International Journal of Epidemiology 2003;**32**:518–526
DOI: 10.1093/ije/dyg099

The World Health Organization Global Database on Child Growth and Malnutrition: methodology and applications

Mercedes de Onis and Monika Blössner

Accepted 7 January 2003

Background For decades nutritional surveys have been conducted using various definitions, indicators and reference populations to classify child malnutrition. The World Health Organization (WHO) Global Database on Child Growth and Malnutrition was initiated in 1986 with the objective to collect, standardize, and disseminate child anthropometric data using a standard format.

Methods The database includes population-based surveys that fulfil a set of criteria. Data are checked for validity and consistency and raw data sets are analysed following a standard procedure to obtain comparable results. Prevalences of wasting, stunting, under- and overweight in preschool children are presented using z-scores based on the National Center for Health Statistics (NCHS)/WHO international reference population. New surveys are included on a continuous basis and updates are published bimonthly on the database's web site.

Results To date, the database contains child anthropometric information derived from 846 surveys. With 412 national surveys from 138 countries and 434 sub-national surveys from 155 countries, the database covers 99% and 64% of the under 5 year olds in developing and developed countries, respectively. This wealth of information enables international comparison of nutritional data, helps identifying populations in need, evaluating nutritional and other public health interventions, monitoring trends in child growth, and raising political awareness of nutritional problems.

Conclusions The 15 years experience of the database can be regarded as a success story of international collaboration in standardizing child growth data. We recommend this model for monitoring other nutritional health conditions that as yet lack comparable data.

Keywords Child growth, malnutrition, global monitoring, stunting, wasting, underweight, overweight, preschool children

Child growth is internationally recognized as an important public health indicator for monitoring nutritional status and health in populations. Children who suffer from growth retardation as a result of poor diets and/or recurrent infections tend to have more frequent episodes of severe diarrhoea and are more susceptible to several infectious diseases, such as malaria, meningitis, and pneumonia.[1–3] A number of studies have demonstrated the association between increasing severity of anthropometric deficits and mortality, and the substantial contribution to child mortality of all degrees of malnutrition is now widely accepted.[4] In addition, there is strong evidence that impaired growth is associated with delayed mental development, poor school performance, and reduced intellectual capacity.[5–7]

The internationally recommended way to assess malnutrition at population level is to take body or anthropometric measurements (e.g. weight and height). Based on combinations of these body measurements anthropometric indices are

Department of Nutrition for Health and Development, World Health Organization, 20 Avenue Appia, 1211 Geneva 27, Switzerland.

Correspondence: Dr Mercedes de Onis, Department of Nutrition for Health and Development, World Health Organization, 1211 Geneva 27, Switzerland. E-mail: deonism@who.int

constructed. These indices are essential for the interpretation of body measurements as, for example, weight alone has no meaning unless it is related to an individual's age or height.[8] In children the three most commonly used anthropometric indices are weight-for-height, height-for-age, and weight-for-age. These indices can be expressed in terms of z-scores, percentiles, or percentage of median, which enable comparison of a child or a group of children with a reference population.

For many years the WHO Department of Nutrition has been using anthropometric data to monitor trends in child malnutrition. A major difficulty has been the non-uniformity of survey analyses and presentation of their results. Although numerous nutritional surveys have been conducted since the 1970s, many of them have used distinct definitions of malnutrition (i.e. different anthropometric indices, reporting systems, cutoff points, and reference values) thus making comparison of results between studies difficult. This lack of comparable data prompted the beginning of WHO's systematic collection and standardization of information on the nutritional status of the world's under-5 population. The *WHO Global Database on Child Growth and Malnutrition* (henceforth referred to as the 'database') was initiated in 1986 to compile, standardize, and disseminate results of nutritional surveys performed worldwide. The specific objectives of this database are to: characterize nutritional status; enable international comparisons of nutritional data; identify populations in need; help evaluate nutritional and health interventions; monitor secular trends in child growth; and raise political awareness of nutritional problems. A distinct feature of the database is the systematic analysis of raw data sets in a standard format to produce comparable results. This paper describes the methodology applied in the database and provides examples of how the compiled information is used for promoting the healthy growth and development of children.

Methods

Data sources

Nutritional surveys for inclusion in the database are identified primarily from:

- A weekly literature MEDLINE search following an established search history. Selected abstracts are reviewed and full articles of relevant surveys obtained from the WHO library.
- A wide network of national and international collaborators, including WHO Departments and Regional Offices, UN-sister organizations (e.g. Food and Agriculture Organization [FAO], United Nations Children's Fund [UNICEF], World Bank), non-govermental organizations (e.g. Helen Keller International, Macro International, Médecins sans Frontières), Ministries of Health and other national institutions, as well as research and academic institutions.
- Principal investigators of nutritional surveys worldwide.

Criteria for inclusion and data quality control

The main criteria for including surveys in the database are:

- A defined population-based sampling frame;
- A probabilistic sampling procedure involving at least 400 children;
- Use of standard anthropometric measurement techniques;
- Presentation of results in z-scores in relation to the (National Center for Health Statistics) NCHS/WHO international reference or availability of the raw data, allowing a standardized analysis.

Before inclusion of a survey in the database the sampling method applied is reviewed to ensure population-based representativeness at the administrative level that applies (e.g. national, regional, province, district, local). The majority of national surveys use multistage random sampling methods with only a few countries—such as Argentina, Chile, Croatia, Uruguay, and Venezuela—basing their estimates on national nutritional surveillance systems with high population coverage. Surveys generally apply standard measurement techniques, such as measuring supine length up to 24 months of age and standing height from 24 months onwards.[8] Detailed information on the procedures and sampling method used in each survey is given in the comprehensive survey reports that are archived in the database's documentation centre and made available to users on request.

As part of routine data quality control, survey results are checked for inconsistencies between the malnutrition estimates based on height-for-age, weight-for-age, and weight-for-height. The observed standard deviations (SD) of the z-score distribution are used to assess the quality of the survey data. With accurate age estimates and anthropometric measurements, the SD of the observed z-score distributions should be relatively constant and close to the expected value of 1.0 for the reference distribution (ranging within approximately 0.2 units).[8] Surveys with an SD outside the expected ranges require closer examination because of possible problems related to age assessment and/or anthropometric measurements. Surveys with obvious inaccurate data resulting from measurement error or incorrect age reporting are generally excluded.

Database work-flow

Figure 1 describes the work-flow of the database. Once a potentially relevant survey is identified and the documentation obtained, the methods are reviewed as described above. If the survey qualifies, the available information is extracted from the documents and filled into a standard data-entry form. To clarify any queries and obtain any additional results, the data holders

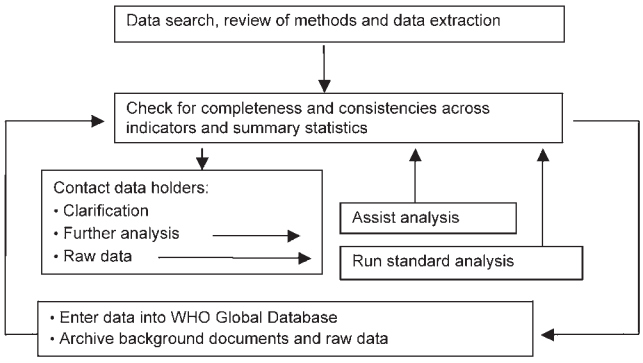

Figure 1 World Health Organization (WHO) Global Database on Child Growth and Malnutrition work-flow

are contacted and a collaboration established. In many occasions further analysis of the raw data is required. These analyses are conducted either by the data holders (with technical assistance from the database managers if necessary) or the raw data are provided to WHO for standard analysis. A software package named ANTHRO—which can be downloaded from the database's web site at http://www.who.int/nutgrowthdb—was developed to facilitate the analysis following the common format of the database. Final consistency checks across indicators take place before the results are entered into the computerized system. The full documentation and correspondence, as well as electronic copies of raw data and analysis files are archived.

Data standardization

A distinct feature of the database is the collection of information in a standard format consisting of:

- Prevalences of underweight (low weight-for-age), stunting (low height-for-age), wasting (low weight-for-height), and overweight (high weight-for-height).
- Use of the NCHS/WHO international reference population to derive estimates.
- Use of z-scores cutoff points (i.e. SD scores): <–2SD, <–3SD, and >+2 SD.
- Calculation of summary statistics: means and standard deviations of z-scores.
- Stratification of the results by age group, sex, urban/rural residence, and administrative region.

Detailed information on the use and interpretation of the anthropometric indices, cutoff points, and summary statistics included in the database has been published elsewhere[8,9] and is also available online from the database's web site.

Current developments with regards to the reference data deserve special mention here. Anthropometric values are compared across individuals or populations in relation to a set of reference values and the choice of the reference population has a significant impact on the proportion of children identified as being under- and over-nourished. Since the late 1970s WHO has been recommending the NCHS growth reference, the so-called NCHS/WHO international reference population, for the comparison of child growth data. A detailed account of the history of the NCHS/WHO reference and general issues that need to be considered when using international reference data are discussed elsewhere.[10,11] In the mid 1990s the NCHS/WHO international reference was found to have important technical and biological drawbacks.[8,12] Consequently, an international effort co-ordinated by WHO is presently developing a new international growth reference for infants and young children.[13] This new international reference, constructed from primary data collected for this purpose, includes a number of features which will result in a reference population substantially different from existing ones. An important characteristic is that it will be based on a truly international sample. Six countries, representing the major global geographical regions, are participating in this effort. Another notable feature is that it takes the breastfed infant as the biological 'norm', recognizing the health and nutritional benefits of breastfeeding.[14] The extent to which the new curves—expected to be available in 2005—differ from the current ones in shape and the spread of values around the mean will affect the estimates of under- and over-nutrition that have been established using the NCHS/WHO international reference.

Data analysis

The analyses related to the database consist of two separate steps. The first step is the primary data analysis of raw data sets to produce standardized results as described above. To date more than 400 national and sub-national nutritional surveys have been analysed to produce standardized prevalences of underweight, wasting, stunting, and overweight. The analysis of raw data is essential because many nutritional surveys use distinct definitions of malnutrition making comparison across surveys impossible. This was also an important barrier to pooling individual survey data for deriving regional and global estimates. It implies gaining access to the raw data and description of codes and, then conducting the analysis of large and complex data files. After making the survey results comparable, in a second step, nationally representative survey data are pooled to derive regional and global estimates of under- and overnutrition. Specific statistical methods used for this purpose (e.g. multilevel modelling) have been described elsewhere.[9,15–17]

Results

As of August 2002 the database included a total of 846 nutrition surveys carried out from 1960 onwards: 412 national surveys from 138 countries and 434 sub-national surveys from 155 countries and territories. A total of 2361 bibliographic citations are included in the reference system. The population coverage of national nutrition surveys is 99% and 64% of children under 5 years of age in developing and developed countries, respectively.

The wealth of information compiled in the database has made it possible to compare levels, trends, and geographical distributions of under- and overnutrition in preschool children worldwide. Initial results from the database were published in 1993[15] and updated in 1997.[9] The latter publication also presented, for the first time, estimates of trends in child growth retardation in developing countries. A more recent analysis updated these earlier estimates and described regional and global trends in childhood malnutrition from 1980 to 2005.[16] Figure 2 shows the distribution of stunting in developing countries according to the latest prevalence data, categorized as low, medium, high, and very high: <20%, 20–29%, 30–39%, and ⩾40%, respectively. The map shows very high rates of stunting in many countries of sub-Saharan Africa, South-central Asia, and South-eastern Asia. In Latin America and the Caribbean the majority of countries have low or moderate rates. Country-specific prevalence rates disaggregated by sex, age group, area of residence, and administrative region can be found on the database's web site.

The large number of countries with at least two data points enabled us to forecast trends in childhood stunting. For this purpose multilevel modelling was applied to the prevalence of stunting, controlling for variation in time, country, and region.[18] Figures 3 and 4 show trends in stunting from 1980 to 2020 in prevalence and numbers, respectively. Estimated trends indicate that overall stunting rates in developing countries will continue to decrease from 29.8% in 2000 to 16.3% in 2020.

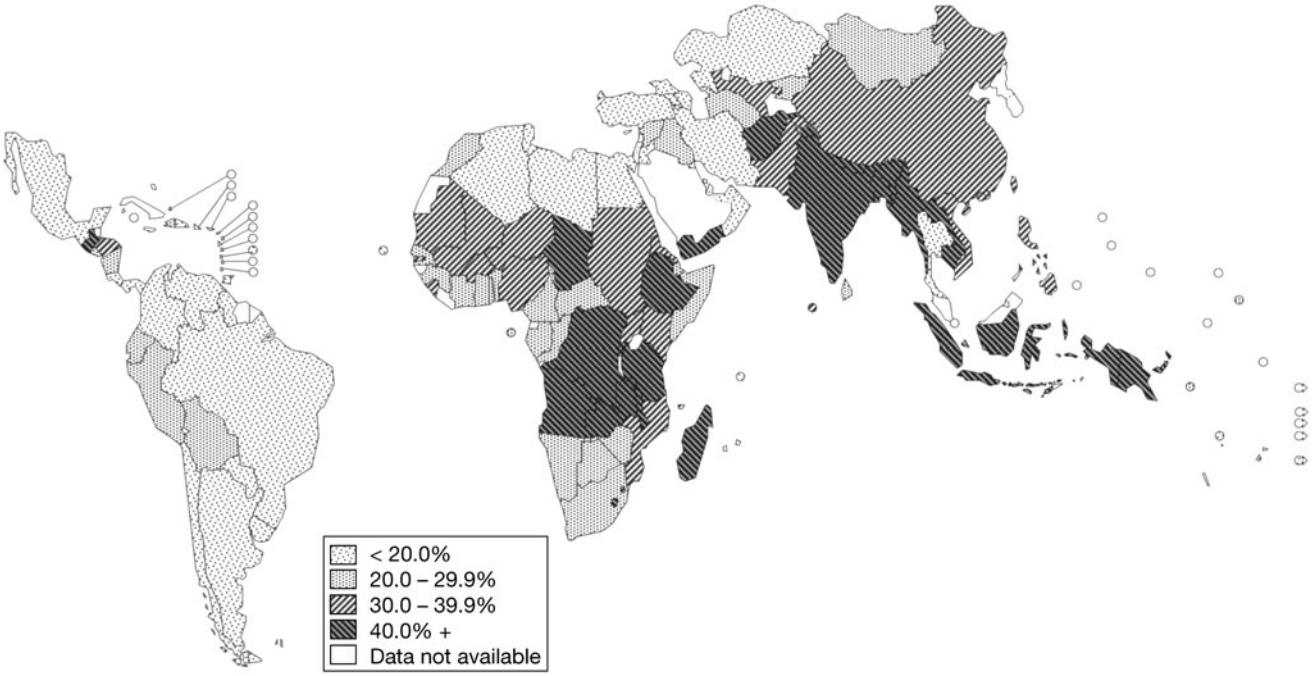

Figure 2 Prevalence of stunted children in developing countries

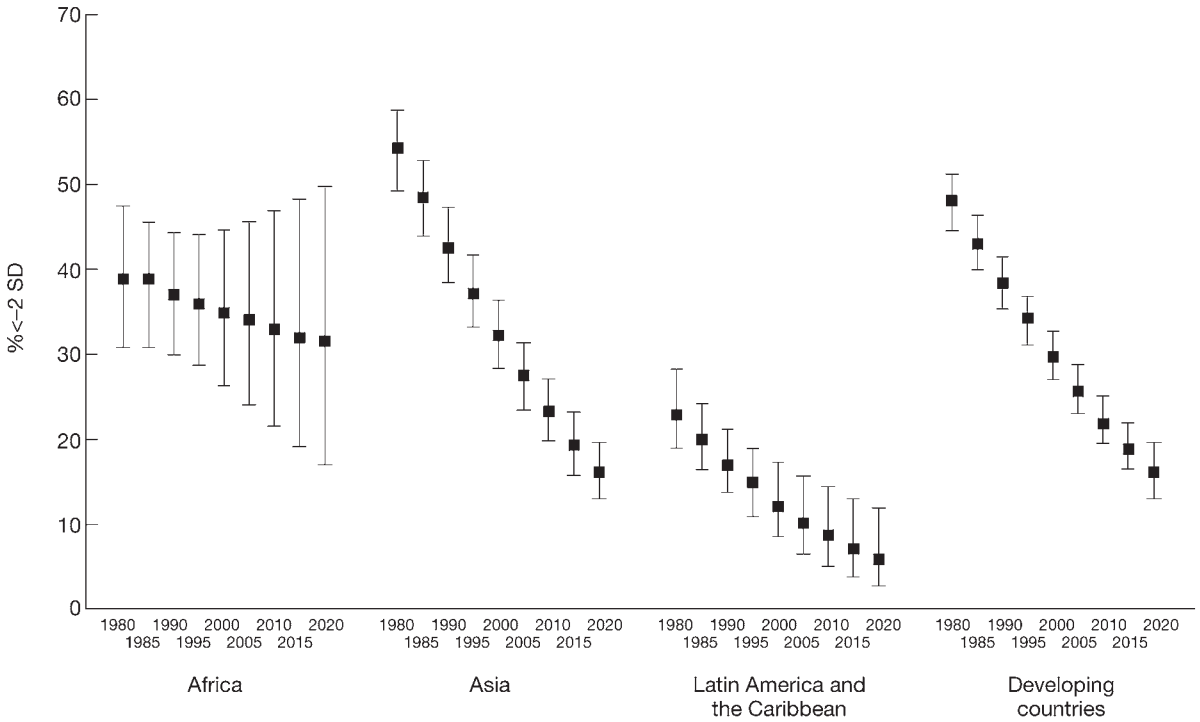

Figure 3 Trends in percentage stunting in preschool children (1980–2020) by UN regions with 95% CI (box-whisker plots are at 5-year intervals)

Source: Blössner *et al.*[18]

Progress will however be uneven in different regions. In Africa a minor improvement in the prevalence from 34.9% to 31.1% is predicted for the next 20 years, translating, however, into increasing numbers of affected children (from 44 million in 2000 to 48 million in 2020) due to population growth. In Asia, Latin America, and the Caribbean, both the prevalence and numbers of stunted children, in turn, are expected to continue to decrease further during the same time period.

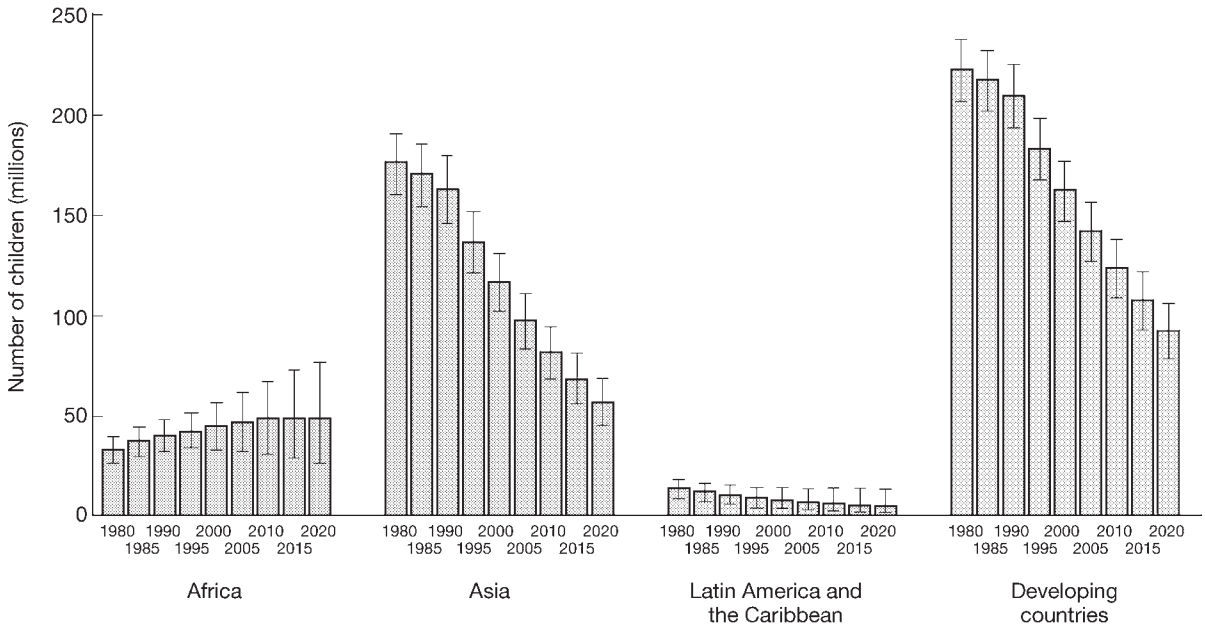

Figure 4 Trends in number of stunted children under 5 years old (1980–2020) by UN regions with 95% CI (bar plots are at 5-year intervals)

Source: Blössner *et al.*[18]

Overweight, reflecting the other extreme of malnutrition in children, has become a matter of growing concern. In developed countries several studies have shown increasing rates of overweight in children, whereas, in developing countries the extent of the problem was unknown, given that available surveys had not been analysed to report this information. The standard analysis of raw data sets for the database made it possible to fill this gap by quantifying patterns and trends of overweight among preschool children in developing countries.[17,19] Figure 5 shows the latest data on prevalence of overweight and wasting in children aged under 5 years in 102 countries, listed by wasting rates in descending order.[19] Prevalences of overweight and wasted children are presented together to enable comparison between both ends of the weight-for-height distribution. Countries with the highest prevalences of overweight are located mainly in the Middle East, North Africa, and Latin America. Rates of wasting are generally higher than those of overweight, and Africa and Asia have 2.5–3.5 times higher wasting rates compared to overweight (Table 1).

The database information was also used to assess the timing of growth faltering worldwide and its implications for interventions to prevent child malnutrition.[20] An analysis of 39 nationally representative datasets from recent surveys in developing countries showed that at birth the mean z-scores of length/height-for-age are very similar in Africa, Asia, and Latin America —and close to the NCHS growth reference. In all three regions, however, the mean z-score falls sharply from birth to about 24 months and continues to fall well into the third year, albeit at a slower rate (Figure 6). The magnitude of the drop in Latin America and the Caribbean is about 1.25 SD, whereas in Africa and Asia it is of approximately 2 SD.[20] The observed increase in mean z-scores at 24 months in all three regions is an artefact resulting from the significant length/height-for-age disjunction immediately before and after 2 years of age in the NCHS/WHO international reference population.[10]

Discussion

The evidence accumulated in the WHO Global Database on Child Growth and Malnutrition permits an accurate description of the magnitude and geographical distribution of childhood under- and overnutrition worldwide. Analyses based on the database's information confirm that child undernutrition remains a major public health problem in many countries, and continues to hamper children's physical growth and mental development. Indeed, it is a major threat to their very survival.

Despite an overall decrease of stunting in developing countries, in some, rates of stunting are rising, while in many others they remain disturbingly high.[15,16] An important finding of these comparisons is the remarkable similarity of the patterns of growth faltering in developing countries, not only within a region but also globally, despite the different instruments and measuring methods used in the surveys. These results show that interventions during the earliest periods of life are likely to have the greatest impact in preventing child malnutrition. Special emphasis should thus be given to the development of effective interventions to stop the critical faltering that occurs from birth to 24 months.[20]

At the other extreme of the spectrum, findings from the database demonstrate that overweight is becoming a matter of growing concern and that attention needs to be paid to monitoring levels and trends of overweight during childhood not only in developed countries, but globally.[17] The information compiled in the database helps identify countries and regions in need of population-wide interventions and provides a baseline for assessing progress.

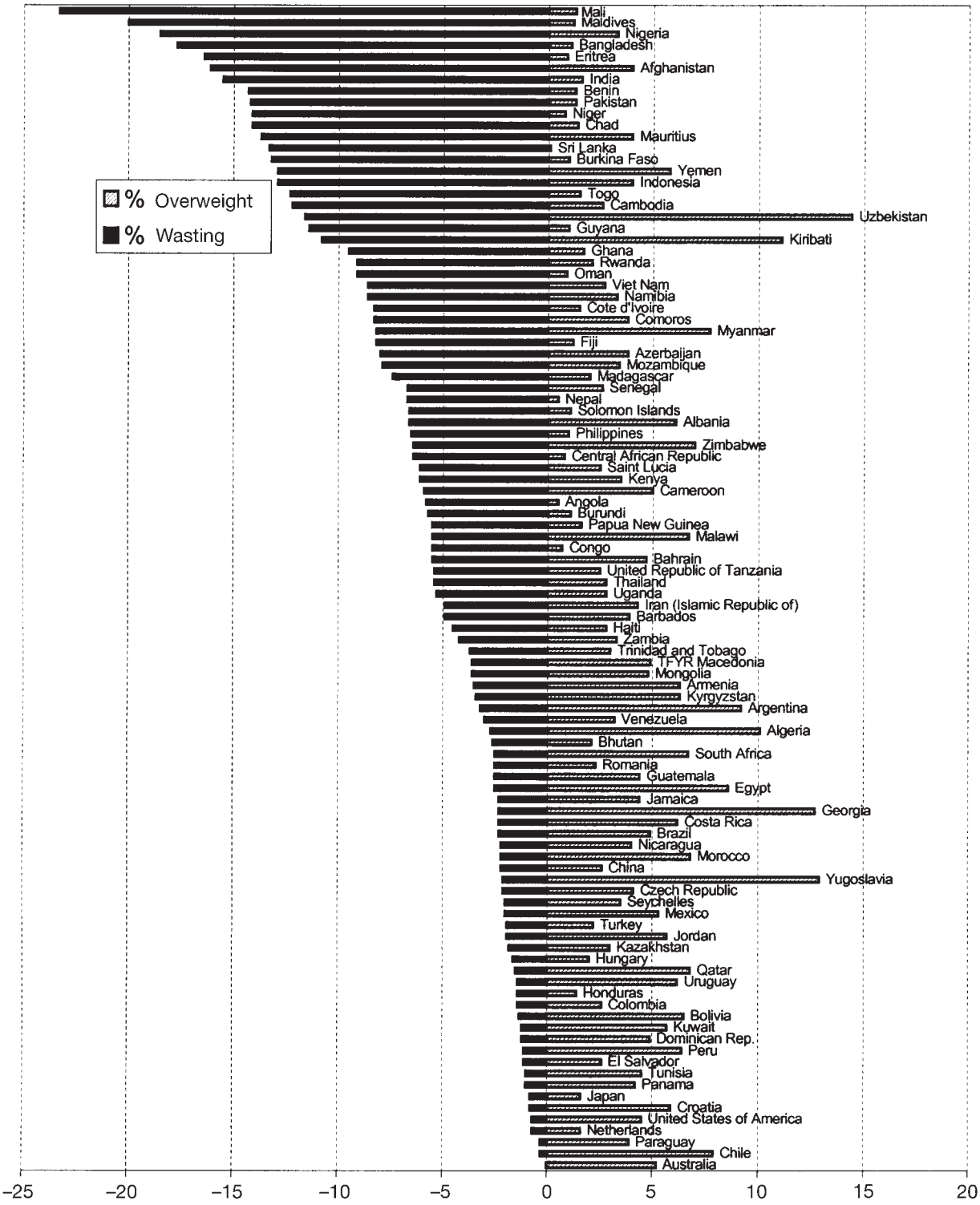

Figure 5 National overweight and wasting prevalence in preschool children in 102 countries

Source: Adapted from de Onis and Blössner.[17]

In May 1999 the database was made accessible on the internet at the web address http://www.who.int/nutgrowthdb. The web site—updated bimonthly—enables its users anywhere in the world to obtain at any time the latest information from the database. Following the launch of this web site the number of its users has been continuously increasing. To this point in time (August 2002), the database's web site has more than 7000 registrations and there are many direct links to it. In addition to

Table 1 National overweight and wasting prevalence in preschool children in 102 countries

Country	Year of survey	% overweight[a]	% wasting[b]
Afghanistan	1997	4.0	16.1
Albania	1996–1998	6.1	6.6
Algeria	2000	10.1	2.7
Angola	1996	0.5	5.8
Argentina	1995–1996	9.2	3.2
Armenia	1998	6.3	3.5
Australia	1995–1996	5.2	0.0
Azerbaijan	2000	3.8	8.0
Bahrain	1989	4.7	5.5
Bangladesh	1996–1997	1.1	17.7
Barbados	1981	3.9	4.9
Benin	1996	1.3	14.3
Bhutan	1999	2.1	2.6
Bolivia	1998	6.5	1.3
Brazil	1996	4.9	2.3
Burkina Faso	1998–1999	1.0	13.2
Burundi	1987	1.1	5.7
Cambodia	1996	2.6	12.2
Cameroon	1998	5.0	5.9
Central African Republic	1995	0.8	6.4
Chad	1996–1997	1.4	14.1
Chile	1999	7.9	0.3
China	2000	2.6	2.2
Colombia	1995	2.6	1.4
Comoros	1995–1996	3.8	8.3
Congo	1987	0.7	5.5
Costa Rica	1996	6.2	2.3
Cote d'Ivoire	1994	1.5	8.3
Croatia	1995–1996	5.9	0.8
Czech Republic	1991	4.1	2.1
Dominican Republic	1996	4.9	1.2
Egypt	2000	8.6	2.5
El Salvador	1998	2.6	1.1
Eritrea	1995–1996	0.9	16.4
Fiji	1993	1.2	8.2
Georgia	1999	12.7	2.3
Ghana	1998–1999	1.7	9.5
Guatemala	1998–1999	4.4	2.5
Guyana	1997	1.0	11.4
Haiti	2000	2.8	4.5
Honduras	1996	1.4	1.4
Hungary	1980–1988	2.0	1.6
India	1998–1999	1.6	15.5
Indonesia	1995	4.0	12.9
Iran (Islamic Republic of)	1998	4.3	4.9
Jamaica	1997	4.4	2.3
Japan	1978–1981	1.6	0.8
Jordan	1997	5.7	1.9
Kazakhstan	1999	3.0	1.8
Kenya	1998	3.5	6.1
Kiribati	1985	11.1	10.8
Kuwait	1996–1997	5.7	1.2
Kyrgyzstan	1997	6.3	3.4
Madagascar	1997	2.0	7.4
Malawi	2000	4.3	5.5
Maldives	1997–1998	1.2	20.0
Mali	1995–1996	1.3	23.3
Mauritius	1995	4.0	13.7
Mexico	1998–1999	5.3	2.0
Mongolia	1999	4.8	3.6
Morocco	1992	6.8	2.2
Mozambique	1997	3.4	7.9
Myanmar	1997	7.7	8.2
Namibia	1992	3.3	8.6
Nepal	1997–1998	0.5	6.7
Netherlands	1980	1.6	0.7
Nicaragua	1997–1998	4.0	2.2
Niger	2000	0.8	14.1
Nigeria	1993	3.3	18.5
Oman	1994–1995	0.9	9.1
Pakistan	1995	1.3	14.2
Panama	1997	4.2	1.0
Papua New Guinea	1982–1983	1.6	5.5
Paraguay	1990	3.9	0.3
Peru	1996	6.4	1.1
Philippines	1998	1.0	6.5
Qatar	1995	6.8	1.5
Romania	1991	2.3	2.5
Rwanda	1996	2.1	9.1
Saint Lucia	1976	2.5	6.1
Senegal	1996	2.6	6.7
Seychelles	1987–1988	3.5	2.0
Solomon Islands	1989	1.1	6.6
South Africa	1994–1995	6.7	2.5
Sri Lanka	1995	0.1	13.3
The Former Yugoslav Republic of Macedonia	1999	4.9	3.6
Thailand	1995	2.8	5.4
Togo	1998	1.5	12.3
Trinidad and Tobago	1987	3.0	3.7
Tunisia	1998	4.5	1.0
Turkey	1998	2.2	1.9
Uganda	1995	2.8	5.3
United Republic of Tanzania	1999	2.5	5.4
United States of America	1988–1994	4.5	0.7
Uruguay	1992–1993	6.2	1.4
Uzbekistan	1996	14.4	11.6
Venezuela	2000	3.2	3.0
Viet Nam	2000	2.7	8.6
Yemen	1997	5.8	12.9
Yugoslavia	1996	12.9	2.1
Zambia	1996–1997	3.3	4.2
Zimbabwe	1999	7.0	6.4

[a] >+2 SD weight-for-height median of the NCHS/WHO international reference.

[b] <–2 SD weight-for-height median of the NCHS/WHO international reference.

the numerous individual users, the UN organizations such as the United Nations Administrative Committee on Coordination/ Sub-Committee on Nutrition (ACC/SCN), FAO, UNICEF, the UN Population Division of the Department of Economics and Social Affairs, and the World Bank use regularly the information included in this database for their routine reporting on child nutritional status and its association with other health and socioeconomic indicators.[21–27] Similarly, many national and international institutions and non-governmental organizations use the database as the source for information on child malnutrition.[28,29]

The 15 years experience of the database can be regarded as a success story of international collaboration in standardizing child growth data. This success can be measured by the wide acceptance of the database's principles, the range of uses of the data by different stakeholders, and the steadily growing network of collaborators. The database relies heavily on this network, which has been developing a dynamic of its own, leading to the early involvement of the database managers in large-scale surveys. This reflects the high interest of collaborators in supporting WHO in this global effort of monitoring child growth and malnutrition.

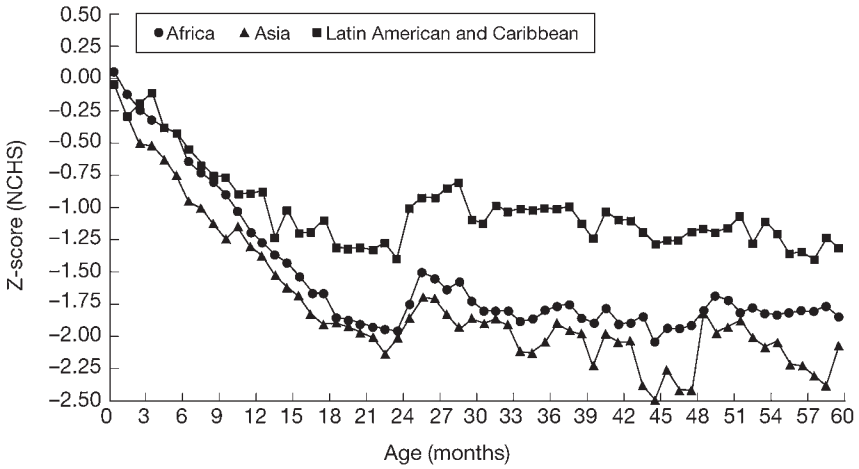

Figure 6 Timing of growth faltering in length-for-age in preschool children by geographical region

Source: Shrimpton *et al.*[20]

This effort is, however, not exempt from constraints. One main limitation of using anthropometry in assessing child nutritional status is its lack of specificity, as changes in body measurements are sensitive to many factors including intake of essential nutrients, infection, altitude, stress, and genetic background. When compiling this information in a database, an additional restriction is that data quality checks are limited to review of the information received in the reports and of summary statistics obtained after the standard analysis of raw data. Assessing the adherence to protocols by each survey team is not possible. Despite these limitations, we nevertheless consider that the experience of the *WHO Global Database on Child Growth and Malnutrition* could be a model to follow for monitoring other nutritional disorders and/or health conditions that lack comparable data.

While continuing its routine, the database faces a number of challenges. First, the release and implementation of the new international growth reference in 2005 will have noteworthy implications for the management of the database. These will include the addition of new indicators such as body mass index (BMI)-for-age and others, and the re-analysis of raw data sets applying the new reference population. Second, trends in nutritional status for countries undergoing nutritional transition indicate the need to pay close attention to the monitoring of overweight and obesity during childhood.[17] To achieve this, users of population-based estimates should shift their concentration on the traditional indicator weight-for-age to focus more on length/height-for-age as well as weight-for-length/height. This would permit identifying stunted children of low weight-for-age but normal weight-for-length/height, who should not receive excess energy since this could lead to obesity.[30] Third, the association between prenatal and postnatal growth, and the magnitude of the problem of intrauterine growth retardation (IUGR) in developing countries[31] underscore the need to incorporate into the database the monitoring of impaired fetal growth. A potential methodology that will facilitate the derivation of population-based estimates of IUGR is presently being developed. Monitoring the patterns and trends of IUGR is expected to trigger public health action in populations where interventions aimed at preventing fetal growth retardation are urgently needed. Lastly, the availability of reference data for motor development milestones being developed as part of the new international growth reference[14] will provide the possibility to monitor motor development, establishing an important link between physical growth and development in children.

The future of human societies relies on children being able to achieve their optimal physical growth and development. The database serves to increase awareness of the magnitude of the problem of child malnutrition worldwide and to alert decision-makers to how much remains to be done in order to ensure children's healthy growth and development.

Acknowledgements

We are grateful to Dr Graeme A Clugston, Director of the WHO Department of Nutrition for Health and Development, for his continuous support in our work of updating and improving the database. We would also like to thank Dr Allen Shoemaker for the help in conducting statistical analysis of raw datasets, and Drs Edward Frongillo and Richard Morris for their assistance in deriving the model estimates of the regional and global trends.

KEY MESSAGES

- The World Health Organization (WHO) Global Database on Child Growth and Malnutrition compiles, standardizes, and disseminates child anthropometric data of nutritional surveys conducted globally.
- Distinct features of the database are the systematic analysis of raw data sets in a standard format to produce comparable results and the thorough data quality control.
- The magnitude of available information has made it possible to compare levels, trends, and geographical distributions of under- and overnutrition in preschool children worldwide.
- This approach could be a model for monitoring other health conditions as yet lacking comparable data.

References

[1] Tomkins A, Watson F. *Malnutrition and Infection: A Review. ACC/SCN State-of-the-art Series, Nutrition Policy Discussion Paper No. 5.* Geneva: United Nations Administrative Committee on Coordination/ Subcommittee on Nutrition, 1989.

[2] Man WD, Weber M, Palmer A *et al.* Nutritional status of children admitted to hospital with different diseases and its relationship to outcome in The Gambia, West Africa. *Trop Med Int Health* 1998;**3:**678–86.

[3] Victora CG, Fuchs SC, Flores JA, Fonseca W, Kirkwood B. Risk factors for pneumonia in a Brazilian metropolitan area. *Pediatrics* 1994;**93(6Pt 1):**977–85.

[4] Pelletier D, Frongillo EA Jr, Habicht JP. Epidemiologic evidence for a potentiating effect of malnutrition on child mortality. *Am J Public Health* 1993;**83:**1130–33.

[5] Mendez MA, Adair LS. Severity and timing of stunting in the first two years of life affect performance on cognitive tests in late childhood. *J Nutr* 1999;**129:**1555–62.

[6] World Health Organization. *A Critical Link. Interventions for Physical Growth and psychological development. a review.* Doc WHO/CHS/CAH/ 99.3. Geneva: WHO, 1999.

[7] de Onis M. Child growth and development. In: Semba RD, Bloem MW (eds). *Nutrition and Health in Developing Countries*. Totowa, NJ: Humana Press, 2001, pp. 71–91.

[8] World Health Organization. *Physical Status: The Use and Interpretation of Anthropometry. Report of a WHO Expert Committee.* Technical Report Series No. 854. Geneva: WHO, 1995.

[9] de Onis M, Blössner M. *WHO Global Database on Child Growth and Malnutrition.* WHO/NUT/97.4. Geneva: World Health Organization, 1997.

[10] de Onis M, Yip R. The WHO growth chart: historical considerations and current scientific issues. *Bibl Nutr Dieta* 1996;**53:**74–89.

[11] de Onis M, Habicht JP. Anthropometric reference data for international use: recommendations from a World Health Organization Expert Committee. *Am J Clin Nutr* 1996;**64:**650–58.

[12] WHO Working Group on Infant Growth. An evaluation of infant growth: the use and interpretation of anthropometry in infants. *Bull World Health Organ* 1995;**73:**165–74.

[13] de Onis M, Garza C, Habicht JP. Time for a new growth reference. *Pediatrics* 1997;**100(5).**

[14] de Onis M, Victora CG, Garza C, Frongillo EA Jr, Cole TJ for the WHO Working Group on the Growth Reference Protocol. A new international growth reference for young children. In: Dasgupta P, Hauspie R (eds). *Perspectives in Human Growth, Development and Maturation.* Dordrecht, The Netherlands: Kluwer Academic Publishers, 2001, pp. 45–53.

[15] de Onis M, Monteiro C, Akré J, Clugston G. The worldwide magnitude of protein-energy malnutrition: an overview from the WHO Global Database on Child Growth. *Bull World Health Organ* 1993;**71:**703–12.

[16] de Onis M, Frongillo EA Jr, Blössner M. Is malnutrition declining? An analysis of changes in levels of child malnutrition since 1980. *Bull World Health Organ* 2000;**78:**1222–33.

[17] de Onis M, Blössner M. Prevalence and trends of overweight among preschool children in developing countries. *Am J Clin Nutr* 2000;**72:**1032–39.

[18] Blössner M, de Onis M, Morris R. Forecast of trends in child malnutrition (3.09.108). *Ann Nutr Metab* 2001;**45(Suppl.1):**298.

[19] de Onis M and Blössner M. Global prevalence and trends of overweight among preschool children (W.11.104). *Ann Nutr Metab* 2001;**45(Suppl.1):**580.

[20] Shrimpton R, Victora CG, de Onis M, Costa Lima R, Blössner M, Clugston G. Worldwide timing of growth faltering: implications for nutritional interventions. *Pediatrics* 2001;**107(5)**.

[21] UN Administrative Committee on Coordination/Subcommittee on Nutrition (ACC/SCN). *Third Report on the World Nutrition Situation*. Geneva: ACC/SCN, 1997.

[22] UN Administrative Committee on Coordination/Subcommittee on Nutrition (ACC/SCN) and International Food Policy Research Institute. *Fourth Report on the World Nutrition Situation*. Geneva: ACC/SCN, 2000.

[23] UNICEF. *The State of the World's Children 1998: Focus on nutrition*. New York: Oxford University Press, 1998.

[24] FAO. *The Sixth World Food Survey*. Rome: Food and Agriculture Organization of the United Nations, 1996.

[25] FAO. *The State of Food Insecurity in the World*. Rome: Food and Agriculture Organization of the United Nations, 2001.

[26] United Nations Secretariat. Department of Economics and Social Affairs Population Division. *Charting the Progress of Populations*. ESA/P/WP.149. New York: United Nations, 1998.

[27] World Bank. *World Development Indicators*. Washington: World Bank, 2002.

[28] Smith LC, Haddad L. *Explaining Child Malnutrition in Developing Countries: A Cross-Country Analysis.* IFPRI Research report 111. Washington: International Food Policy Research Institute, 2000.

[29] Bread for the World Institute. *Hunger in a Global Economy: Hunger 1998*. Eighth annual report on the state of world hunger. Silver Spring, Maryland: Bread for the World Institute, 1997.

[30] Uauy R, Kain J. The epidemiologic transition: need to incorporate obesity prevention into nutrition programs. *Public Health Nutr* 2002;**5(1A):**223–29.

[31] de Onis M, Blössner M, Villar J. Levels and patterns of intrauterine growth retardation in developing countries. *Eur J Clin Nutr* 1998;**52:**S1,S5–S15.