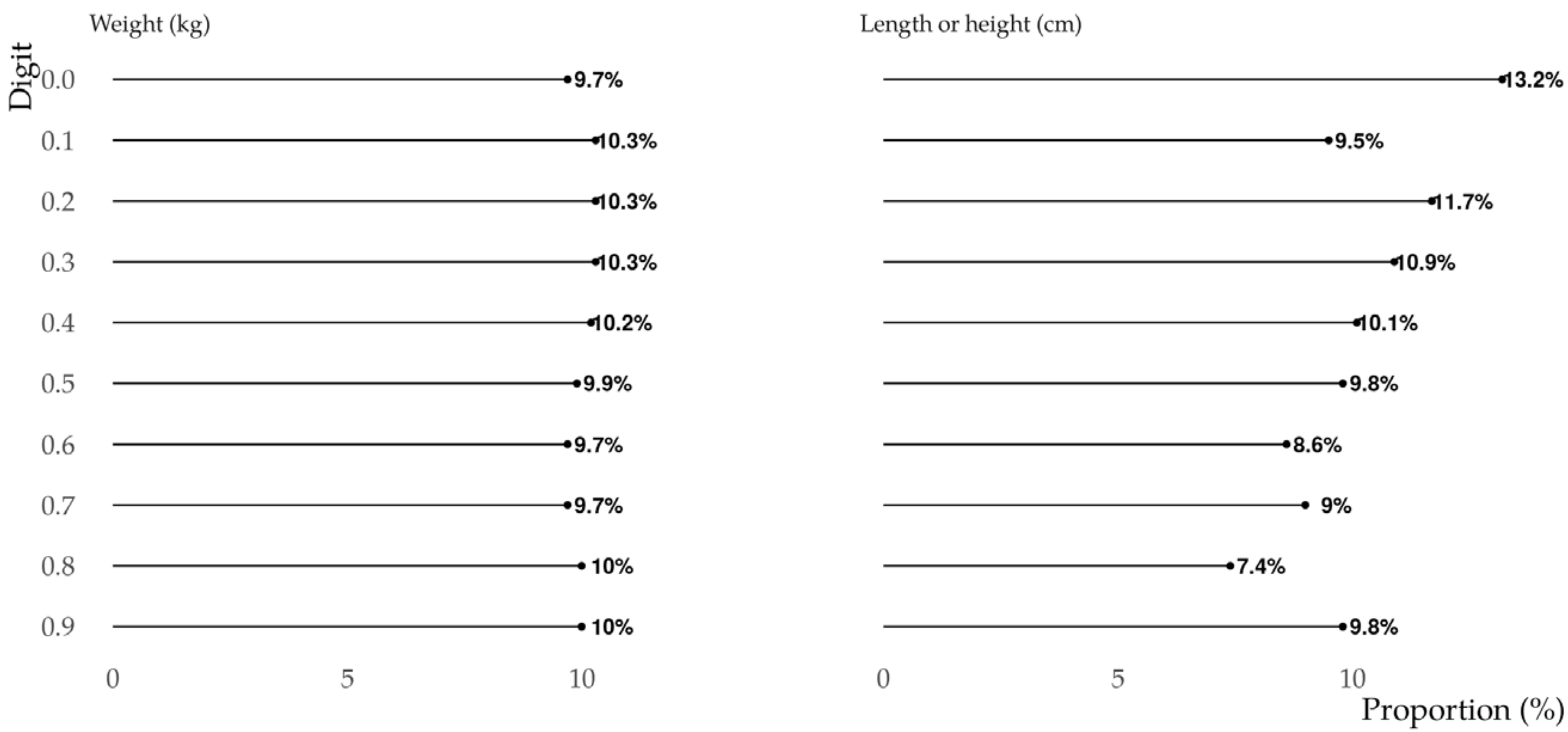
Age group	Expected position	Total	Observed mismatch*	% mismatch*
00-11 mo	lying	3504	515	14.7%
00-08 mo	lying	2780	405	14.6%
12-23 mo	lying	2980	515	17.3%
24-35 mo	standing	2797	1861	66.5%
36-47 mo	standing	2753	1009	36.7%
48-59 mo	standing	1871	548	29.3%
Total		13905	4448	32.0%

Number of children with missing information on measurement position: 1825

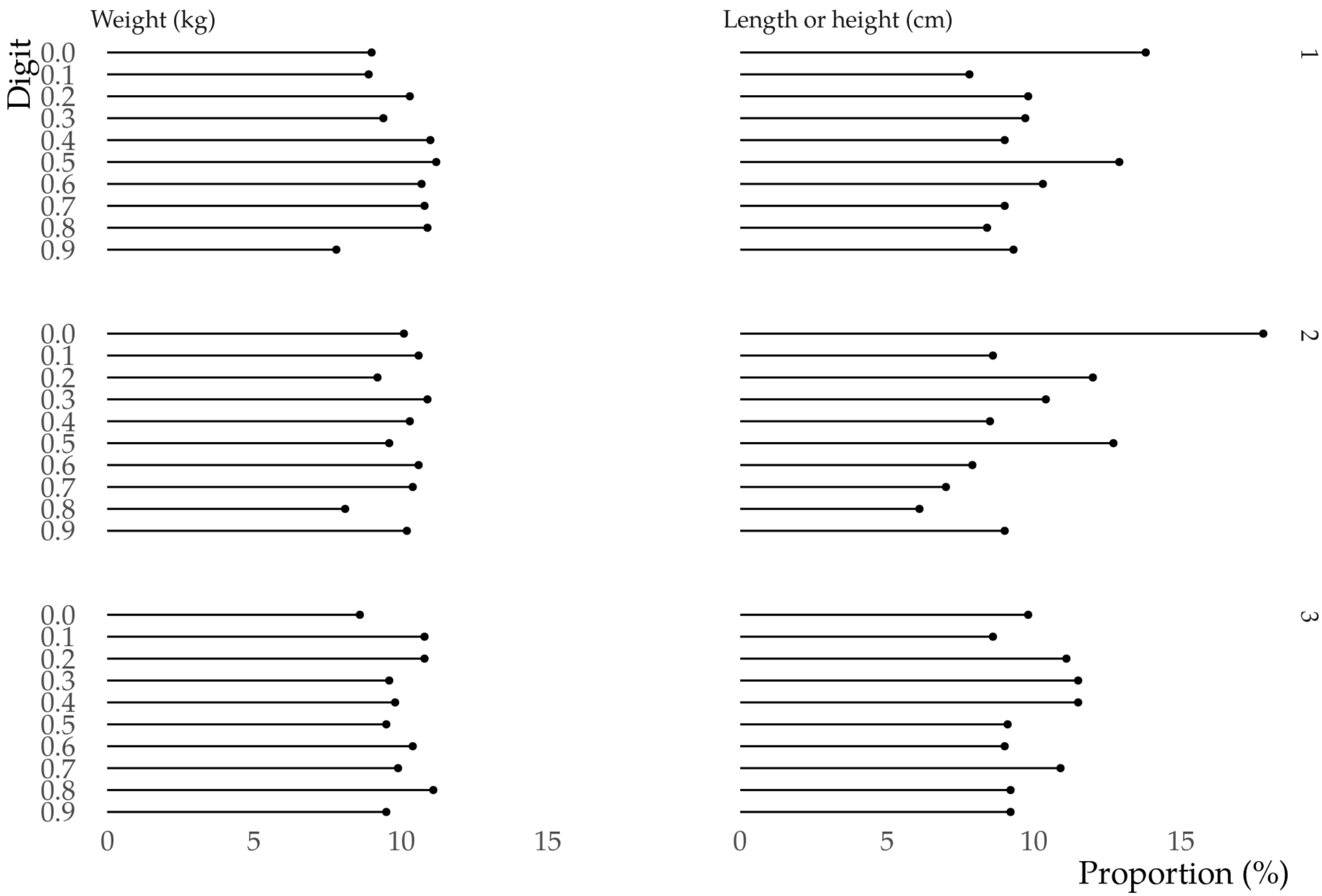
Mismatch means children under 24 months were measured standing (height) or children 24 months or older were measured laying down (recumbent length), as opposed to the recommendation.

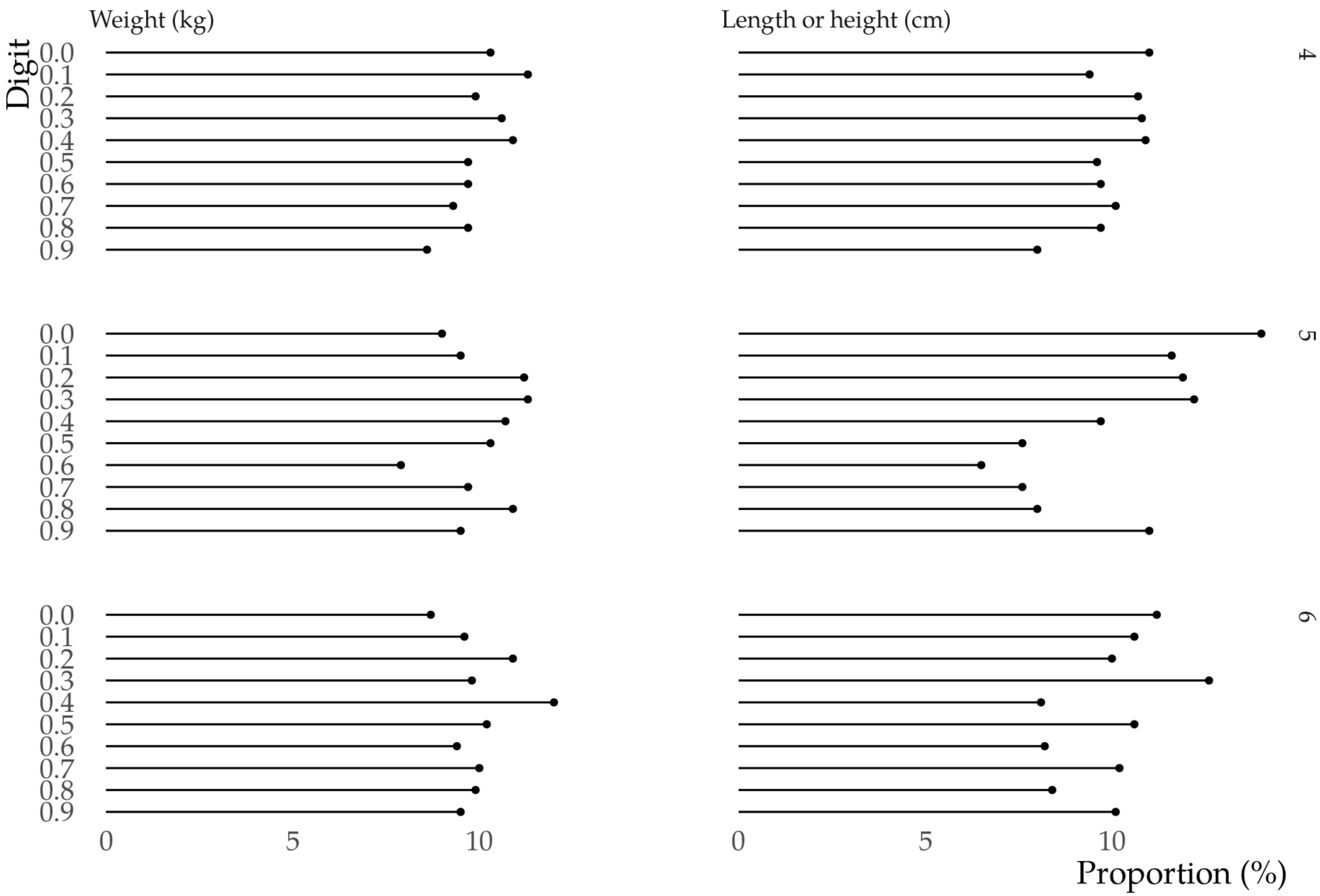
Digit preference charts

Decimal digit preference for weight and length/height

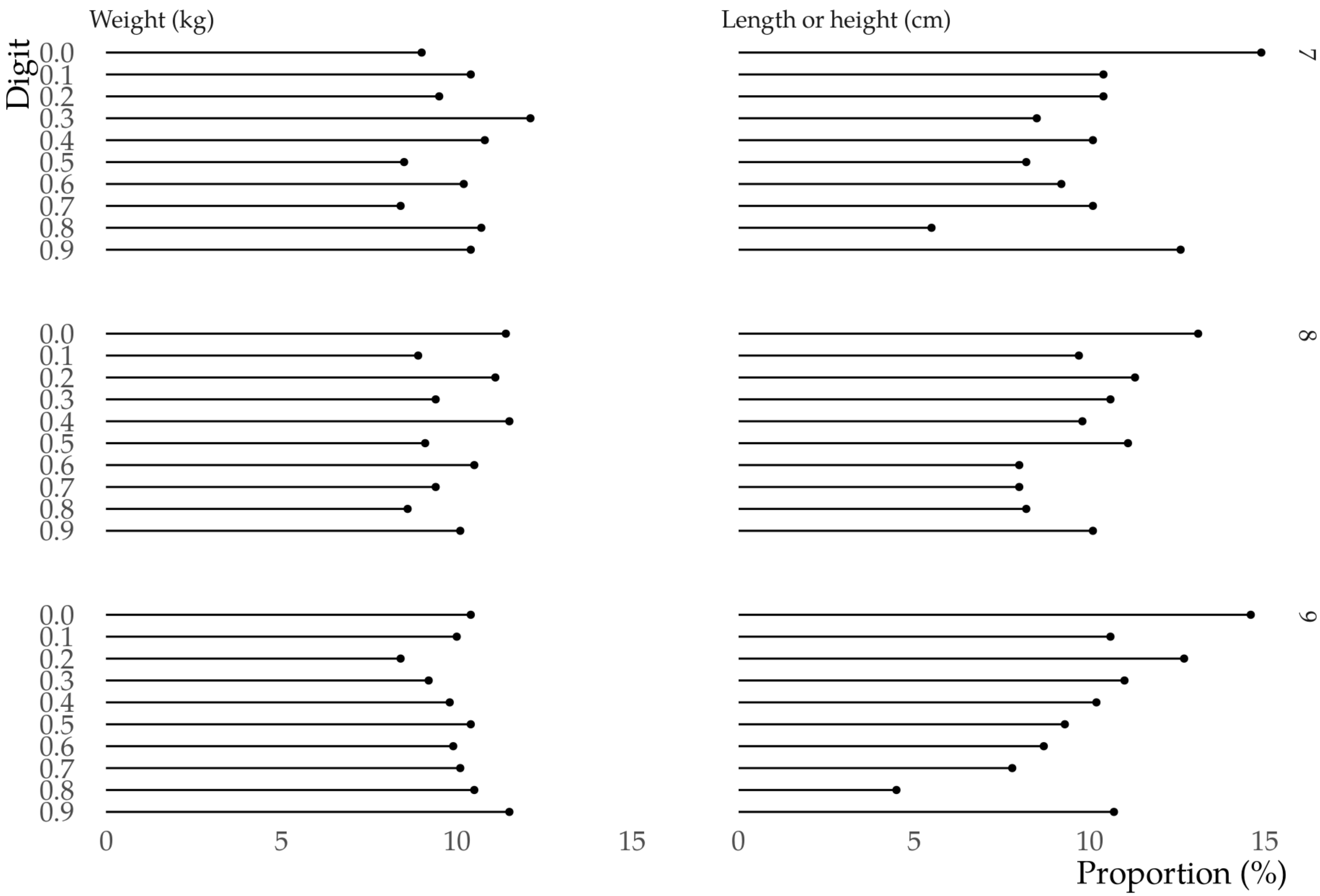


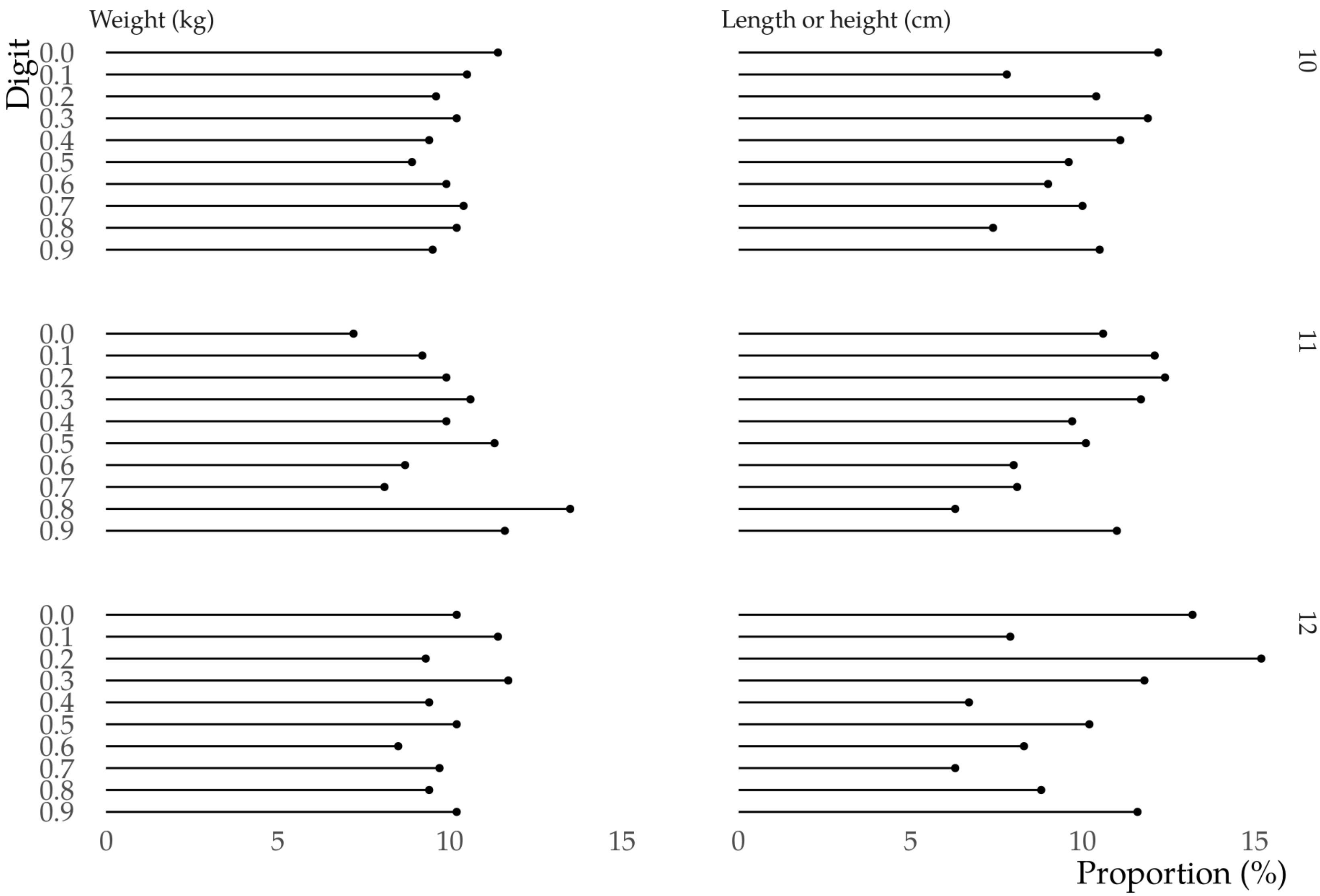
Decimal digit preference by Geographical Region

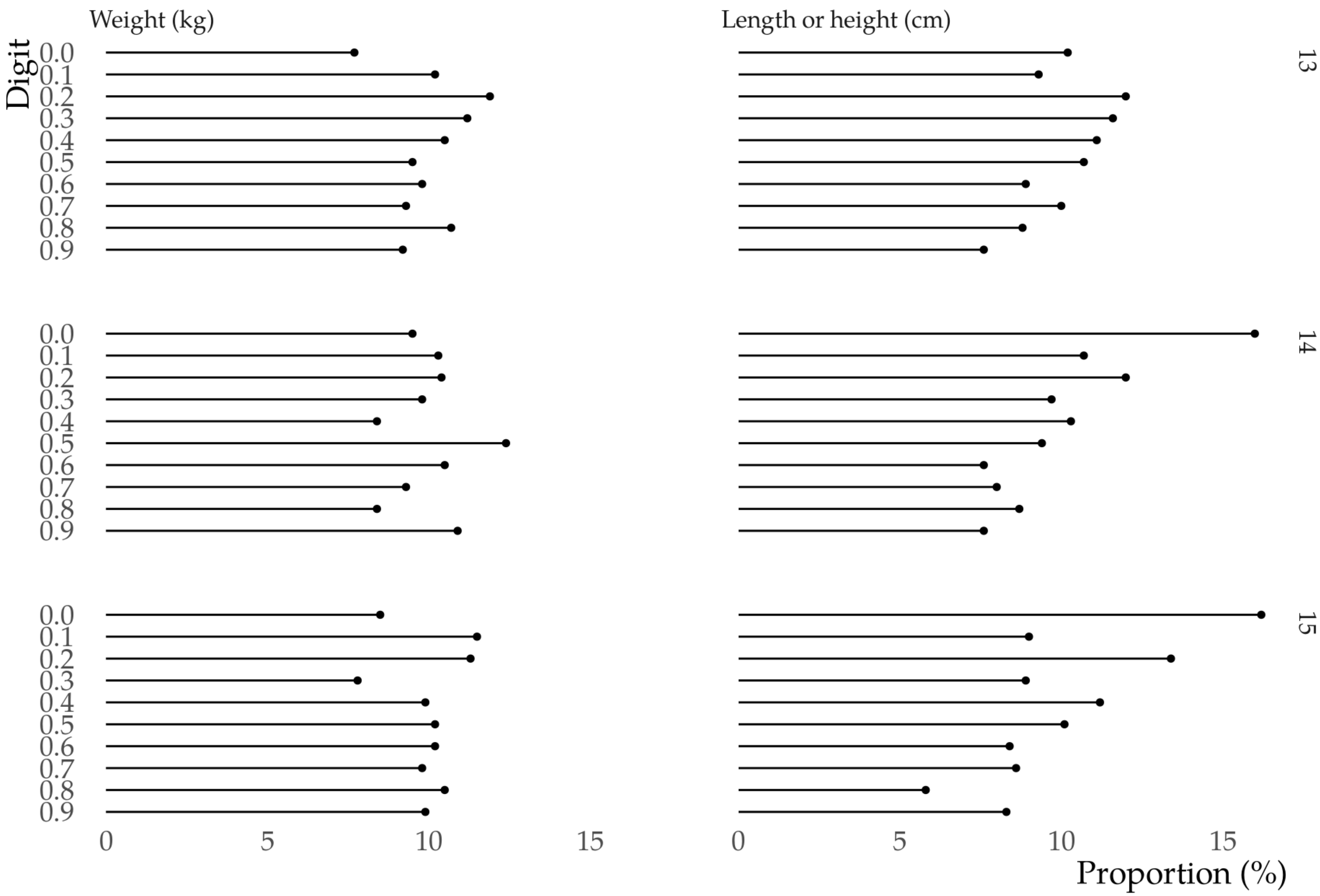


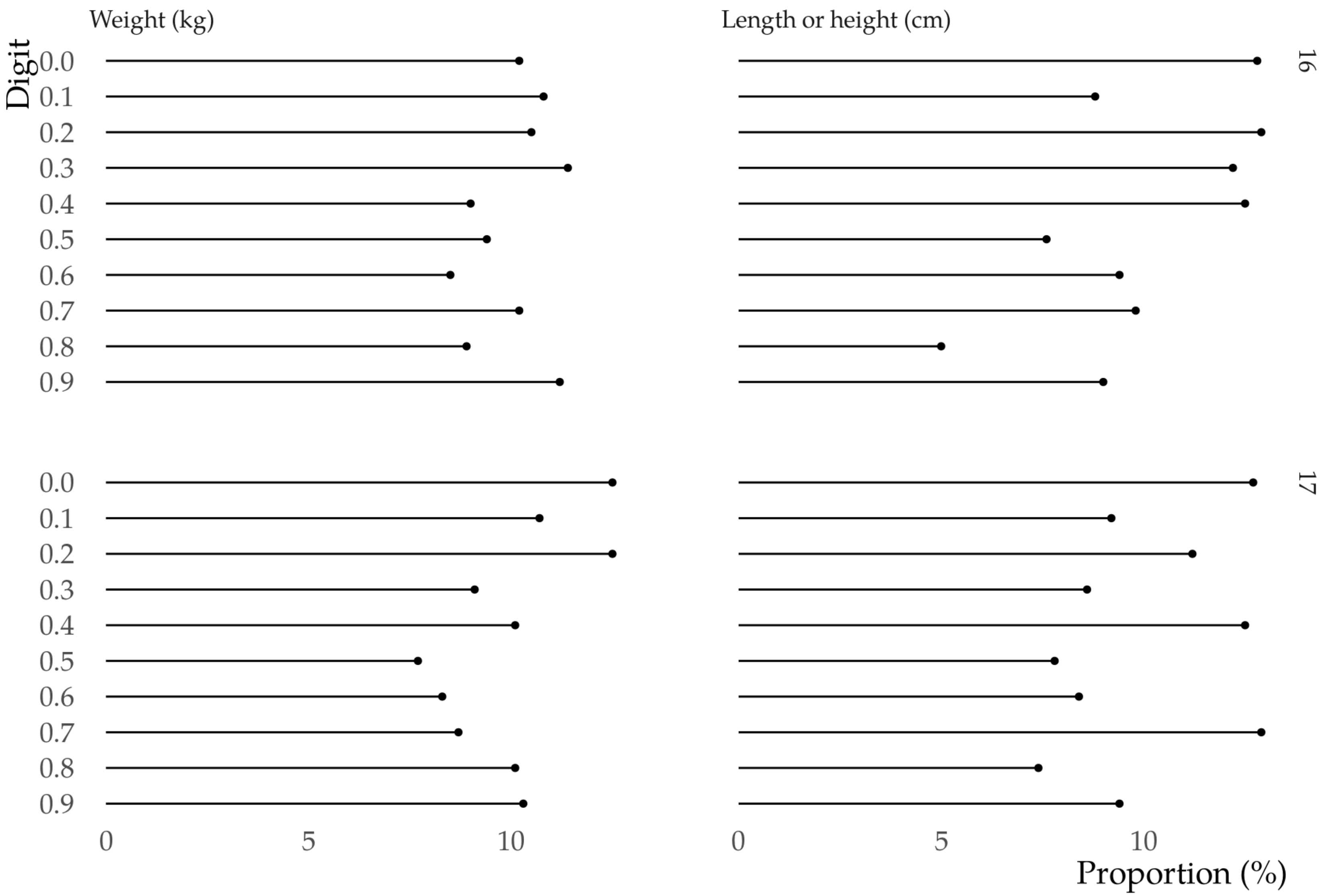


Weight (kg)
Length or height (cm)
Digit
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
4
5
6
0
5
10
Proportion (%)

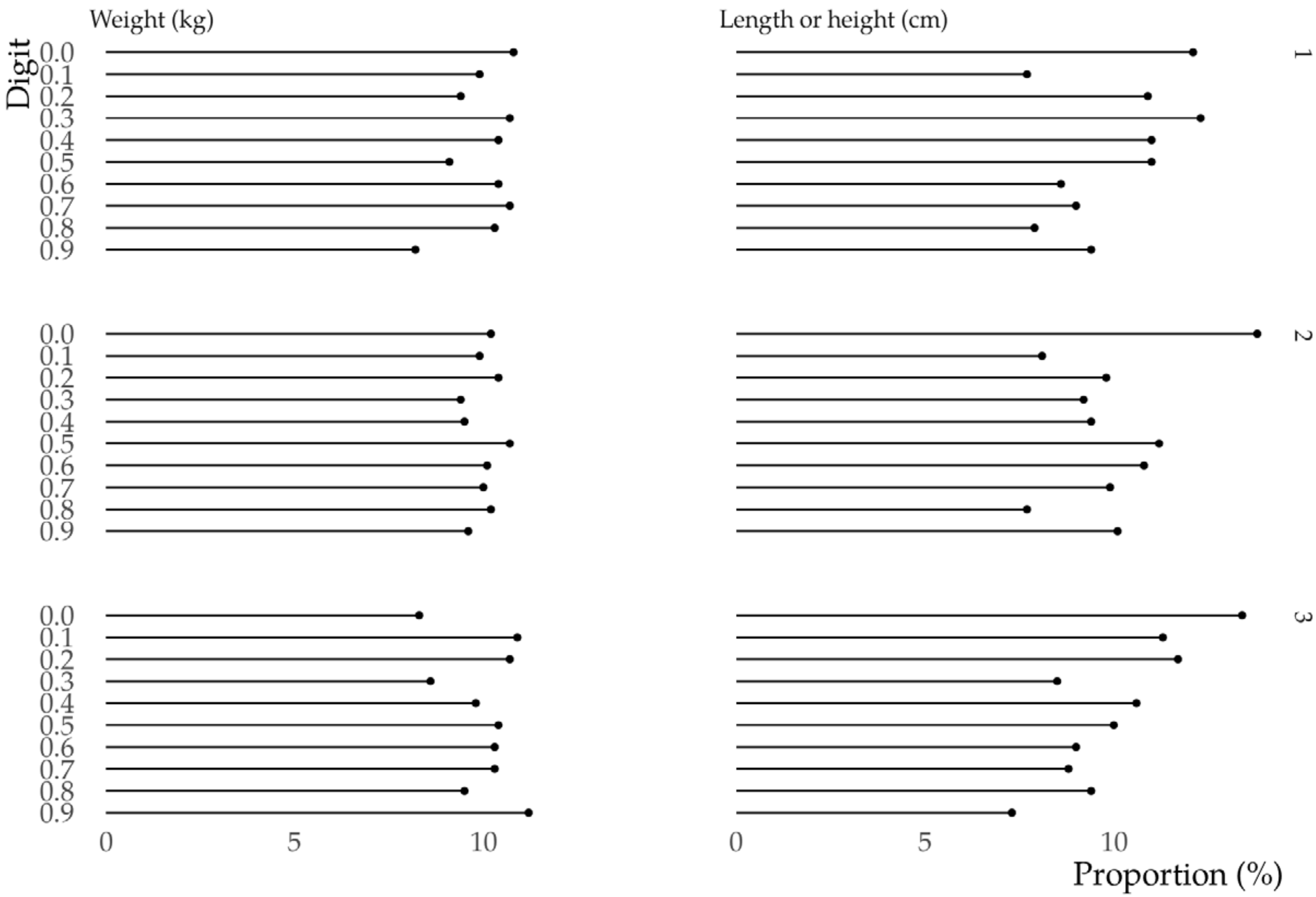

Weight (kg)
Length or height (cm)
Digit
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
7
8
9
0
5
10
15
Proportion (%)

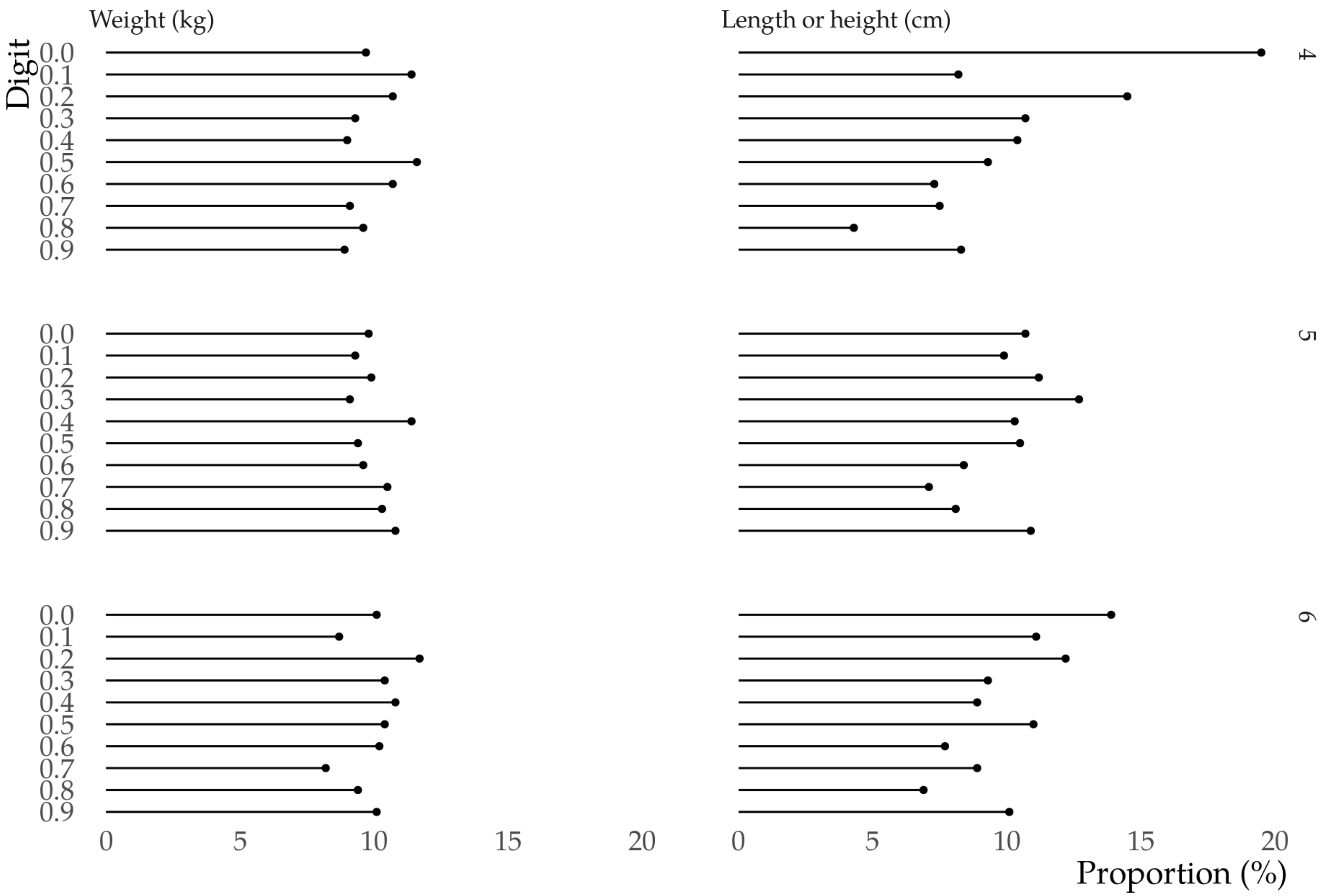

Weight (kg)
Length or height (cm)
Digit
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
10
11
12
0
5
10
15
Proportion (%)


Weight (kg)
Length or height (cm)
Digit
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
13
14
15
0
5
10
15
Proportion (%)


Weight (kg)
Length or height (cm)
Digit
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
16
17
0
5
10
Proportion (%)

Decimal digit preference by Team





Weight (kg)
Length or height (cm)
Digit
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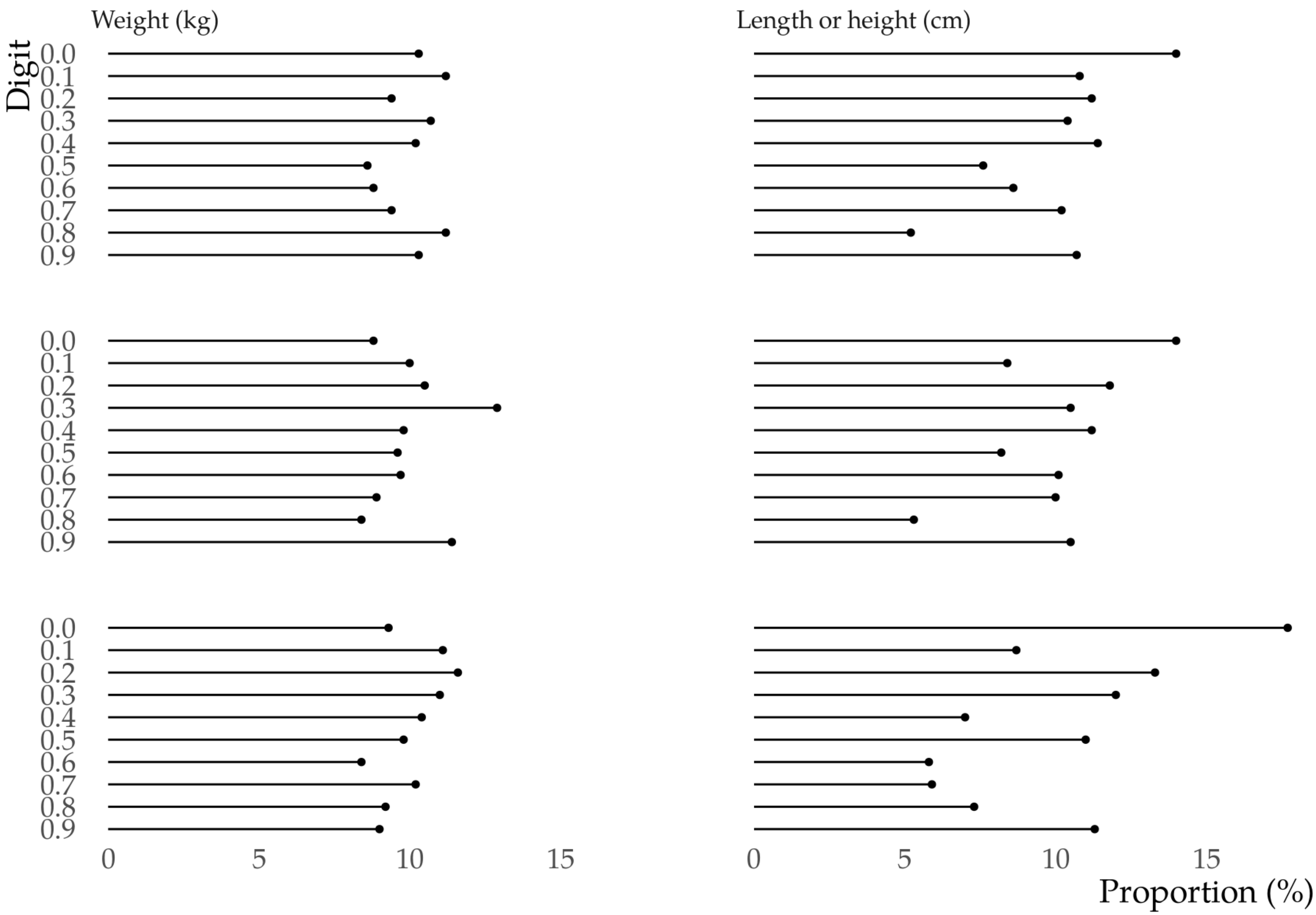
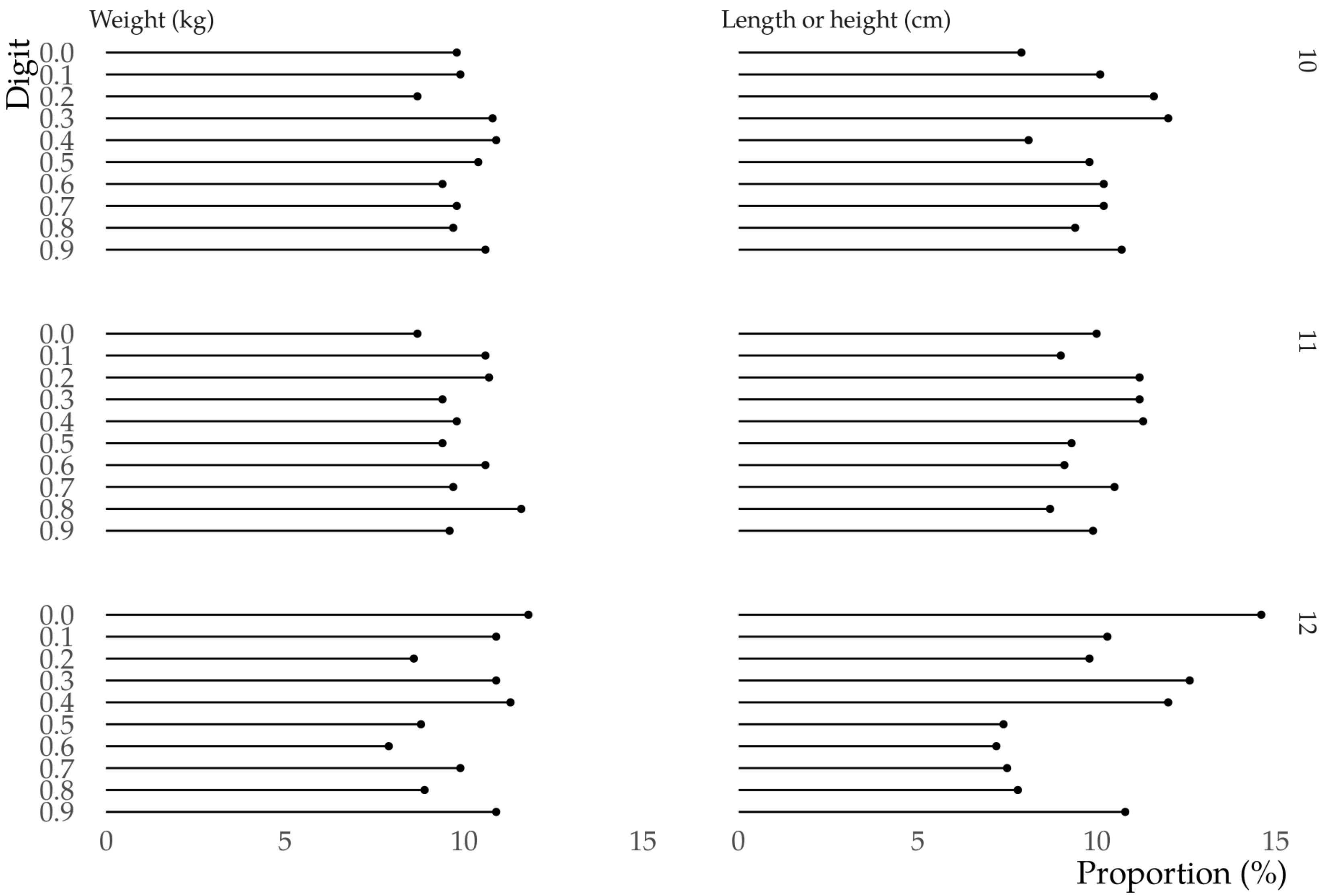
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
4
5
6
0
5
10
15
20
Proportion (%)



Weight (kg)
Length or height (cm)
Digit
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
7
8
9
0
5
10
15
Proportion (%)


Weight (kg)
Length or height (cm)
Digit
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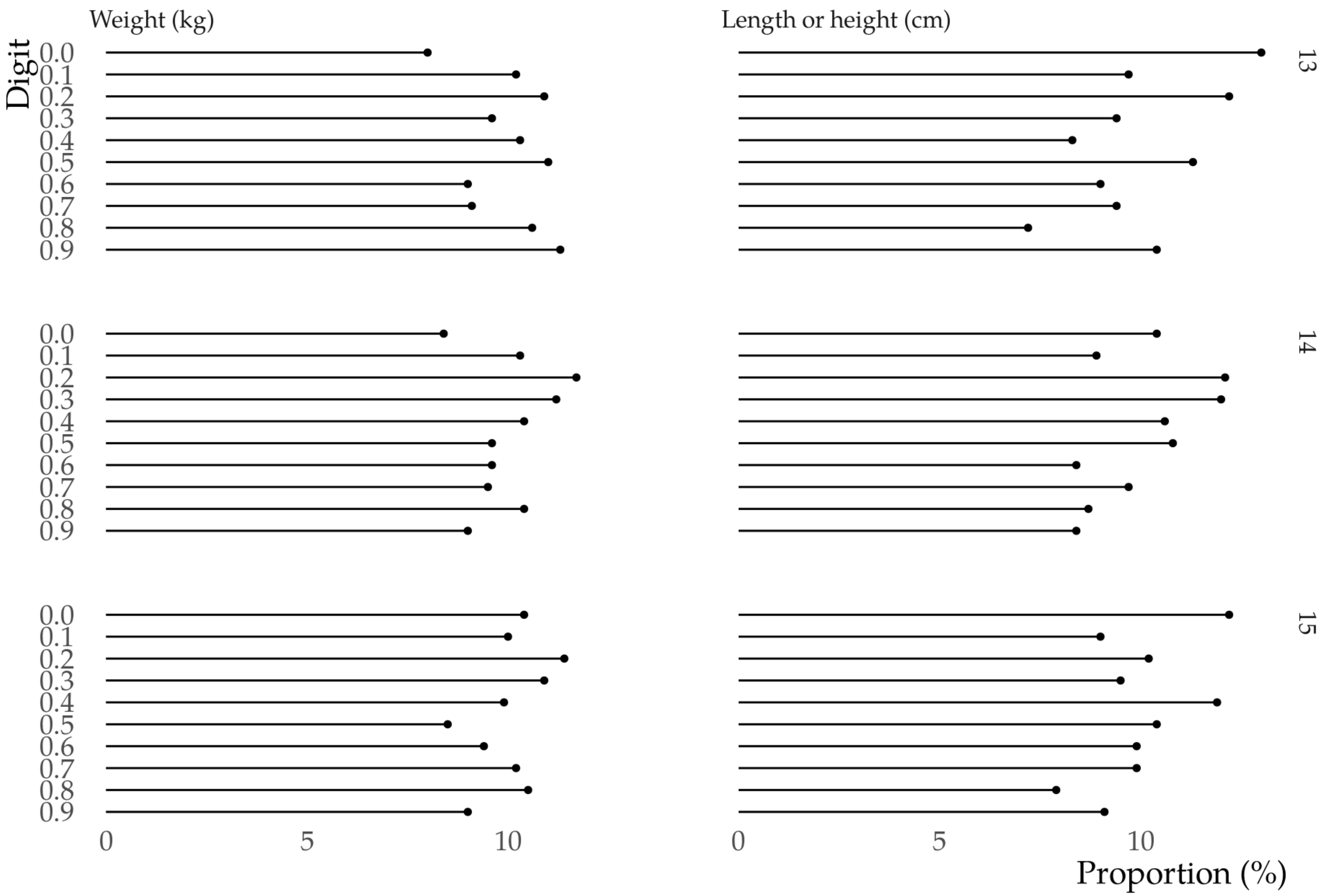
0.3
0.4
0.5
0.6
0.7
0.8
0.9
10
11
12
0
5
10
15
Proportion (%)



Weight (kg)
Length or height (cm)
Digit
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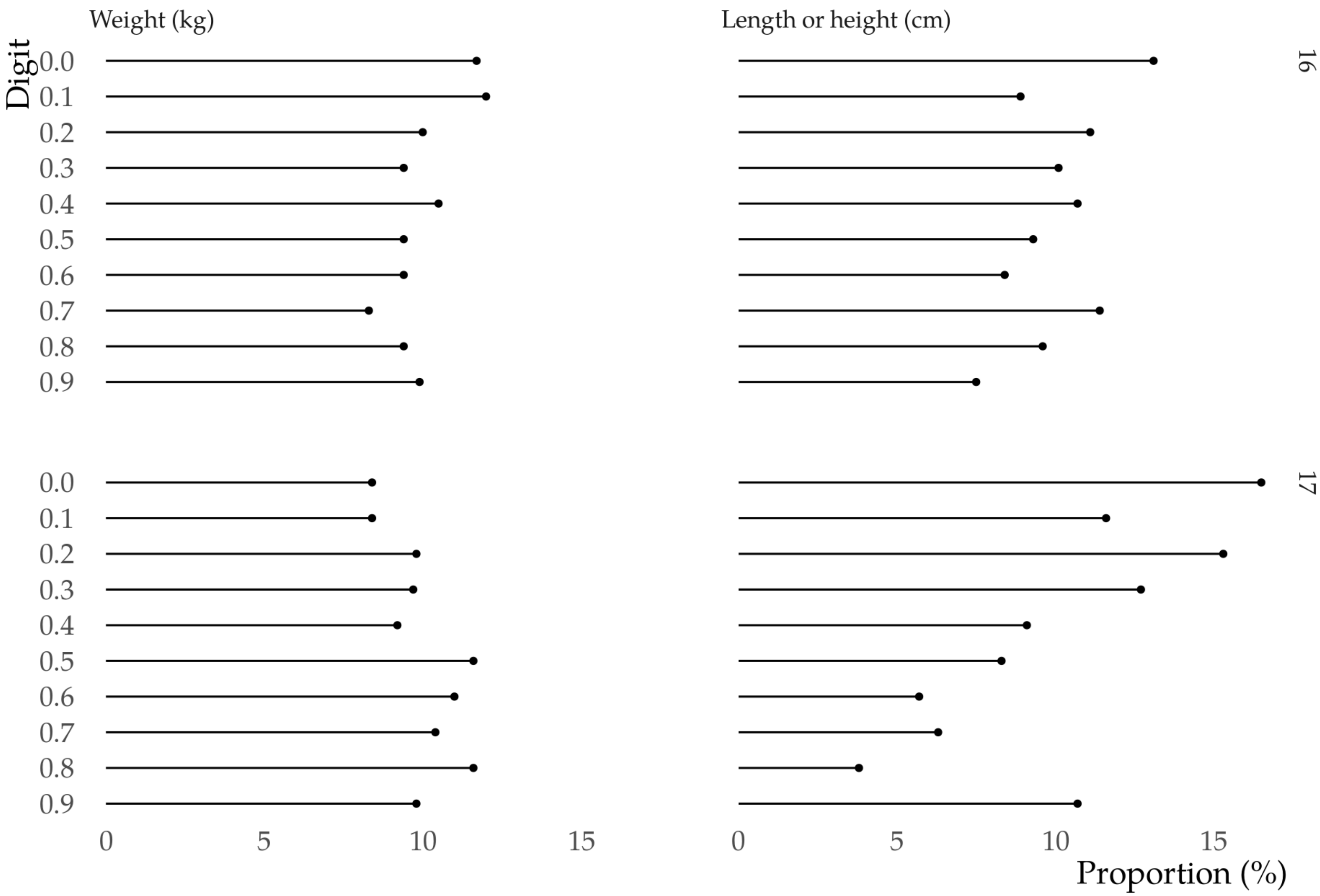
0.5
0.6
0.7
0.8
0.9
13
14
15
0
5
10
Proportion (%)



Weight (kg)
Length or height (cm)
Digit
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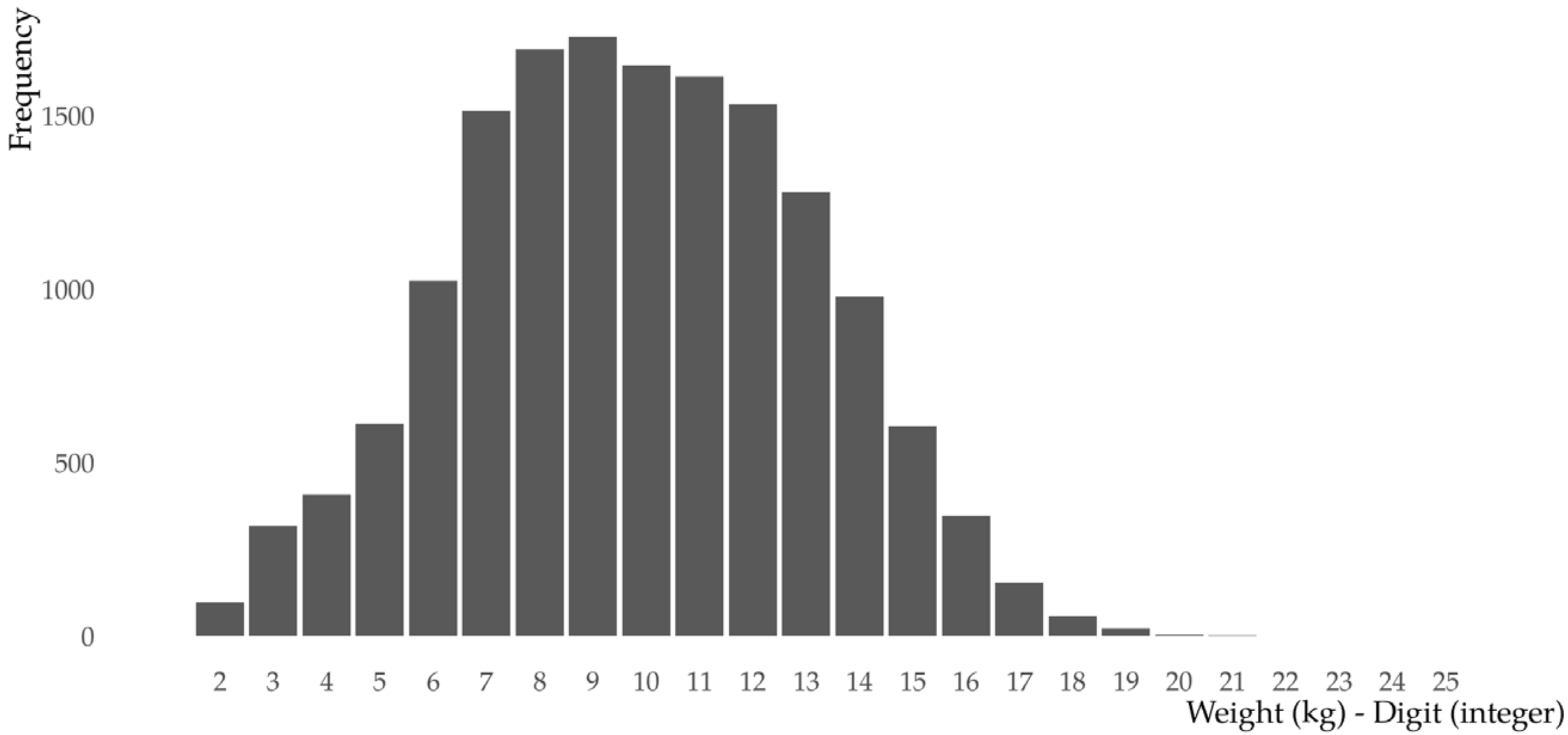
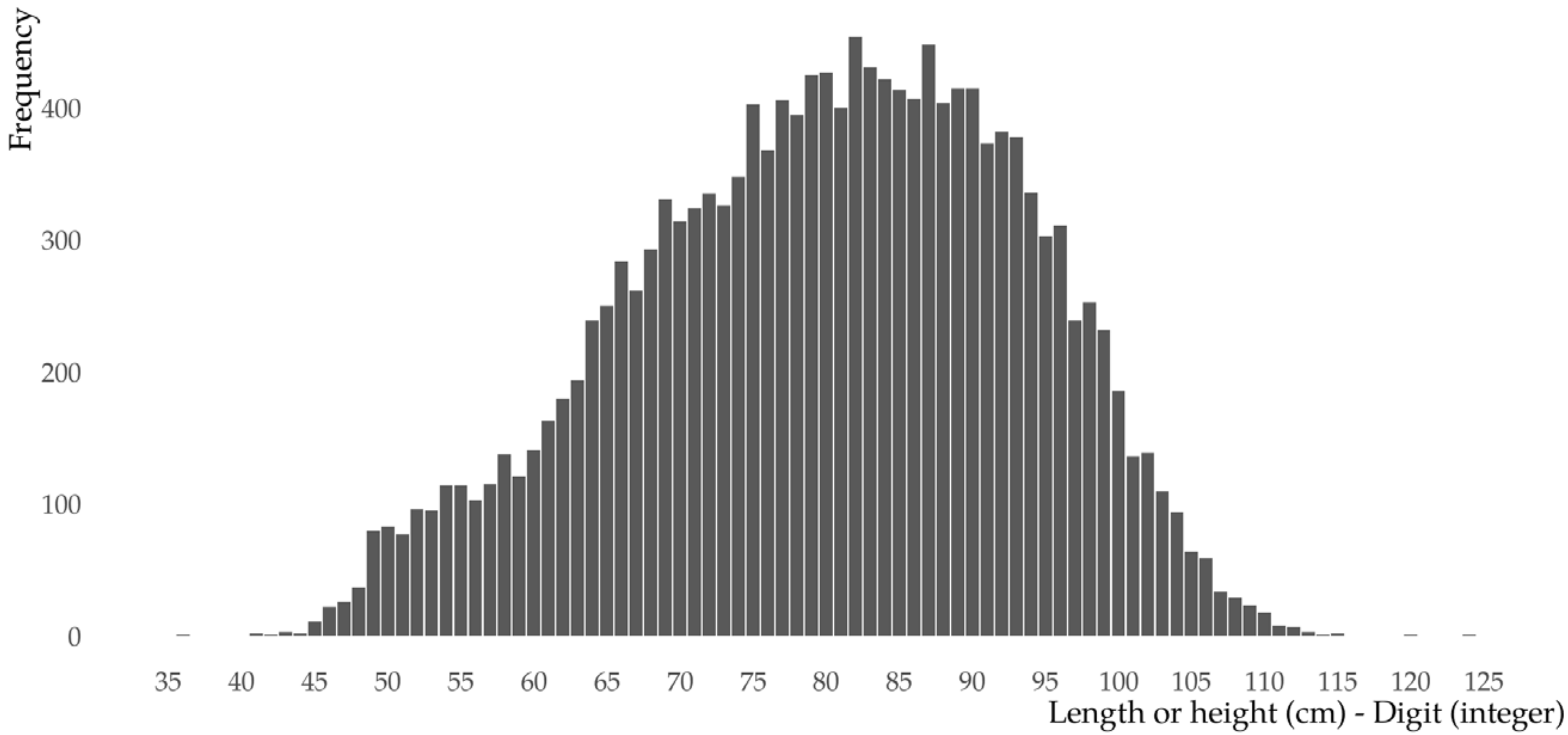
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
16
17
0
5
10
15
Proportion (%)

Whole number digit preference for weight

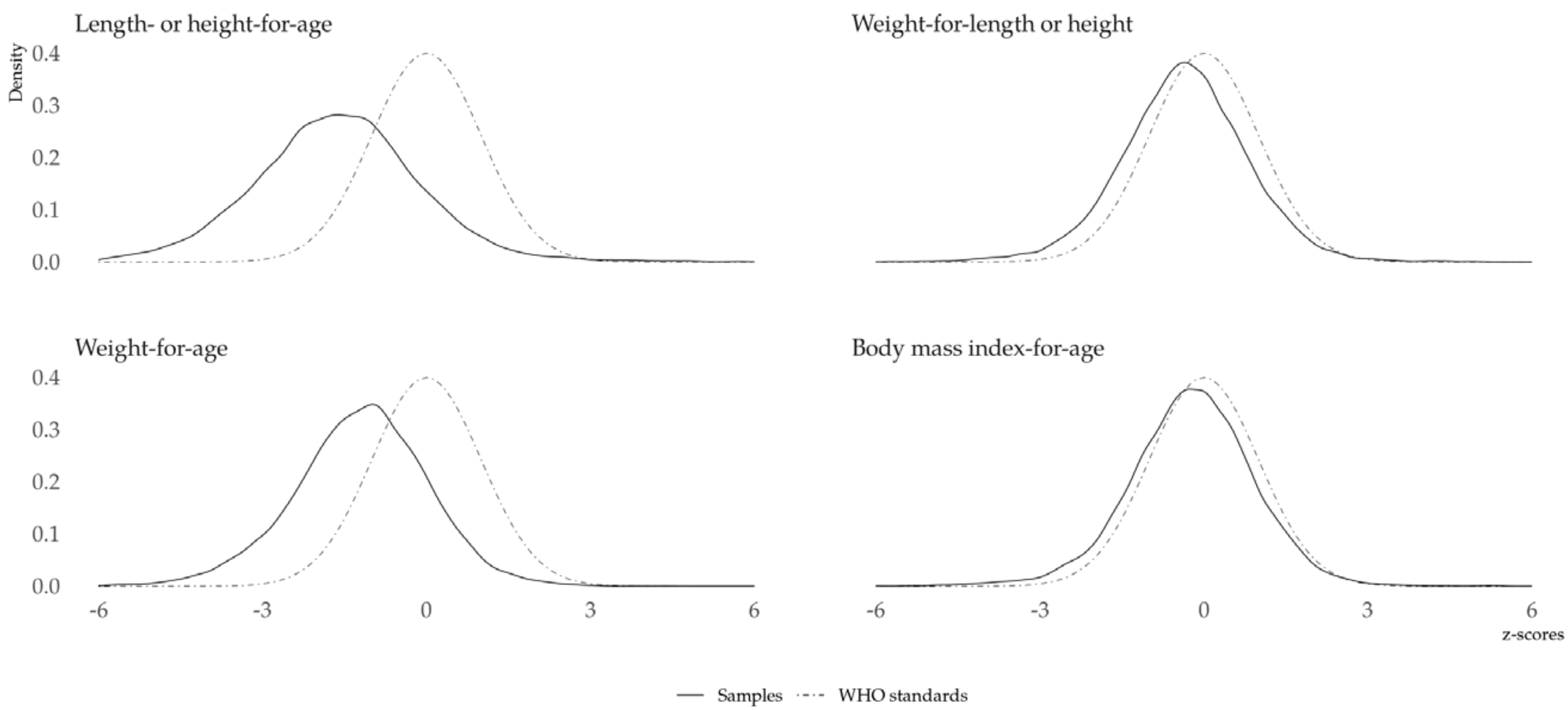


Whole number digit preference for length/height

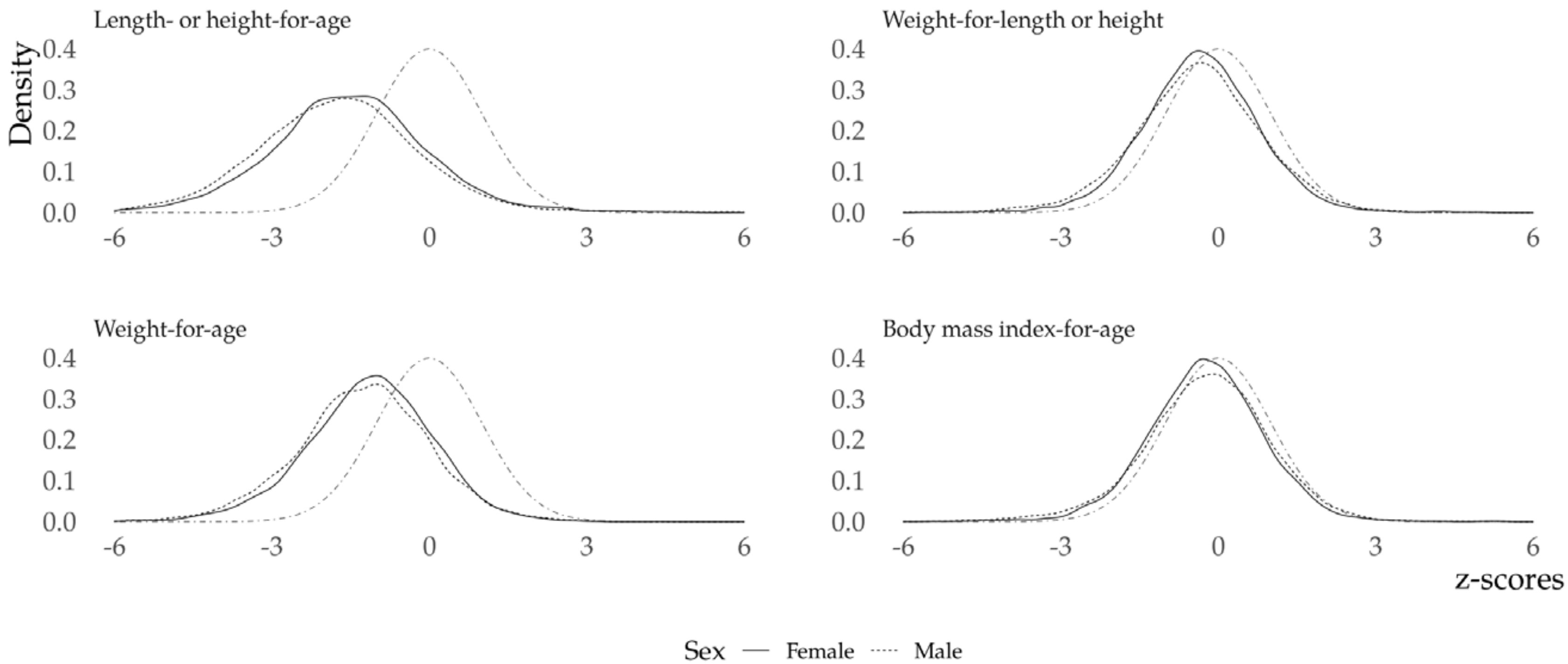


Z-score distribution of indicators

Z-score distribution by index

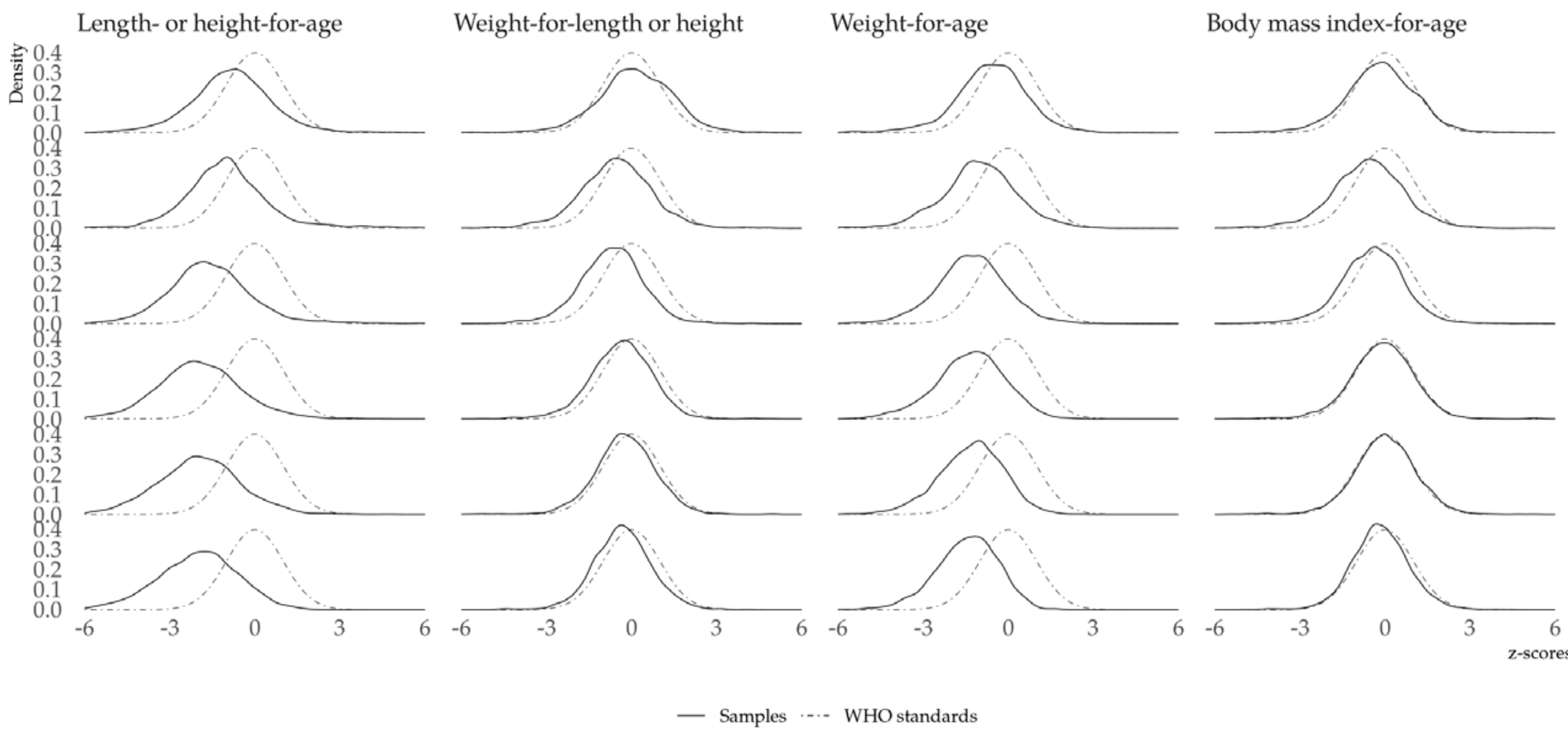


Z-score distribution by index and sex

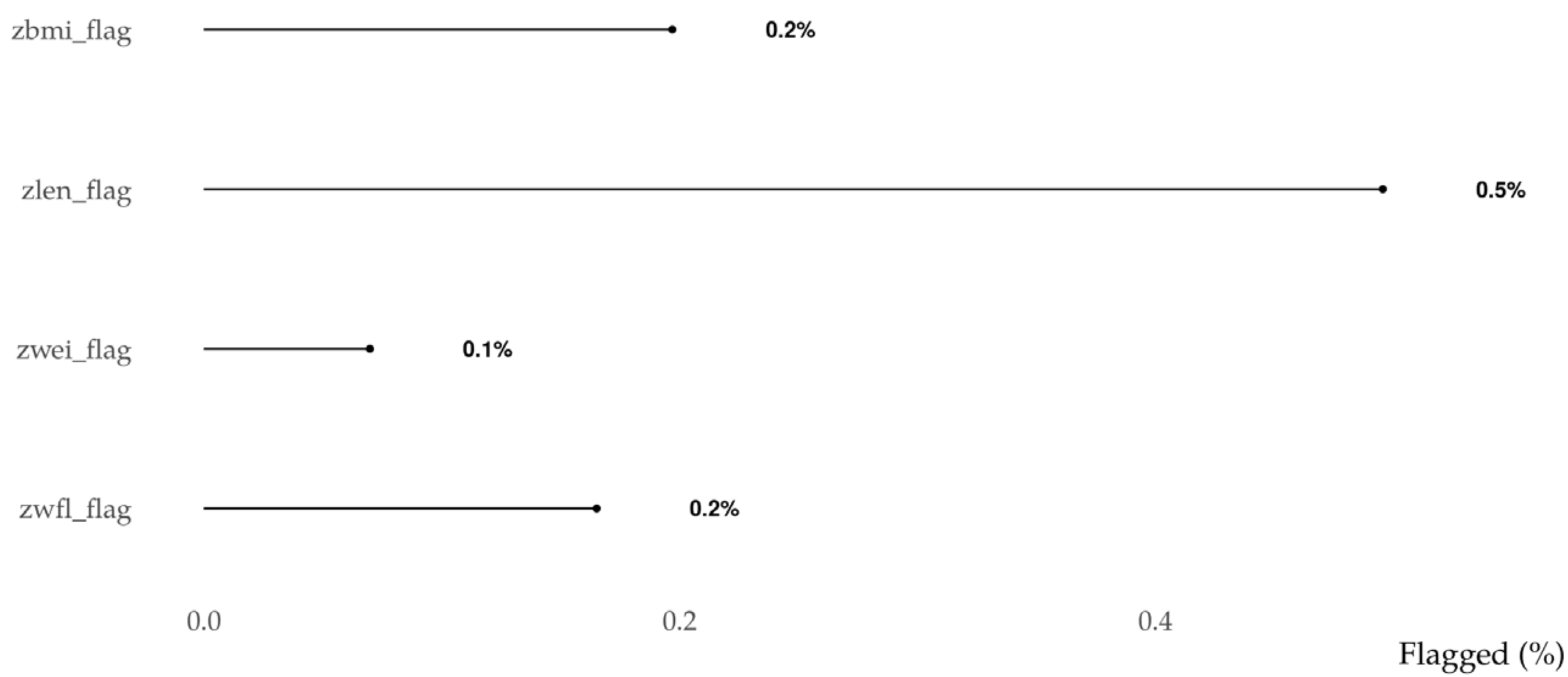


The standard normal density distribution curve is overlaid as a dashed-and-dotted line to provide a visual reference.

Z-score distribution by index and age group



Percentage of flagged z-scores based on WHO flagging system by index



Z-score summary table

Z-score distribution of unweighted summary statistics by index

Group	Unweighted N	Mean (zlen)	Standard deviation (zlen)	Skewness (zlen)	Kurtosis (zlen)	Mean (zwei)	Standard deviation (zwei)	Skewness (zwei)	Kurtosis (zwei)
All	15735	-1.62	1.50	0.26	3.94	-1.20	1.23	-0.17	3.43
Age group: 00-05 mo	2151	-0.83	1.42	0.15	4.23	-0.60	1.25	-0.40	4.20
Age group: 06-11 mo	1825	-0.99	1.47	0.65	5.36	-1.02	1.29	-0.16	3.54
Age group: 12-23 mo	3342	-1.57	1.46	0.57	4.75	-1.30	1.22	-0.06	3.53
Age group: 24-35 mo	3169	-1.94	1.45	0.22	3.42	-1.34	1.22	-0.26	3.11
Age group: 36-47 mo	3101	-1.96	1.44	0.09	3.24	-1.31	1.14	-0.30	3.23
Age group: 48-59 mo	2132	-2.00	1.38	-0.17	2.85	-1.45	1.09	-0.38	3.29
Sex: Male	7911	-1.72	1.53	0.35	4.14	-1.26	1.26	-0.12	3.39
Sex: Female	7821	-1.52	1.47	0.19	3.77	-1.14	1.20	-0.21	3.50
Team: 1	1059	-1.46	1.43	0.10	3.42	-1.21	1.19	-0.30	3.58
Team: 2	919	-1.33	1.51	0.37	4.27	-1.08	1.17	-0.09	3.41
Team: 3	1060	-1.55	1.63	0.46	3.86	-1.16	1.26	-0.10	3.55
Team: 4	887	-1.61	1.54	0.45	4.38	-1.17	1.23	-0.19	3.36
Team: 5	1016	-1.95	1.53	0.35	3.81	-1.45	1.29	-0.25	3.48
Team: 6	1052	-2.15	1.53	0.13	3.20	-1.48	1.27	-0.10	3.27
Team: 7	1181	-1.85	1.33	0.04	3.38	-1.38	1.16	-0.05	3.38
Team: 8	1075	-2.01	1.49	0.43	4.12	-1.46	1.24	0.05	3.42

Team: 9	943	-1.57	1.36	0.15	3.28	-1.26	1.13	-0.09	3.44
Team: 10	1009	-1.60	1.40	-0.10	3.66	-1.24	1.25	-0.44	3.43
Team: 11	999	-1.81	1.59	0.41	4.24	-1.37	1.24	-0.23	3.34
Team: 12	706	-1.43	1.47	0.26	4.39	-0.99	1.16	-0.15	3.62
Team: 13	743	-1.29	1.53	0.22	4.22	-0.82	1.26	-0.27	3.55
Team: 14	840	-1.58	1.51	0.45	4.69	-1.25	1.24	-0.12	3.47
Team: 15	806	-1.21	1.45	0.29	3.90	-0.92	1.18	0.00	3.23
Team: 16	774	-1.22	1.53	0.45	4.04	-0.92	1.19	0.01	3.28
Team: 17	666	-1.34	1.24	0.01	4.08	-0.77	1.06	-0.39	4.02
Geographical region: 1	812	-1.12	1.53	0.11	3.75	-1.02	1.20	-0.15	3.33
Geographical region: 2	918	-1.12	1.51	0.19	4.06	-1.00	1.23	-0.32	3.78
Geographical region: 3	946	-1.87	1.59	0.46	4.46	-1.40	1.24	-0.21	3.36
Geographical region: 4	950	-1.32	1.49	0.56	4.42	-0.90	1.17	0.01	3.22
Geographical region: 5	974	-1.20	1.30	0.06	3.99	-0.69	1.08	-0.11	3.51
Geographical region: 6	933	-1.70	1.30	0.07	3.73	-1.34	1.19	-0.37	3.58
Geographical region: 7	1091	-2.01	1.39	0.27	4.11	-1.51	1.17	0.11	3.36
Geographical region: 8	1296	-2.18	1.50	0.27	3.71	-1.56	1.28	-0.11	3.51
Geographical region: 9	983	-1.55	1.49	0.39	4.92	-1.04	1.20	-0.32	3.77
Geographical region: 10	1073	-1.63	1.36	0.16	3.76	-1.25	1.15	-0.28	3.45

Geographical region: 11	657	-1.87	1.53	0.17	3.25	-1.29	1.27	-0.29	3.30
Geographical region: 12	891	-1.52	1.46	-0.05	3.23	-1.20	1.21	-0.21	3.25
Geographical region: 13	797	-1.64	1.49	0.45	4.83	-1.28	1.25	-0.10	3.45
Geographical region: 14	824	-1.42	1.55	0.41	3.93	-1.18	1.26	-0.14	3.23
Geographical region: 15	997	-1.72	1.61	0.54	4.17	-1.14	1.23	-0.08	3.72
Geographical region: 16	1083	-1.92	1.41	0.19	3.44	-1.39	1.21	-0.10	3.42
Geographical region: 17	510	-1.11	1.54	0.17	3.57	-0.98	1.23	0.04	3.27

Z-score distribution of unweighted summary statistics by index (continued)

Group	Unweighted N	Mean (zbmi)	Standard deviation (zbmi)	Skewness (zbmi)	Kurtosis (zbmi)	Mean (zwfl)	Standard deviation (zwfl)	Skewness (zwfl)	Kurtosis (zwfl)
All	15735	-0.23	1.13	-0.20	3.84	-0.36	1.15	-0.03	3.82
Age group: 00-05 mo	2151	-0.15	1.23	-0.11	3.72	0.14	1.29	-0.11	3.48
Age group: 06-11 mo	1825	-0.60	1.24	-0.15	3.58	-0.55	1.24	-0.01	3.88
Age group: 12-23 mo	3342	-0.46	1.12	-0.13	3.98	-0.71	1.10	-0.06	3.82
Age group: 24-35 mo	3169	-0.11	1.08	-0.29	3.72	-0.37	1.07	-0.17	3.93
Age group: 36-47 mo	3101	0.01	1.06	-0.17	3.86	-0.21	1.04	-0.05	3.77

Age group: 48-59 mo	2132	-0.16	1.00	-0.03	4.14	-0.32	1.02	-0.06	3.91
Sex: Male	7911	-0.22	1.19	-0.27	3.78	-0.38	1.20	-0.09	3.60
Sex: Female	7821	-0.24	1.08	-0.10	3.86	-0.33	1.10	0.05	4.05
Team: 1	1059	-0.42	1.14	-0.07	4.21	-0.54	1.13	-0.07	3.78
Team: 2	919	-0.32	1.08	-0.01	3.57	-0.44	1.09	0.06	3.48
Team: 3	1060	-0.22	1.18	-0.26	3.92	-0.36	1.18	-0.13	4.15
Team: 4	887	-0.18	1.16	-0.16	3.67	-0.28	1.20	0.20	3.77
Team: 5	1016	-0.27	1.15	-0.33	3.96	-0.43	1.18	-0.10	3.81
Team: 6	1052	-0.07	1.10	-0.24	4.03	-0.26	1.09	-0.21	3.59
Team: 7	1181	-0.27	1.04	-0.25	4.21	-0.42	1.06	-0.04	3.98
Team: 8	1075	-0.21	1.10	-0.24	3.72	-0.38	1.15	0.20	4.32
Team: 9	943	-0.37	1.08	0.04	3.49	-0.49	1.09	0.08	3.37
Team: 10	1009	-0.33	1.20	-0.52	3.94	-0.45	1.21	-0.38	3.56
Team: 11	999	-0.24	1.15	-0.28	3.99	-0.39	1.15	-0.12	3.74
Team: 12	706	-0.10	1.16	-0.37	3.32	-0.23	1.14	-0.38	3.29
Team: 13	743	-0.01	1.16	-0.28	3.83	-0.12	1.17	-0.21	3.78
Team: 14	840	-0.35	1.14	0.11	3.59	-0.45	1.18	0.24	3.98
Team: 15	806	-0.23	1.11	-0.36	3.68	-0.32	1.14	-0.14	4.02
Team: 16	774	-0.20	1.12	-0.10	3.97	-0.29	1.14	0.03	4.10
Team: 17	666	0.10	1.14	0.16	3.87	0.03	1.17	0.37	3.62
Geographical region: 1	812	-0.43	1.07	0.17	4.65	-0.53	1.07	0.25	4.12
Geographical region: 2	918	-0.43	1.11	-0.11	3.86	-0.52	1.12	-0.08	3.76
Geographical region: 3	946	-0.24	1.15	-0.28	4.06	-0.40	1.15	-0.12	3.77

Geographical region: 4	950	-0.09	1.13	-0.23	3.88	-0.18	1.17	0.01	4.13
Geographical region: 5	974	0.09	1.10	-0.07	3.37	0.01	1.11	0.03	3.66
Geographical region: 6	933	-0.39	1.21	-0.49	4.08	-0.50	1.21	-0.30	3.80
Geographical region: 7	1091	-0.28	1.02	-0.07	3.77	-0.45	1.08	0.39	4.73
Geographical region: 8	1296	-0.16	1.12	-0.35	4.05	-0.34	1.13	-0.21	3.64
Geographical region: 9	983	-0.06	1.20	-0.27	4.08	-0.18	1.21	-0.13	3.80
Geographical region: 10	1073	-0.33	1.12	-0.16	3.41	-0.47	1.13	-0.16	3.33
Geographical region: 11	657	-0.11	1.14	-0.23	3.97	-0.27	1.15	-0.12	3.87
Geographical region: 12	891	-0.29	1.08	0.01	3.06	-0.43	1.10	-0.03	2.93
Geographical region: 13	797	-0.34	1.13	0.13	3.64	-0.44	1.18	0.25	4.05
Geographical region: 14	824	-0.39	1.13	-0.12	3.62	-0.48	1.16	0.11	3.84
Geographical region: 15	997	-0.02	1.17	-0.36	4.08	-0.17	1.19	-0.06	4.14
Geographical region: 16	1083	-0.21	1.13	-0.42	4.08	-0.36	1.12	-0.18	3.86
Geographical region: 17	510	-0.38	1.07	-0.34	3.72	-0.47	1.07	-0.30	3.62

Annex: Summary of recommended data quality checks

The Working Group (WG) on Anthropometry Data Quality recommendation is that data quality be assessed and reported based on assessment on the following 7 parameters: (i) Completeness; (ii) Sex ratio; (iii) Age distribution; (iv) Digit preference of heights and weights; (v) Implausible z score values; (vi) Standard deviation of z scores; and (vii) Normality of z scores.

The WG recommends that (i) data quality checks should not be considered in isolation; (ii) formal tests or scoring should not be conducted; (iii) the checks should be used to help users identify issues with the data quality to improve interpretation of the malnutrition estimates from the survey. Although not exhaustive, a summary of details on the various checks is provided below to help their use. Full details and more comprehensive guidance, including on how to calculate, can be found at the full report on the WG's recommendations[10].

(i) Completeness: although not all statistics are included in the WHO Anthro Survey Analyser, report on structural integrity of the aspects listed below should be included in the final report:

- PSUs: % of selected PSUs that were visited.
- Households: % of selected households in the PSUs interviewed or recorded as not interviewed (specifying why).
- Household members: % of household rosters that were completed.
- Children: % of all eligible children are interviewed and measured, or recorded as not interviewed or measured (specifying why), with no duplicate cases.
- Dates of birth: % of dates of birth for all eligible children that were complete.

(ii) Sex ratio:

- What - ratio of girls to boys in the survey and compare to expected for country. The observed ratios should be compared to the expect patterns based on reliable sources.
- Why – to identify potential selection biases.

(iii) Age distribution:

- What – age distributions by age in completed years (6 bars weighted), months (72 bars) and calendar month of birth (12 bars), as histograms.

[10] Working Group on Anthropometric Data Quality, for the WHO-UNICEF Technical Expert Advisory Group on Nutrition Monitoring (TEAM). Recommendations for improving the quality of anthropometric data and its analysis and reporting. Available at www.who.int/nutrition/team (under "Technical reports and papers").

- Why – to identify potential selection biases or misreporting.

(iv) Height and weight digit preference:

- What –terminal digits as well as whole number integer distributions through histograms.
- Why – Digit preference may be a tell-tale sign of data fabrication or inadequate care and attention during data collection and recording. When possible, it should be presented by team or other relevant disaggregation categories.

(v) Implausible z score values:

- What – the % of cases outside of WHO flags[11] for each HAZ, WHZ and WAZ.
- Why – a percent above 1% can be indicative of potential data quality issues in measurements or age determination It should be presented by team or other relevant disaggregation categories.

(vi) Standard deviations:

- What –SD for each HAZ, WHZ and WAZ.
- Why – large SDs may be a sign of data quality problems and/or population heterogeneity. It is unclear what causes SD's size and more research is needed to determine appropriate interpretation. It should be noted that SDs are typically wider for HAZ than WHZ or WAZ, and that HAZ SD is typically widest in youngest (0-5 mo) and increases as children age through to 5 years. No substantial difference should be observed between boys and girls. It should be presented by team or other relevant disaggregation categories.

(vii) Checks of normality:

- What – measures of asymmetry (skew) and tailedness (kurtosis) of HAZ, WHZ and WAZ, as well as density plots.
- Why – general assumption that 3 indices are normally distributed but unclear if applicable to populations with varying patterns of malnutrition. One can use the rule of thumb ranges of <-0.5 or >+0.5 for skewness to indicate asymmetry and <2 or >4 for kurtosis to indicate heavy or light tails. Further research needed to understand patterns in different contexts. Anyhow the comparisons amongst the distribution by disaggregation categories might help with the interpretation of results.

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[11] WHO Anthro Software for personal computers - Manual (2011). Available at www.who.int/childgrowth/software/anthro_pc_manual_v322.pdf?ua=1.

APPENDIX B: EXAMPLE OF SUMMARY REPORT

SURVEY TITLE

ADD SURVEY DETAILS - STUDY LOCATION, STUDY PERIOD, ETC

AUTHOR

Recommended citation:

Report template with results from WHO Anthro Survey Analyser

Analysis date: 2019-03-14 16:41:22

Link: https://whonutrition.shinyapps.io/anthro/

Overall survey results summary

Outcome plots

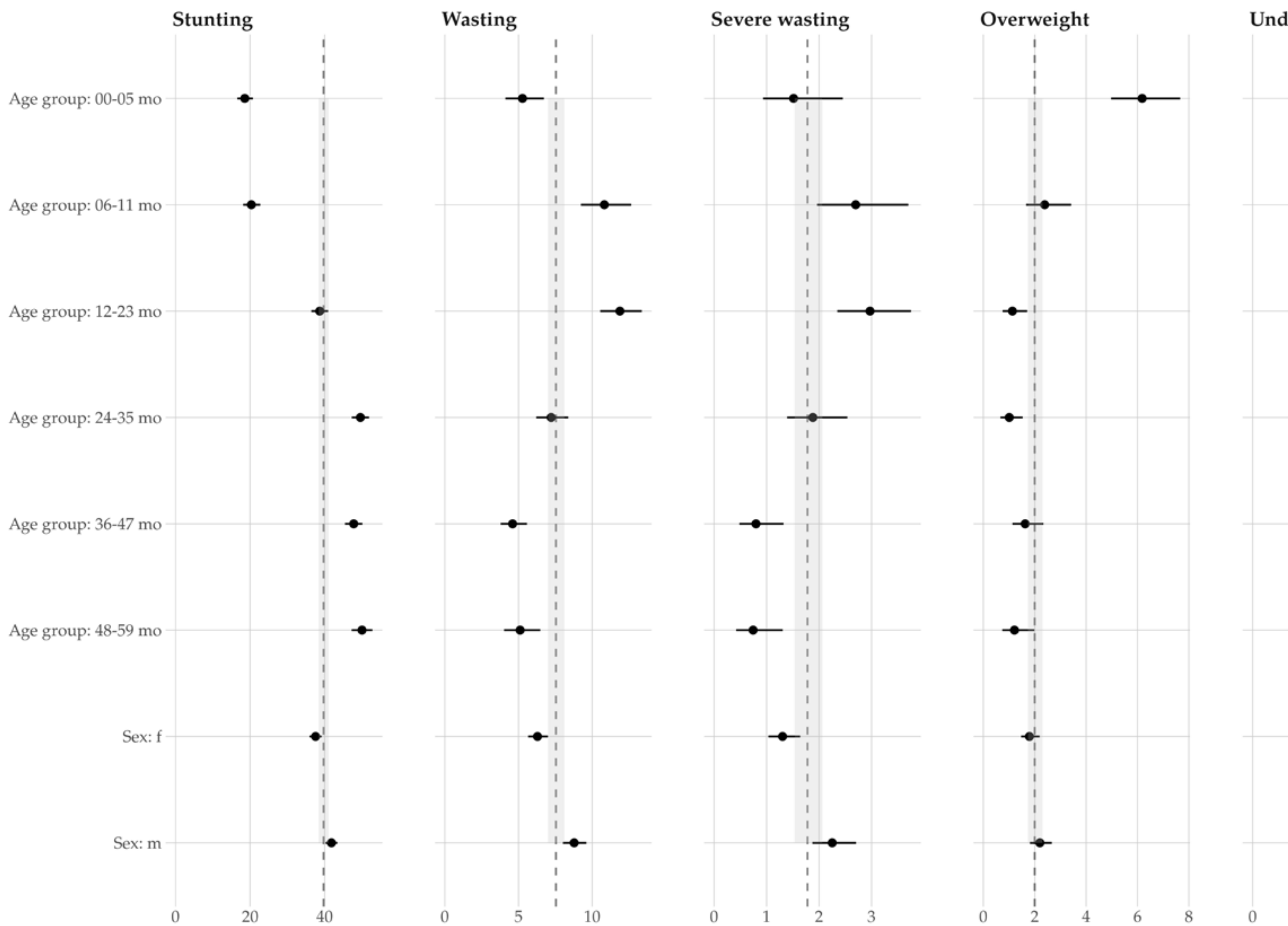

Figure 1: Nutritional status by stratification variable

Summary on survey description

Sample size:

The original sample was of 15741 children. There were 15735 children retained after filtering for **[INSERT DETAILS OF ANY FILTERING APPLIED]**; height measurements were obtained for 15580 (99%) children and weight measurements were obtained for 15647 (99.4%). There were 3 (0%) children with missing information on sex and there were 13 (0.1%) children with missing age and 2 (0%) children with negative values for age. There were 6 (0%) children aged greater than sixty months who were excluded from the analysis. There were 39 cases of oedema reported.

Sample design:

Household listing (source or how was it done to update existing information)

Training of field staff: How many, how many teams, how many measurements per team per day

Standardization

Equipment and calibration

Data collection period

Data collection: Start: [**enter month and year the survey started MM/YYYY**]; End: [**enter month and year the survey ended MM/YYYY**]

Data entry

Supervision

Other survey context important for the interpretation of results

Seasonality (e.g. harvest and malaria)

Climate conditions (e.g. monsoon, drought, natural catastrophes)

Epidemics, high mortality

Security issues, civil unrest

Population groups not covered (e.g. slums, refugees)

Summary of survey analysis

Data processing: Software …..

Data cleaning:

Imputations:

Data quality indicators and assessment

Flags:

Flags were calculated as follows: …

There were 78 (0.5%) flags for length- or height-for-age, 11 (0.1%) flags for weight-for-age, 31 (0.2%) flags for body mass index-for-age, 26 (0.2%) flags for weight-for-length or height.

Missing data

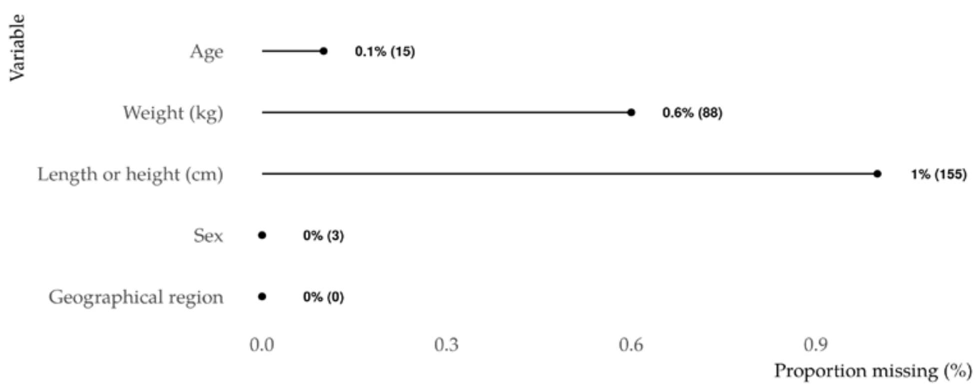

Figure 2: Missing data

Digit heaping charts (with mapping variable labels)

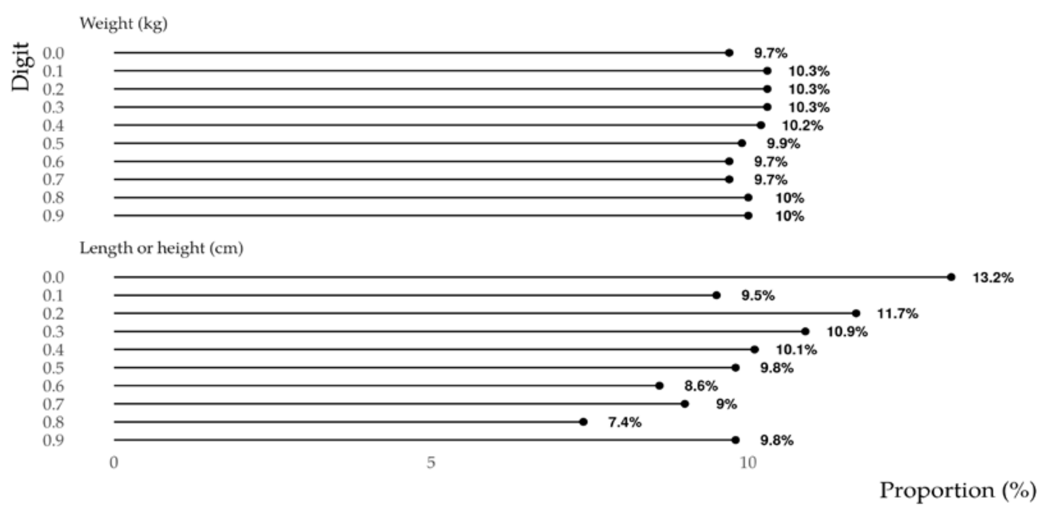

Figure 3: Digit preference for weight & height measurements

Z-score distribution issues

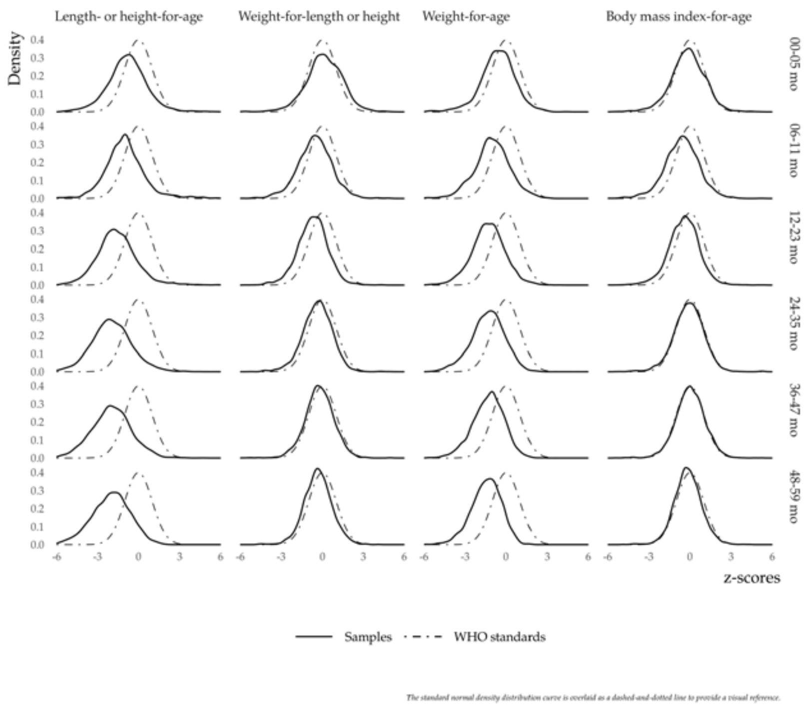

Figure 4: Z-score distributions by age group

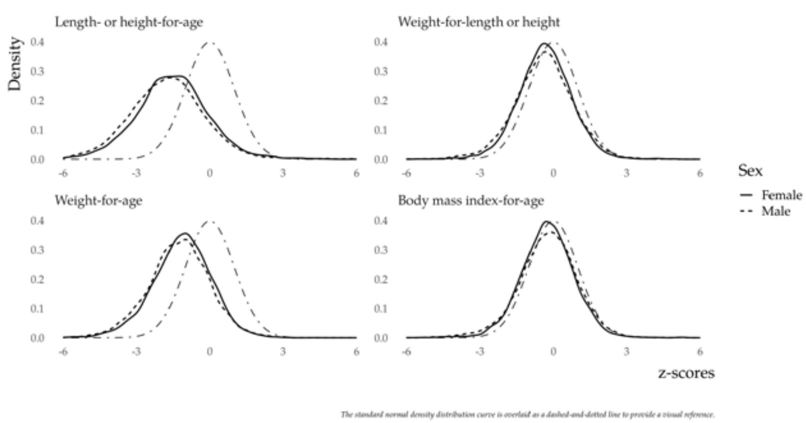

Figure 5: Z-score distributions by sex

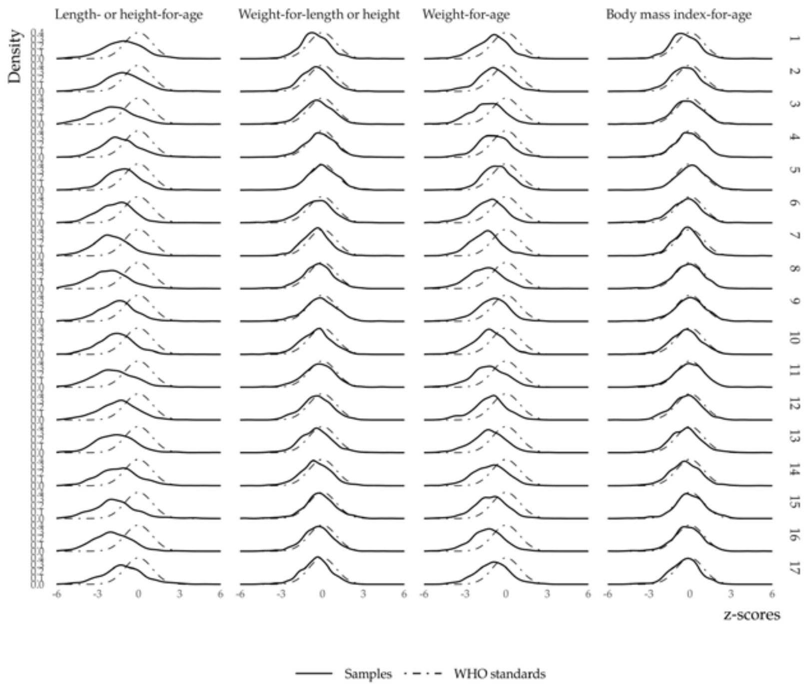

Figure 6: Z-score distributions by geographical region

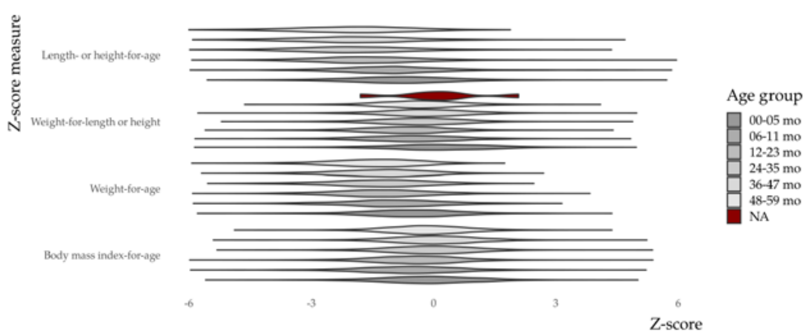

Figure 7: z-score distribution violin plot by age group

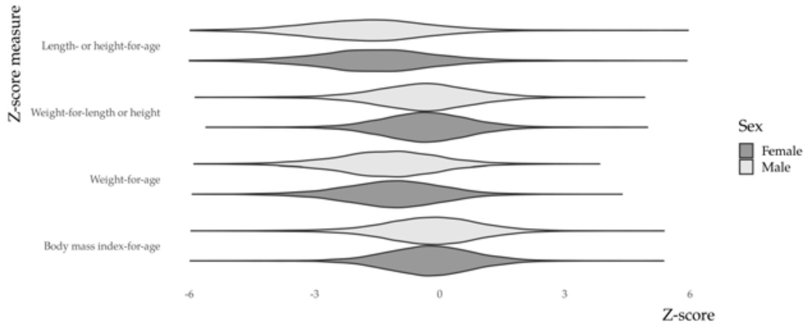

Figure 8: z-score distribution violin plot by sex

Appendix: Nutritional status tables

Height-for-age

Group	Weighted N	Unweighted N	-3SD (95% CI)	-2SD (95% CI)	z-score SD
All	15272.0	15496	17.1 (16.2; 18.1)	39.7 (38.4; 41.0)	1.54
Age group: 00-05 mo	1930.4	2058	5.7 (4.6; 7.1)	18.6 (16.6; 20.8)	1.45
Age group: 06-11 mo	1765.1	1812	5.8 (4.7; 7.1)	20.3 (18.1; 22.7)	1.46
Age group: 12-23 mo	3196.3	3313	14.7 (13.2; 16.3)	38.7 (36.5; 41.0)	1.50
Age group: 24-35 mo	3178.6	3136	22.2 (20.4; 24.1)	49.6 (47.3; 51.9)	1.48
Age group: 36-47 mo	3058.9	3068	23.0 (21.2; 25.0)	47.8 (45.5; 50.2)	1.48
Age group: 48-59 mo	2142.7	2109	24.2 (22.0; 26.6)	50.0 (47.2; 52.8)	1.40
Sex: f	7605.5	7720	14.9 (13.8; 16.0)	37.6 (36.0; 39.2)	1.51
Sex: m	7666.4	7776	19.3 (18.1; 20.5)	41.8 (40.3; 43.4)	1.56
Age + sex: 00-05 mo.f	963.5	1006	3.8 (2.7; 5.4)	15.2 (12.7; 18.2)	1.44
Age + sex: 06-11 mo.f	878.7	896	3.3 (2.2; 4.9)	16.5 (13.9; 19.4)	1.40
Age + sex: 12-23 mo.f	1593.8	1677	12.1 (10.2; 14.2)	36.3 (33.3; 39.4)	1.40
Age + sex: 24-35 mo.f	1559.4	1542	19.2 (17.0; 21.5)	47.0 (43.8; 50.2)	1.45
Age + sex: 36-47 mo.f	1548.8	1545	21.4 (18.9; 24.0)	45.6 (42.6; 48.7)	1.45
Age + sex: 48-59 mo.f	1061.3	1054	22.9 (20.1; 26.1)	51.8 (47.9; 55.6)	1.37
Age + sex: 00-05 mo.m	966.9	1052	7.7 (5.9; 9.9)	21.9 (19.0; 25.1)	1.45
Age + sex: 06-11 mo.m	886.3	916	8.2 (6.4; 10.5)	24.2 (21.0; 27.7)	1.50
Age + sex: 12-23 mo.m	1602.5	1636	17.3 (15.1; 19.7)	41.1 (38.0; 44.3)	1.59
Age + sex: 24-35 mo.m	1619.2	1594	25.1 (22.7; 27.7)	52.2 (49.2; 55.1)	1.50
Age + sex: 36-47 mo.m	1510.2	1523	24.8 (22.1; 27.6)	50.0 (46.7; 53.4)	1.51
Age + sex: 48-59 mo.m	1081.4	1055	25.4 (22.3; 28.8)	48.3 (44.6; 52.1)	1.42
Geographical region: 1	171.3	806	10.3 (8.3; 12.7)	27.3 (24.4; 30.4)	1.53
Geographical region: 2	2501.9	880	9.3 (6.8; 12.7)	26.1 (21.7; 31.1)	1.51
Geographical region: 3	964.8	921	24.0 (20.7; 27.7)	47.8 (43.2; 52.4)	1.59
Geographical region: 4	357.3	945	11.2 (8.9; 14.0)	31.6 (28.2; 35.3)	1.49
Geographical region: 5	228.6	972	7.2 (5.7; 9.0)	25.8 (22.1; 29.9)	1.30
Geographical region: 6	467.5	926	15.6 (12.6; 19.1)	40.2 (35.5; 45.1)	1.30
Geographical region: 7	974.7	1083	22.1 (19.2; 25.3)	51.2 (47.5; 55.0)	1.39
Geographical region: 8	1411.9	1264	27.5 (24.1; 31.1)	54.7 (51.1; 58.3)	1.50
Geographical region: 9	649.7	979	14.5 (11.8; 17.7)	35.6 (31.9; 39.6)	1.49

Geographical region: 10	467.3	1070	14.8 (12.3; 17.6)	37.6 (34.3; 41.0)	1.36
Geographical region: 11	912.4	645	22.3 (18.9; 26.2)	48.1 (43.1; 53.1)	1.53
Geographical region: 12	1395.0	876	15.1 (11.9; 18.9)	35.6 (30.7; 40.9)	1.46
Geographical region: 13	1066.2	774	16.4 (13.6; 19.7)	40.4 (35.8; 45.2)	1.49
Geographical region: 14	1424.0	799	14.1 (12.0; 16.6)	35.4 (31.1; 39.9)	1.55
Geographical region: 15	1674.6	976	19.8 (16.2; 23.9)	44.6 (40.3; 49.0)	1.61
Geographical region: 16	400.2	1078	22.3 (18.6; 26.5)	48.3 (44.6; 52.1)	1.41
Geographical region: 17	204.6	502	11.2 (8.3; 14.8)	26.1 (22.1; 30.6)	1.54

Weight-for-age

Group	Weighted N	Unweighted N	-3SD (95% CI)	-2SD (95% CI)	z-score SD	Oedema_cases
All	15457.8	15630	8.3 (7.7; 9.0)	24.6 (23.6; 25.6)	1.24	39
Age group: 00-05 mo	2023.6	2114	4.0 (3.0; 5.2)	10.8 (9.2; 12.6)	1.26	0
Age group: 06-11 mo	1772.5	1818	7.1 (5.8; 8.6)	20.2 (18.1; 22.4)	1.29	3
Age group: 12-23 mo	3219.0	3330	8.9 (7.7; 10.2)	26.6 (24.8; 28.6)	1.25	14
Age group: 24-35 mo	3198.5	3155	10.4 (9.1; 11.8)	28.3 (26.4; 30.4)	1.22	15
Age group: 36-47 mo	3083.1	3088	8.7 (7.5; 10.0)	26.4 (24.6; 28.4)	1.17	5
Age group: 48-59 mo	2161.1	2125	9.0 (7.7; 10.6)	29.9 (27.6; 32.3)	1.09	2
Sex: f	7676.5	7771	7.2 (6.5; 8.0)	22.9 (21.6; 24.3)	1.21	18
Sex: m	7781.3	7859	9.4 (8.5; 10.4)	26.2 (25.0; 27.5)	1.27	21
Age + sex: 00-05 mo.f	1006.7	1033	3.6 (2.5; 5.3)	9.0 (6.9; 11.6)	1.23	0
Age + sex: 06-11 mo.f	881.8	899	4.6 (3.2; 6.6)	17.7 (14.9; 20.8)	1.23	1
Age + sex: 12-23 mo.f	1600.3	1682	6.3 (5.0; 8.0)	24.9 (22.4; 27.7)	1.19	6
Age + sex: 24-35 mo.f	1562.9	1546	9.4 (7.8; 11.3)	26.2 (23.6; 29.0)	1.21	8
Age + sex: 36-47 mo.f	1557.0	1551	8.2 (6.7; 10.0)	25.1 (22.6; 27.8)	1.15	2
Age + sex: 48-59 mo.f	1067.8	1060	9.4 (7.5; 11.7)	29.4 (26.2; 32.9)	1.07	1
Age + sex: 00-05 mo.m	1016.9	1081	4.3 (3.0; 6.1)	12.6 (10.4; 15.3)	1.28	0
Age + sex: 06-11 mo.m	890.7	919	9.5 (7.5; 12.1)	22.7 (19.6; 26.2)	1.35	2
Age + sex: 12-23 mo.m	1618.8	1648	11.4 (9.7; 13.4)	28.3 (25.8; 30.9)	1.30	8
Age + sex: 24-35 mo.m	1635.6	1609	11.3 (9.6; 13.2)	30.3 (27.6; 33.2)	1.23	7
Age + sex: 36-47 mo.m	1526.1	1537	9.1 (7.4; 11.1)	27.8 (25.1; 30.7)	1.19	3
Age + sex: 48-59 mo.m	1093.3	1065	8.7 (6.9; 10.8)	30.4 (27.2; 33.7)	1.11	1
Geographical region: 1	171.5	807	5.7 (4.2; 7.7)	20.3 (17.3; 23.8)	1.20	0
Geographical region: 2	2536.1	892	7.0 (4.7; 10.1)	17.8 (14.9; 21.2)	1.23	2
Geographical region: 3	981.6	937	10.5 (8.7; 12.6)	29.5 (25.7; 33.5)	1.24	4
Geographical region: 4	358.1	947	4.3 (3.2; 5.8)	15.0 (12.4; 18.0)	1.17	0
Geographical region: 5	228.9	973	2.0 (1.2; 3.1)	9.2 (7.1; 12.0)	1.08	1
Geographical region: 6	468.0	927	9.5 (7.4; 12.1)	26.5 (23.3; 30.1)	1.19	4
Geographical region: 7	981.9	1091	10.0 (7.8; 12.8)	33.1 (29.8; 36.5)	1.17	4
Geographical region: 8	1438.7	1288	12.7 (10.6; 15.1)	35.7 (32.3; 39.3)	1.28	1
Geographical region: 9	651.0	981	6.6 (4.6; 9.5)	19.3 (16.3; 22.7)	1.20	5
Geographical region: 10	467.7	1071	7.2 (5.7; 9.0)	23.7 (21.2; 26.4)	1.15	4
Geographical region: 11	925.2	654	9.8 (7.7; 12.3)	28.3 (24.7; 32.2)	1.27	3
Geographical region: 12	1401.3	880	8.0 (5.7; 11.0)	22.6 (19.8; 25.7)	1.21	0
Geographical region: 13	1078.6	783	9.7 (7.9; 11.8)	25.9 (22.7; 29.5)	1.25	4
Geographical region: 14	1454.3	816	7.2 (5.5; 9.4)	24.9 (20.9; 29.3)	1.26	1
Geographical region: 15	1707.2	995	6.8 (4.9; 9.4)	21.9 (18.1; 26.3)	1.23	2
Geographical region: 16	402.0	1083	9.4 (7.3; 12.1)	29.2 (25.3; 33.4)	1.21	4
Geographical region: 17	205.8	505	5.0 (3.2; 7.6)	19.2 (16.3; 22.5)	1.23	0

There were 39 cases of bilateral oedema, for which weight-for-age and weight-for-height z-scores were considered as below -3 for prevalence calculation purposes.

Weight-for-height

Group	Weighted N	Unweighted N	-3SD (95% CI)	-2SD (95% CI)	+2SD (95% CI)	+3SD (95% CI)	z-score SD	Oedema_cases
All	15324.5	15541	1.8 (1.5; 2.1)	7.5 (7.0; 8.1)	2.0 (1.7; 2.3)	0.4 (0.3; 0.5)	1.15	39
Age group: 00-05 mo	1917.9	2049	1.5 (0.9; 2.5)	5.3 (4.1; 6.7)	6.2 (5.0; 7.7)	1.5 (0.9; 2.3)	1.30	0
Age group: 06-11 mo	1769.9	1815	2.7 (2.0; 3.7)	10.8 (9.2; 12.6)	2.4 (1.7; 3.4)	0.5 (0.2; 1.1)	1.23	3
Age group: 12-23 mo	3207.9	3321	3.0 (2.3; 3.7)	11.9 (10.5; 13.4)	1.1 (0.7; 1.7)	0.2 (0.1; 0.5)	1.12	14
Age group: 24-35 mo	3192.6	3149	1.9 (1.4; 2.5)	7.2 (6.2; 8.4)	1.0 (0.7; 1.5)	0.2 (0.1; 0.5)	1.08	15
Age group: 36-47 mo	3069.5	3078	0.8 (0.5; 1.3)	4.6 (3.8; 5.6)	1.6 (1.1; 2.3)	0.2 (0.1; 0.5)	1.04	5
Age group: 48-59 mo	2158.8	2123	0.7 (0.4; 1.3)	5.1 (4.0; 6.5)	1.2 (0.7; 2.0)	0.1 (0.0; 0.5)	1.02	2
Sex: f	7622.1	7732	1.3 (1.0; 1.6)	6.3 (5.7; 7.0)	1.8 (1.5; 2.2)	0.4 (0.3; 0.6)	1.11	18
Sex: m	7702.3	7809	2.2 (1.9; 2.7)	8.8 (8.0; 9.6)	2.2 (1.8; 2.7)	0.3 (0.2; 0.5)	1.19	21
Age + sex: 00-05 mo.f	956.7	999	1.0 (0.5; 2.2)	4.5 (3.1; 6.4)	4.8 (3.4; 6.7)	1.1 (0.5; 2.3)	1.23	0
Age + sex: 06-11 mo.f	880.0	898	2.4 (1.4; 4.0)	9.4 (7.3; 12.0)	2.6 (1.6; 4.3)	0.7 (0.3; 1.7)	1.20	1
Age + sex: 12-23 mo.f	1596.9	1678	1.7 (1.1; 2.5)	9.1 (7.4; 11.1)	1.2 (0.7; 2.1)	0.2 (0.0; 0.5)	1.06	6
Age + sex: 24-35 mo.f	1561.6	1544	1.7 (1.1; 2.7)	6.0 (4.7; 7.7)	0.9 (0.5; 1.7)	0.4 (0.2; 1.0)	1.06	8
Age + sex: 36-47 mo.f	1554.1	1549	0.6 (0.3; 1.4)	4.1 (3.1; 5.5)	1.5 (0.9; 2.4)	0.3 (0.1; 0.8)	1.02	2
Age + sex: 48-59 mo.f	1067.8	1060	0.5 (0.1; 1.6)	4.7 (3.4; 6.6)	1.0 (0.5; 2.0)	0.2 (0.0; 1.0)	1.01	1
Age + sex: 00-05 mo.m	961.2	1050	2.0 (1.1; 3.7)	6.1 (4.4; 8.2)	7.6 (5.9; 9.7)	1.8 (1.0; 3.2)	1.37	0
Age + sex: 06-11 mo.m	889.9	917	3.0 (2.0; 4.4)	12.2 (10.0; 14.8)	2.1 (1.3; 3.6)	0.3 (0.1; 1.1)	1.27	2
Age + sex: 12-23 mo.m	1611.0	1643	4.3 (3.2; 5.6)	14.7 (12.7; 16.9)	1.1 (0.6; 2.0)	0.2 (0.0; 1.1)	1.17	8
Age + sex: 24-35 mo.m	1631.0	1605	2.0 (1.3; 3.1)	8.3 (6.8; 10.2)	1.1 (0.6; 2.0)	0.0 (0.0; 0.1)	1.09	7
Age + sex: 36-47 mo.m	1515.4	1529	1.0 (0.5; 1.9)	5.1 (3.9; 6.6)	1.7 (1.1; 2.8)	0.1 (0.0; 0.4)	1.07	3
Age + sex: 48-59 mo.m	1091.0	1063	1.0 (0.6; 1.8)	5.5 (4.0; 7.4)	1.4 (0.8; 2.7)	0.1 (0.0; 0.2)	1.04	1
Geographical region: 1	171.5	807	1.1 (0.6; 2.1)	8.1 (5.8; 11.1)	1.1 (0.6; 1.9)	0.5 (0.2; 1.3)	1.07	0
Geographical region: 2	2507.6	882	1.9 (1.2; 3.2)	8.3 (6.6; 10.3)	1.4 (0.8; 2.4)	0.3 (0.1; 1.0)	1.12	2
Geographical region: 3	971.1	927	2.4 (1.4; 3.9)	7.8 (6.1; 9.9)	1.6 (1.0; 2.7)	0.4 (0.2; 1.1)	1.15	4
Geographical region: 4	357.3	945	1.1 (0.6; 1.9)	5.7 (4.2; 7.7)	2.6 (1.9; 3.8)	0.8 (0.4; 1.7)	1.17	0
Geographical region: 5	228.9	973	0.7 (0.4; 1.4)	3.4 (2.2; 5.1)	3.5 (2.5; 4.9)	0.8 (0.4; 1.7)	1.11	1
Geographical region: 6	468.0	927	3.3 (2.3; 4.9)	10.4 (8.2; 13.0)	1.2 (0.6; 2.3)	0.4 (0.2; 1.1)	1.21	4
Geographical region: 7	979.2	1088	1.3 (0.8; 2.0)	6.6 (5.3; 8.3)	1.6 (0.9; 2.7)	0.6 (0.2; 1.6)	1.08	4
Geographical region: 8	1426.4	1277	1.6 (1.1; 2.5)	7.1 (5.6; 9.0)	1.6 (1.0; 2.6)	0.1 (0.0; 0.5)	1.13	1
Geographical region: 9	650.3	980	2.2 (1.4; 3.6)	7.6 (5.5; 10.2)	2.9 (1.8; 4.5)	0.6 (0.2; 1.6)	1.21	5
Geographical region: 10	467.3	1070	2.2 (1.5; 3.4)	8.1 (6.8; 9.7)	1.1 (0.6; 2.0)	0.1 (0.0; 0.7)	1.13	4
Geographical region: 11	920.9	651	1.5 (0.8; 2.9)	7.7 (5.9; 10.0)	1.7 (1.0; 3.0)	0.3 (0.1; 1.2)	1.15	3
Geographical region: 12	1398.2	878	0.8 (0.4; 1.6)	8.4 (6.4; 11.1)	1.6 (0.9; 2.8)	0.1 (0.0; 0.8)	1.10	0

Geographical region: 13	1070.3	777	1.9 (1.2; 3.1)	8.0 (6.5; 9.7)	2.3 (1.6; 3.4)	0.8 (0.4; 1.6)	1.18	4
Geographical region: 14	1422.2	798	1.9 (1.1; 3.2)	8.6 (6.7; 11.1)	2.3 (1.4; 3.6)	0.5 (0.2; 1.3)	1.16	1
Geographical region: 15	1679.7	979	1.9 (1.2; 3.1)	5.2 (3.8; 7.0)	4.0 (2.8; 5.7)	0.4 (0.2; 1.0)	1.19	2
Geographical region: 16	400.9	1080	2.0 (1.3; 3.2)	7.5 (5.9; 9.6)	1.5 (0.9; 2.5)	0.3 (0.1; 0.8)	1.12	4
Geographical region: 17	204.6	502	1.8 (1.0; 3.4)	6.8 (5.0; 9.1)	0.6 (0.1; 2.5)	0.0 (0.0; 0.0)	1.07	0

There were 39 cases of bilateral oedema, for which weight-for-age and weight-for-height z-scores were considered as below -3 for prevalence calculation purposes.

APPENDIX C: KEY CONSIDERATIONS FOR DATA STANDARDISATION

Table 6. Suggested components and key considerations for standardising the analysis of anthropometric data.

Component	Key considerations
1. Reference data for z-score calculation	• Use the WHO Child Growth Standards[12] for child malnutrition monitoring.
2. Missing data	• Any recode of missing values (depending on the software or code used for the analysis, e.g. 9998, 9999, 99 recode to blank cells) or imputation should be made by creating a new variable. The original variables should always be retained since their presence in the file guarantees data reproducibility and transparency. • It is important that all records, including those with missing all measurements or sampling weights, are available for analysis, since they are important for data quality assessment (e.g. non-response). • Imputation of missing day of birth: if only the month and year of birth are provided, it is recommended that the missing information for the day of birth be imputed. This can be done in different ways, but the use of day 15 for all missing days of birth is recommended in the standard analysis. The approach used for imputing the date of birth and the number or proportion of cases falling on the imputed day should be mentioned in the report for data quality assessment. • If the month or year of birth is missing, then the date of birth and consequently the child's age should be considered as missing. • Some surveys use a code number for missing values such as 9999, 9998, 98, etc. Such numbers should always be treated as missing data and not as extreme values, since it is important to differentiate between implausible z-score values and missing measurements when assessing data quality.
3. Age calculation	• Age should be calculated using the date of visit and date of birth. Subsequently both variables should remain in the analysis file. • If exact date of birth is unknown, the month and year of birth should be estimated using a local events calendar. In such cases, age should be calculated after imputing the day of birth as the 15th.
4. Oedema (Althaus assessment of oedema is not recommended for systematic inclusion in all surveys except in settings where	• Oedema measurement is only appropriate in surveys where local experts, specifically clinicians or individuals from the Ministry of Health working at a local level, can clearly indicate if they have seen recent cases where nutritional oedema was present (see Note 1 in Chapter 1 for more details). • If information on oedema is collected following the above recommendation, it should be included in each child's dataset and used in the analysis. In this event:

[12] WHO Child Growth Standards. Available at http://www.who.int/childgrowth/standards/en/.

Component	Key considerations
collecting this information is appropriate)	▪ all children, even those with oedema, should be weighed to reduce the likelihood of biased decisions in the field; ▪ children with oedema should automatically be classified with "severe acute malnutrition" (<-3SD for weight-related indexes) to calculate prevalence estimates; ▪ weight-related indices z-scores will not be calculated for children with oedema (i.e. set to missing); ▪ the number of cases of oedema should be included in the survey report; ▪ prevalence levels based on analyses both including and excluding oedema-related data should be included in the survey report.
5. Conversion of recumbent length to standing height or vice versa	Recumbent length or standing height • Verify that child's measurement position (standing height or recumbent, i.e. supine or lying length) was recorded in the questionnaire during measurement to allow for age-linked adjustments in height/length measurement depending on whether they were lying or standing. • Based on the recorded measurement position, software performing the standard analysis ought to make automatic adjustments when calculating z-scores, adding 0.7cm if the standing height was measured for children aged < 24 months and subtracting 0.7cm if the recumbent (lying) length was measured for children aged ⩾ 24 months. • If data on the measurement position are missing, recumbent length is assumed to have been adopted for children aged <731 days (<24 months) and standing height for those with aged >=731 days (24+ months). • For children under 9 months of age, data which suggests that the infant was "standing" rather than the expected "lying" should be disregarded in the analysis, i.e. set to missing, since this is deemed to be an error. This is done to avoid the wrong automatic adjustment in such cases (adding 0.7 cm), which would result in an overestimation of wasting and underestimation of stunting.
6. Handling remeasurement data	• The remeasurements (height, weight, date of birth, and sex) of children selected randomly or flagged should be retained in the datafile. Use the height, weight, date of birth, and sex from the first measurement for children randomly selected for remeasurement in the calculation of z-scores. Use the height, weight, date of birth, and sex from the second measurement for children flagged for remeasurement in the calculation of z-scores.

Component	Key considerations
7. Exclusion of flagged z-scores (WHO flag system)	• The recommended flags for z-score values follow the WHO flag system[13] (see section 3.2.1 below for a discussion of flagging systems): - height-for-age: < -6 or > +6 - weight-for-length/height: < -5 or > +5 - weight-for-age: < -6 or > +5 - body mass index-for-age: < -5 or > +5. • The number and percentage of values excluded should be reported. • Exclusions should be made based on the indicator (rather than child), e.g. measurements for a child with a HAZ of -6.5 and a WHZ of -4.5 would be included in analysis of wasting (WHZ) but not of stunting (HAZ). • All measurements should be retained in the dataset for transparency. • Flagged z-scores are excluded before calculating prevalence estimates and other z-score summary statistics.
8. Sampling design	Strata and Cluster • The purpose of stratification is to ensure that the sample is representative of the population of interest and divides the population into homogeneous groups (typically geographic groups) before sampling. Stratification in the sampling design helps to reduce sampling errors when introduced at the initial stage of sampling (its effect on the sampling error is minor when introduced at the second or later stages). • Strata should not be confused with survey domains, i.e. a population subgroup for which separate survey estimates are desirable (e.g. urban/rural areas, see bullet point 8 below)[14]. Both categories may be the same, but do not need to be. A cluster is a group of neighbouring households which usually serves as the Primary Sampling Unit (PSU) for efficient field work. • Each child/household should be assigned to a cluster and strata and analyses should take that information into account to boost the stability of estimated variance. Sampling weights • A sampling statistician should create the weights. • A sampling weight must be assigned to each individual in the sample to compensate for unequal probabilities of case selection in a sample, usually owing to the design. In a self-weighted

[13] WHO Anthro 2005 for personal computers manual. page 41: http://www.who.int/childgrowth/software/WHOAnthro2005_PC_Manual.pdf
[14] DHS Sampling manual, p. 4: https://dhsprogram.com/pubs/pdf/DHSM4/DHS6_Sampling_Manual_Sept2012_DHSM4.pdf.

Component	Key considerations
	sample, the weight is the same for each child (usually equals to 1 for simplicity). • To derive anthropometric indicator estimates, appropriate sampling weights should be applied in each survey while taking into consideration sample stratification. This is done to make sure that the sample population is fully representative. • Sampling weights can also be adjusted for non-responses. • All individuals not assigned a sampling weight should be excluded from analyses for generating malnutrition estimates but remain in the data set for reporting purposes.
9. Stratified analysis for population sub-groups (when available)	• The most common population disaggregation factors are age (different age groups), sex (male or female), type of residence (urban or rural) and regions or districts. For age grouping, standard analysis relies on the exact age in days (where available) to define age groups in months (e.g. <6, 6 to <12, 12 to <24, 24 to < 36, 36 to <48 and 48 to <60). One month is equivalent to 30.4375 days. • Monitoring equity is of increasing importance for health and development. Disaggregated analysis is also recommended to derive estimates by wealth quintiles (1=lowest, 2, 3, 4, 5=highest) and mother's education (no education, primary school and secondary school or higher), whenever this is possible.