PART 6. Comparison of Anthropometric Data to Reference Standards

Comparing the measurements of children to reference standards is an easy procedure because of readily available, public-domain computer software. This section describes some underlying principles for efficient use of the available software, beginning with how individual measurements are compared to the reference standard.

6.1. NCHS/WHO Reference Standards

The reference standards most commonly used to standardize measurements were developed by the US National Center for Health Statistics (NCHS) and are recommended for international use by the World Health Organization. The reference population chosen by NCHS was a statistically valid random population of healthy infants and children. Questions have frequently been raised about the validity of the US-based NCHS reference standards for populations from other ethnic backgrounds. Available evidence suggests that until the age of approximately 10 years, children from well-nourished and healthy families throughout the world grow at approximately the same rate and attain the same height and weight as children from industrialized countries. The NCHS/WHO reference standards are available for children up to 18 years old but are most accurate when limited to use with children up to the age of 10 years. The NCHS/WHO international reference tables can be used for standardizing anthropometric data from around the world and can be found on FANTA's website at www.fantaproject.org/publications/anthropometry.shtml.

6.2. Comparisons to the Reference Standard

References are used to standardize a child's measurement by comparing the child's measurement with the median or average measure for children at the same age and sex. For example, if the length of a 3 month old boy is 57 cm, it would be difficult to know if that was reflective of a healthy 3 month old boy without comparison to a reference standard. The reference or median length for a population of 3 month old boys is 61.1 cm and the simple comparison of lengths would conclude that the child was almost 4 cm shorter than could be expected.

When describing the differences from the reference, a numeric value can be standardized to enable children of different ages and sexes to be compared. Using the example above, the boy is 4 cm shorter than the reference child but this does not take the age or the sex of the child into consideration. Comparing a 4 cm difference from the reference for a child 3 months old is not the same as a 4 cm difference from the reference for a 9 year old child, because of their relatively different body sizes.

Taking age and sex into consideration, differences in measurements can be expressed a number of ways:

- standard deviation units, or Z-scores
- percentage of the median
- percentiles

To standardize reporting, USAID recommends that Cooperating Sponsors calculate percentages of children below cut-offs as well as other statistics using Z-scores. If Z-scores cannot be used, percentage of the median should be used.

6.3. Standard Deviation Units or Z-Scores

Z-scores are more commonly used by the international nutrition community because they offer two major advantages. First, using Z-scores allows us to identify a fixed point in the distributions of different indices and across different ages. For all indices for all ages, 2.28% of the reference population lie below a cut-off of -2 Z-scores. The percent of the median does not have this characteristic. For example, because weight and height have different distributions (variances), -2 Z-scores on the weight-for-age distribution is about 80% of the median, and -2 Z-scores on the height-for-age distribution is about 90% of the median. Further, the proportion of the population identified by a particular percentage of the median varies at different ages on the same index.

The second major advantage of using Z-scores is that useful summary statistics can be calculated from them. The approach allows the mean and standard deviation to be calculated for the Z-scores for a group of children. The Z-score application is considered the simplest way of describing the reference population and making comparisons to it. It is the statistic recommended for use when reporting results of nutritional assessments. Examples of Z-score calculations are presented in Appendix 1.

The **Z-score** or **standard deviation unit (SD)** is defined as the difference between the value for an individual and the median value of the reference population for the same age or height, divided by the standard deviation of the reference population. This can be written in equation form as:

$$\textbf{Z-score (or SD-score)} = \frac{\textbf{(observed value) - (median reference value)}}{\textbf{standard deviation of reference population}}$$

6.4. Percentage of the Median and Percentiles

The percentage of the median is defined as the ratio of a measured or observed value in the individual to the median value of the reference data for the same age or height for the specific sex, expressed as a percentage. This can be written in equation form as:

$$\textbf{Percent of median} = \frac{\textbf{observed value}}{\textbf{median value of reference population}} \times 100$$

The median is the value at exactly the mid-point between the largest and smallest. If a child's measurement is exactly the same as the median of the reference population we say that they are "100% of the median." Examples of calculations for percent of median can be found in Appendix 1.

The percentile is the rank position of an individual on a given reference distribution, stated in terms of what percentage of the group the individual equals or exceeds. Percentiles will not be presented in this guide.

The distribution of Z-scores follows a normal (bell-shaped or Gaussian) distribution. The commonly used cut-offs of -3, -2, and -1 Z-scores are, respectively, the 0.13th, 2.28th, and 15.8th percentiles. The percentiles can be thought of as the percentage of children in the reference population below the equivalent cut-off. Approximately 0.13 percent of children would be expected to be below -3 Z-score in a normally distributed population.

Z-score	Percentile
-3	0.13
-2	2.28
-1	15.8

6.5. Cut-offs

The use of a cut-off enables the different individual measurements to be converted into prevalence statistics. Cut-offs are also used for identifying those children suffering from or at a higher risk of adverse outcomes. The children screened under such circumstances may be identified as eligible for special care.

The most commonly-used cut-off with Z-scores is **-2 standard deviations**, irrespective of the indicator used. This means children with a Z-score for underweight, stunting or wasting, below -2 SD are considered moderately or severely malnourished. For example, a child with a Z-score for height-for-age of -2.56 is considered stunted, whereas a child with a Z-score of -1.78 is not classified as stunted.

In the reference population, by definition, 2.28% of the children would be below -2 SD and 0.13% would be below -3 SD (a cut-off reflective of a severe condition). In some cases, the cut-off for defining malnutrition used is -1 SD (e.g. in Latin America). In the reference or healthy population, 15.8% would be below a cut-off of -1 SD. The use of -1 SD is generally discouraged as a cut-off due to the large percentage of healthy children normally falling below this cut-off. For example, the 1995 DHS survey using a –2 SD cut-off for stunting in Uganda found a 36% prevalence of stunting in under-three year olds. This level of stunting is about 16 times the level of the reference population.

A comparison of cutoffs for percent of median and Z-scores illustrates the following:

90% = -1 Z-score
80% = -2 Z-score
70% = -3 Z-score (approx.)
60% = -4 Z-score (approx.)

6.5.1. Cut-off points for MUAC for the 6 - 59 month age group

MUAC cut-offs are somewhat arbitrary due to its lack of precision as a measure of malnutrition. A cut-off of 11.0 cm can be used for screening severely malnourished children. Those children with MUAC below 12.5 cm with or without edema are classified as moderate and severe.

Global Acute Malnutrition is a term generally used in emergency settings. The global malnutrition rate refers to the percent of children 6 to 59 months with weight-for-height below -2 Z-scores or 80% median or MUAC below 12.5 cm, with or without edema. This refers to all moderate and severe malnutrition combined. The combination of a low weight-for-height and any child with edema contributes to those children counted as in the global acute malnutrition statistic.

6.5.2. Malnutrition Classification Systems

The cut-off points for different malnutrition classification systems are listed below. The most widely used system is WHO classification (Z-scores). The Road-to-Health (RTH) system is typically seen in clinic-based growth-monitoring systems. The Gomez system was widely used in the 1960s and 1970s, but is only used in a few countries now. An analysis of prevalence elicits different results from different systems. These results would not be directly comparable. The difference is especially broad at the severe malnutrition cut-off between the WHO method (Z-scores) and percent of median methods. At 60% of the median, the closest corresponding Z-score is –4. The WHO method is recommended for analysis and presentation of data (see Part 6.2).

Mild, moderate and severe are different in each of the classification systems listed below. It is important to use the same system to analyze and present data. The RTH and Gomez classification systems typically use weight-for-age.

System	Cut-off	Malnutrition classification
WHO	< -1 to > -2 Z-score	mild
	< -2 to > -3 Z-score	moderate
	< -3 Z-score	severe
RTH	> 80% of median	normal
	60% - < 80% of median	mild-to-moderate
	< 60% of median	severe
Gomez	> 90% of median	normal
	75% - < 90% of median	mild
	60% - < 75% of median	moderate
	< 60% of median	severe