Methodology

Data sources and adjustments

In 2011, UNICEF and the WHO Department of Nutrition initiated an annual joint data review and prepared a global database of national child prevalence estimates to be used for computing regional and global averages and examining regional and global trends in child malnutrition.

UNICEF and WHO receive and review survey data from the published and grey literature as well as reports from national authorities on a continual basis. WHO maintains the WHO Global Database on Child Growth and Malnutrition (www.who.int/nutgrowthdb), a repository of standardized anthropometric child data which has existed for 20 years (de Onis and Blössner, 2003). UNICEF maintains a global database populated in part through its annual data collection exercise that draws on submissions from more than 150 country offices.

Based on these data, with due consideration to potential biases and the views of local experts, UNICEF and WHO developed, and now maintain, a joint analysis dataset of national child malnutrition prevalence estimates for children under-five years of age for all countries or territories using available survey data since 1985. Prevalences are based on the WHO Child Growth Standards (WHO, 2006) median for

- stunting – proportion of children with height-for-age below –2 standard deviations (SD);
- underweight – proportion of children with weight-for-age below –2 SD;
- wasting – proportion of children with weight-for-height below –2 SD; and
- overweight – proportion of children with weight-for-height above +2 SD.

Because of the different prevalence estimates obtained using the NCHS/WHO growth reference and the WHO Child Growth Standards (de Onis et al, 2006), historical survey estimates based on the NCHS/WHO growth reference, for which no raw data are available, have been converted to WHO-based prevalences using an algorithm developed by Yang and de Onis, 2008.

Surveys presenting anthropometric data for age groups other than 0–59 months or 0–60 months are adjusted using national survey results – gathered as close in time as possible – from the same country that include the age range 0–59/60 months. Details of the adjustment process are available online at www.childinfo.org/files/Technical_Note_age_adj.pdf.

Measuring standing height in a child above 2 years of age in the Maldives.
National rural estimates are adjusted similarly using another national survey for the same country as close in time as possible with available data on national urban and rural data to derive an "adjusted national estimate".

In those instances where conversion of a prevalence estimate based on the NCHS/WHO growth reference is needed in addition to age adjustment, the age adjustment is completed first, followed by conversion to the WHO Child Growth Standards. All adjustments and conversions are documented in the analysis dataset. Survey data extracted from reports for which the raw data are not yet available are labeled as "pending re-analysis".

Where multiple survey results exist for the same country-year combination, preference is given to a re-analyzed result (using the raw data) over a converted result; to a survey result with all available indicators over results for only some indicators; and to a survey result which includes the full age range (e.g., 0–59/60 months) over one which includes a partial age range (e.g., 0–36 months).

Because of the need for re-analysis and/or adjustments (e.g., for age and/or urban-rural residence, or conversion from NCHS/WHO growth reference to the WHO Child Growth Standards), national malnutrition prevalence estimates included in the joint UNICEF-WHO analysis dataset may differ slightly from those in original reports. Re-analysis and adjustments are completed for the sole purpose of obtaining comparable data. The re-analysis or adjustment does not imply the expression of any opinion whatsoever on the part of UNICEF or WHO concerning the integrity of the originally reported data. Lastly, the mere availability of data on child malnutrition for a given country-year combination does not warrant inclusion into the joint analysis dataset. UNICEF and WHO evaluate survey estimates for inclusion in the joint analysis dataset on a case-by-case basis. In some cases, survey estimates have been excluded due to lack of comparable data for deriving global and regional trends.

The joint analysis dataset contains country classifications for UN regions and sub-regions, MDG, UNICEF, WHO regions and World Bank income groups. Estimates are presented for each of these classifications. An annex to this document lists the countries included in each of the regional classifications.

Lastly, the dataset includes the latest under-five population estimates from the United Nations Population Division corresponding to the survey year (variable YEAR1). Survey year is based on the time period during which a survey was conducted, except when surveys are conducted over two or more years, in which case the survey year is the mean when odd or the nearest year above the mean when even. For the joint analysis dataset constructed using survey data available through May 2012 (UNICEF-WHO Joint Global Nutrition Database, 2011 revision, completed

Weighing an infant in India.
July 2012), population estimates are from the 2010 revision of the World Population Prospects released in April 2011 by the United Nations Department of Economic and Social Affairs, Population Division.

(N.B. The dataset presents the code of "-1.0" for prevalence estimates and sample sizes with missing data. The dataset also includes information on author and primary reference of the surveys as well as the reference number under which the data appear in the WHO Global Database on Child Growth and Malnutrition.)

**Estimating trends multi-level modelling by regions or income groups**

The joint analysis dataset completed in July 2012 includes 639 nationally representative surveys from 142 countries/territories conducted over the period 1985 to 2011 (N.B. one exception, a survey from Papua New Guinea conducted during 1982-83). For 17 countries, only one national survey was available; 24 countries had two surveys, and 101 countries had three or more surveys.

About 48% (n=304) of the surveys were conducted before 2000 and 52% (n=335) were completed during 2000 or later. Of the 142 countries/territories represented in this dataset, no survey data was available since 2005 for 28 countries: Afghanistan, Bahrain, Bulgaria, Cape Verde, Comoros, Cuba, Czech Republic (The), Ecuador, Equatorial Guinea, Eritrea, Fiji, Gabon, Iran, Kiribati, Lebanon, Mauritius, Qatar, Romania, Samoa, Seychelles, Singapore, Tonga, Trinidad and Tobago, Turkmenistan, Ukraine, United States of America, Uruguay and Yemen.

Linear mixed-effect modeling is used to estimate prevalence rates by region or income group from 1990 to 2015. This method has been used in previous trend analyses and is described in detail in de Onis et al. (2004). Briefly, for the UN regions, a single linear mixed-effect model is fit to the data for each group of sub-regions belonging to the same region.

Weighing a toddler in Democratic Republic of the Congo.
The basic model contains the factors sub-region, year, and the interaction between year and the sub-region as fixed effects with country as a random effect. Unstructured (which allows an intercept and slope to be estimated for each country) or compound symmetry covariance structures were considered. Model fitting was performed on the logistic transform (“logit”) of the prevalence to ensure that all prevalence estimates and their confidence intervals (CIs) would lie between zero and one. Analyses are weighted by the latest estimate of under-five population during the survey year.

**Figure 1** shows an example of the fitting exercise for the UN region of Africa. UN regional prevalence estimates were derived using the sum of the estimated numbers affected in the sub-regions divided by the total under-five population of that region. Corresponding confidence limits were derived using the delta method based on the standard errors of the sub-region prevalence estimates. The same approach was used to derive prevalence estimates and confidence intervals for aggregate levels for developing countries and all countries (i.e., global) (de Onis et al., 2004).

For the MDG, WHO, UNICEF regions and The World Bank income groups, the same approach is used wherein all regions or income groups are included in a single model as these regional or income classifications do not incorporate a sub-regional level.

Estimates for the UN and WHO regions were obtained using Statistical Analysis Systems package version 9.2 (SAS Institute, Cary, NC, USA). Estimates for MDG and UNICEF regions and World Bank income groups were obtained using Stata v11 statistical software (Stata Corp. College Station, TX, USA).
Harmonizing country surveys

Harmonizing data in a way that allows for meaningful comparisons of data poses a major challenge in generating malnutrition estimates at the global and regional level. In many instances, differences across countries and over time are not amenable to harmonization. In others, such as in the selection of the survey target population (both in terms of age and/or residency), post-survey harmonization may be possible. In the case of non-standard analysis, for example, when data processing algorithms do not use the recommended flag limits (e.g., weight-for-age z-score $-6 / +5$ SD), it is necessary to re-calculate anthropometric prevalence estimates using a standard method. Further details can be found at www.who.int/childgrowth/software.

Data quality issues

Increased awareness of problems with anthropometric data quality in national surveys has raised consciousness on the importance of data quality procedures as well as the question of what is to be done if reported data are of poor quality. Data quality problems can be eliminated or minimized through proper survey planning, thorough training, continuous standardization, and close field supervision to ensure adherence to measurement protocols throughout the data collection process. Even data collected through large-scale surveys may not be suitable for inclusion in the joint analysis dataset if data quality issues exist, but are not identified until after publication.

WHO and UNICEF are committed to the collection of high quality data for monitoring the nutritional status of children and ensuring that the data included in the agencies’ respective databases are of the highest quality. To this end, the WHO Global Database on Child Growth and Malnutrition maintains a well-established data quality review for inclusion of survey results (de Onis and Blössner, 2003) that is closely aligned with that maintained by UNICEF. The minimum criteria for inclusion require that a survey:

- employs a cross-sectional population-based random sample,
- covers the full, or nearly full, age range of children 0 to 5 years,
- has a minimum sample size of 400,
- utilizes standard measurement techniques for height and weight (WHO, 2008),
- provides full documentation of survey design, implementation (including limitations) and analysis, and
- derives estimates based on the WHO Growth Standards using the standard indicators and cut-off points (e.g., for stunting—proportion of children with height-for-age below $-2$ standard deviations (SD); underweight—proportion of children with weight-for-age below $-2$ SD; wasting—proportion of children with weight-for-height below $-2$ SD; and overweight—proportion of children with weight-for-height above $+2$ SD)(a standardized data collection form is available from WHO at: www.who.int/nutgrowthdb/en), else raw data is available for re-analysis.

Efforts such as the International Household Survey Network and the Health Metrics Network, among others have highlighted improvements made to-date in health information systems worldwide. Moreover they underline the substantial work that remains to enhance the availability, accessibility and overall quality of data, as well as their timely analysis and utilization for evidence-based decision making.

It is unfortunate when survey data are of insufficient quality or are of good quality but go unanalyzed or unreported particularly given the scarcity of resources for conducting surveys and the time and effort involved in survey planning, implementation and dissemination. Scientists, NGOs and government officials conducting national surveys are encouraged to contact WHO and/or UNICEF for technical assistance during the survey planning and data collection processes.
in order to improve data quality as well as during the post-survey period in order to explore opportunities for increasing the availability of and access to data for monitoring childhood nutritional status.

**Scarcity of data**

Despite dramatic improvements in the number of population-based, nationally representative surveys (e.g., UNICEF-supported Multiple Cluster Indicator Surveys, the USAID-supported Demographic and Health Surveys, national nutrition surveys and others) conducted since 1990, many countries do not have high quality data on anthropometric indicators that allow an examination of trends over time. In some instances, surveys have been completed and reports written but documentation is either sub-optimal or the reports are not made available. These deficiencies in data collection, analysis and dissemination limit national, regional and global monitoring efforts (e.g., lacking data can lead to distortions in regional trend analyses). As previously noted, 28 of the 142 countries/territories represented in the July 2012 joint analysis dataset have had no survey-based anthropometric estimates available since 2005.

Marasmic-kwashiorkor child in Solomon Islands.