

# Global prevalence and trends of overweight and obesity among preschool children<sup>1–4</sup>

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## ABSTRACT

**Background:** Childhood obesity is associated with serious health problems and the risk of premature illness and death later in life. Monitoring related trends is important.

**Objective:** The objective was to quantify the worldwide prevalence and trends of overweight and obesity among preschool children on the basis of the new World Health Organization standards.

**Design:** A total of 450 nationally representative cross-sectional surveys from 144 countries were analyzed. Overweight and obesity were defined as the proportion of preschool children with values  $>2$  SDs and  $>3$  SDs, respectively, from the World Health Organization growth standard median. Being “at risk of overweight” was defined as the proportion with values  $>1$  SD and  $\leq 2$  SDs, respectively. Linear mixed-effects modeling was used to estimate the rates and numbers of affected children.

**Results:** In 2010, 43 million children (35 million in developing countries) were estimated to be overweight and obese; 92 million were at risk of overweight. The worldwide prevalence of childhood overweight and obesity increased from 4.2% (95% CI: 3.2%, 5.2%) in 1990 to 6.7% (95% CI: 5.6%, 7.7%) in 2010. This trend is expected to reach 9.1% (95% CI: 7.3%, 10.9%), or  $\approx 60$  million, in 2020. The estimated prevalence of childhood overweight and obesity in Africa in 2010 was 8.5% (95% CI: 7.4%, 9.5%) and is expected to reach 12.7% (95% CI: 10.6%, 14.8%) in 2020. The prevalence is lower in Asia than in Africa (4.9% in 2010), but the number of affected children (18 million) is higher in Asia.

**Conclusions:** Childhood overweight and obesity have increased dramatically since 1990. These findings confirm the need for effective interventions starting as early as infancy to reverse anticipated trends. *Am J Clin Nutr* 2010;92:1257–64.

## INTRODUCTION

The prevalence of childhood overweight and obesity has increased worldwide in recent decades. Historically, a heavy child meant a healthy child, and the concept “bigger is better” was widely accepted. Today, this perception has drastically changed on the basis of evidence that obesity in childhood is associated with a wide range of serious health complications and an increased risk of premature illness and death later in life (1).

In 2000, we reported on the prevalence and trends of overweight among preschool children in developing countries (2) based on data from 160 nationally representative samples from 94 countries. The overall prevalence of overweight was 3.3%, but some countries and regions had considerably higher rates. Overweight was shown to increase in 16 of the 38 countries with

trend data. The data highlighted the importance of monitoring levels and trends of overweight and obesity in children.

These earlier analyses were based on estimates derived by using the National Center for Health Statistics (NCHS) growth reference (3), which was recommended for international use at that time. In 2006, the World Health Organization (WHO) released the WHO Child Growth Standards (4) based on a multi-country study involving breastfed infants and young children from 6 geographically distinct sites (Brazil, Ghana, India, Norway, Oman, and the United States). These new standards differ substantially from the NCHS reference (5).

The present analyses describe levels and trends of overweight and obesity in preschool children using the WHO standards instead of the NCHS reference. We relied on a much larger and more recent set of national surveys than used previously. Moreover, whereas the earlier report covered only the prevalence and numbers of affected children in 1995 in developing countries, these analyses include trends from 1990 to 2020 and estimates for developed countries as well.

## SUBJECTS AND METHODS

Cross-sectional data on the prevalence of overweight and obesity were obtained from national nutrition surveys included in the WHO Global Database on Child Growth and Malnutrition (6). A total of 450 nationally representative surveys were available from 144 countries. Of the 450 surveys, 413 were conducted in developing countries and 37 in developed countries. For 33 countries, national survey data were available from only 1 survey, 38 countries had 2 surveys, and 73 countries had  $\geq 3$  surveys. About 38% of the surveys (171 surveys) were conducted between 1991 and 1999, 16% (70 surveys) dated from 1990 and earlier, and 46% (209) were performed in 2000 or later (**Table 1**).

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**TABLE 1**  
Description of the 450 surveys included in the analysis by United Nations (UN) regions

UN regions and subregions	No. of surveys	Countries with surveys/total no. of countries	Population coverage, age <5 y	No. of surveys by survey period		
				≤1990	1991–1999	≥2000
			%			
Africa	148	52/55	99.4	20	49	79
Eastern	49	17/18	99.1	7	19	23
Middle	20	9/9	100	1	6	13
Northern	22	6/7	99.9	5	7	10
Southern	10	5/5	100	0	3	7
Western	47	15/16	99.9	7	14	26
Asia <sup>1</sup>	146	41/47	99.4	14	61	71
Eastern	9	3/4	96.7	0	3	6
South Central	63	13/14	99.1	9	30	24
Southeastern	40	10/11	99.1	3	12	25
Western	34	15/18	96.1	2	16	16
Latin America and Caribbean	112	26/37	97.0	25	47	40
Caribbean	28	6/16	72.1	7	11	10
Central America	28	8/8	100	8	11	9
South America	56	12/13	98.6	10	25	21
Oceania <sup>2</sup>	7	5/22	87.7	4	2	1
Developing countries	413	124/161	99.2	63	159	191
Developed countries <sup>3</sup>	37	20/45	62.8	7	12	18
Global	450	144/206	96.5	70	171	209

<sup>1</sup> Excluding Japan.

<sup>2</sup> Excluding Australia and New Zealand.

<sup>3</sup> Including Europe, Northern America, Australia, New Zealand, and Japan.

The earliest survey (from the United States) dates from 1969, whereas the most recent surveys (Bhutan, Cambodia, Chile, Egypt, and Vietnam) were conducted in 2008. All surveys included boys and girls, and age groups ranged from birth to 5 y. Surveys applied standard measuring protocols, ie, supine length was measured in children up to 24 mo, and standing height was measured in those aged ≥24 mo. A complete set of the surveys used in the analysis is available as supplemental material under “Supplemental data” in the online issue.

A data file was constructed by using the following variables: region, subregion, country, survey year, sample size, prevalence of 1 SD above the weight-for-height median, prevalence of 2 SDs above the weight-for-height median, prevalence of 1 SD above the body mass index (BMI)-for-age median, prevalence of 2 SDs above the BMI-for-age median, and population of children aged <5 y during the survey year. To obtain comparable prevalences across countries, surveys with available raw data (321 of 450) were analyzed following a standard format with use of the WHO Child Growth Standards (7). In the case of the remaining 129 surveys (28.7%) for which raw data were not available, a conversion method was applied to transfer prevalences based on the NCHS reference to prevalences based on the WHO standards (8). The steps taken to ensure standardized quality control and analysis of surveys are described elsewhere (9).

Linear mixed-effects modeling was used to estimate prevalence rates and numbers of affected children by region from 1990 to 2020. This methodology, which has been used in previous trend analyses (10, 11), is described in detail elsewhere (12). In brief, a single linear mixed-effect model was considered for each group of subregions belonging to the same region. The basic model contained the factors *subregion*, *year*, and the interaction be-

tween *year* and the *subregion* as fixed effects, and *country* as a random effect. Consequently, we obtained from each model an intercept and a slope estimate for every subregion within the region. Unstructured covariance (which allows each country to have its intercept and slope estimated) was used, reflecting country accelerating trends (12). The fitting was performed on the logistic transform (“logit”) of the prevalence to ensure that all prevalence estimates and their CIs would lie between zero and one. To account for the different country populations, we carried out a weighted analysis. For the regional level, prevalence estimates were derived by using the sum of the estimated numbers affected in the subregions divided by the total population of that region aged <5 y. This overall regional estimate is thus the weighted average of the subregion prevalence estimates (weighted by the respective population proportions aged <5 y). The CIs were estimated by using the delta method based on the SE of the subregion prevalence estimates (12). A similar approach was used for the aggregate levels developing countries and global. Estimates for the group of developed countries were derived by using a single model, with *year* as a fixed effect and *country* as a random effect, and an unstructured covariance model. Analyses were done by using SAS (version 9; SAS Institute, Inc, Cary, NC).

The definitions of overweight and obesity are similar to the ones we used in the previous report (2), in line with WHO recommendations (13). Overweight and obesity were defined as the proportion of preschool children with values >2 SDs and >3 SDs, respectively, from the WHO growth standard median. Being “at risk of overweight,” defined as the proportion of preschool children with values >1 SD and ≤2 SDs from the median, was added following the release of the WHO Child

Growth Standards (14). These cutoffs are based on statistical convention rather than on health outcomes.

The countries were grouped into regions and subregions following the United Nations (UN) classification system. The number of affected children aged <5 y was estimated by using the 2008 edition of *World Population Prospects* (15). Population coverage refers to the sum of the latest-year-survey populations of the countries forming the group divided by the group's total population referent to the median of the years used in the sum. Thus, coverage reflects the contribution of all surveys involved in fitting the trend but varies across the analysis period. Because all 62 countries for which data were not available have small populations, there was a negligible effect on coverage.

## RESULTS

The distribution, by geographic region, of surveys included in the analysis together with the <5 y population coverage are shown in Table 1. Overall, Africa and Asia had a population coverage of 99%, whereas coverage for Latin America and the Caribbean was somewhat lower (97%). For all developing countries and globally, the population coverage was very high (99% and 97%, respectively), whereas it was much lower (63%) for developed countries, because of either a lack of national surveys or reported estimates that were based on local standards.

Estimates of the prevalence and total numbers of overweight and obese preschool children from 1990 to 2010, together with projections for 2015 and 2020 (95% CIs) are shown in **Tables 2 and 3**, respectively. Worldwide, the prevalence of childhood overweight and obesity increased from 4.2% (95% CI: 3.2%, 5.2%) in 1990 to 6.7% in 2010 (95% CI: 5.6%, 7.7%), for a relative increase of 60%. This trend is expected to continue and reach a prevalence of 9.1% (95% CI: 7.3%, 10.9%) in 2020, for a relative increase of 36% from 2010.

Developing and developed countries followed a similar pattern of increased prevalence for the study period, but at different levels. In 2010, the prevalence of childhood overweight and obesity is estimated to be 11.7% (95% CI: 8.9%, 15.3%) in developed countries and 6.1% (95% CI: 5.0%, 7.2%) in developing countries. However, the relative percentage change is higher in developing countries (an increase of 65% between 1990 and 2010) than in developed countries (an increase of 48% between 1990 and 2010). Global trends (95% CI) for overweight and obese children during the period 1990–2020 are shown in **Figure 1**.

For 2010, it is estimated that 43 million preschool children will have a weight-for-height >2 SDs from the WHO median, 35 million of whom live in developing countries. It is estimated that the number of overweight and obese children will increase to close to 60 million in 2020 (Table 3).

The estimated prevalence of childhood overweight and obesity in Africa in 2010 is 8.5% (95% CI: 7.4%, 9.5%) and is expected to reach 12.7% (95% CI: 10.6%, 14.8%) in 2020. The prevalence is lower in Asia than in Africa (4.9% in 2010), but the number of affected children (18 million) is higher (Tables 2 and 3).

Trends in overweight and obesity are available for 111 countries (countries with more than one survey). Of these, 31 showed no obvious changes in the prevalence of overweight and obesity (yearly change rate between  $-0.1$  and  $0.1$ ), 53 showed a rising trend ( $\geq 0.1$ ), and 27 showed a falling trend ( $\leq -0.1$ ).

Nationally, there is great variation in rates of childhood overweight. Very high rates appear in countries such as Albania, Bosnia and Herzegovina, and Ukraine, with levels >25% in most recent surveys. At the other end of the spectrum, levels <1% are found in Nepal and the Democratic People's Republic of Korea. Country-specific prevalence data disaggregated by age group, sex, urban/rural, and region are available from the WHO Global Database on Child Growth and Malnutrition (6).

The prevalence and numbers of preschool children defined as being at risk of overweight in 2010 (ie, >1 SD and  $\leq 2$  SDs of the median weight-for-height) are shown in **Table 4**. Worldwide, 14.4% (95% CI: 12.5%, 16.3%) of children (92 million) aged 0–5 y are estimated to be at risk of overweight. Of these, almost half live in Asia (44 million), with Eastern Asia contributing the highest number (20 million) of all the subregions. In developed countries, the estimated prevalence and number of children at risk of overweight in 2010 are 21.4% (95% CI: 19.7%, 23.1%) and 15 million, respectively. The corresponding estimates in developing countries are 13.6% (95% CI: 11.4%, 15.7%) and  $\approx 78$  million children. A comparison of the estimates of children “at risk of overweight” with those classified for these analyses as “overweight and obese” during the period 1990–2010 is shown in **Figure 2**.

A comparison of the percentage of preschool children in developed countries with a weight-for-height >2 SDs and a BMI-for-age >2 SDs from the WHO Child Growth Standards median is shown in **Figure 3**. The estimates and the 95% CIs are alike. Similar results were found for other regions.

## DISCUSSION

Our main objective was to describe global levels and patterns of early childhood overweight and obesity using the WHO Child Growth Standards to assess the present situation relative to what we described a decade ago (2). The earlier analyses were based on 160 nationally representative surveys from 94 countries with trend data for only 38 countries, whereas the current analyses are based on 450 surveys from 144 countries with trend data for 111 countries. This is the largest set of data ever available to assess trends of overweight and obesity in early childhood.

The number of children affected by excessive body weight relative to linear growth has increased rapidly. Worldwide, in 2010 it is estimated that there will be 43 million overweight and obese preschool children (ie, >2 SDs above the median WHO standards) in developing and developed countries. In addition, 92 million preschool children are estimated to be at risk of overweight (>1 SD and  $\leq 2$  SDs of the median weight-for-height).

Although the prevalence of overweight and obesity in developed countries is about double that in developing countries (11.7% and 6.1%, respectively), the vast majority of affected children (35 million) live in developing countries. In addition, the relative increase in the past 2 decades has been higher in developing countries (+65%) than in developed countries (+48%).

Marked differences were observed across regions. In Africa, the prevalence of childhood overweight and obesity in 2010 is 8.5%, and it is expected to increase to 12.7% in 2020—a relative increase of 49%. In Asia, the estimated prevalence is lower than in Africa (4.9% in 2010, increasing to 6.8% in 2020); however, in absolute numbers, Asia has the highest number of overweight and

**TABLE 2**

Prevalence of overweight and obesity (&gt;2 SDs from weight-for-height median) and 95% CIs in children aged 0–5 y, by United Nations (UN) regions: 1990–2020

UN regions and subregions	Overweight and obese						
	1990	1995	2000	2005	2010	2015	2020
	%						
Africa							
(%)	4.0	4.7	5.7	6.9	8.5	10.4	12.7
(95% CI)	3.1, 4.9	3.8, 5.6	4.8, 6.6	6.0, 7.8	7.4, 9.5	9.0, 11.8	10.6, 14.8
Eastern							
(%)	3.9	4.4	5.1	5.8	6.7	7.6	8.7
(95% CI)	2.6, 5.6	3.3, 5.9	4.0, 6.4	4.7, 7.2	5.2, 8.5	5.6, 10.3	5.9, 12.6
Middle							
(%)	2.5	3.4	4.7	6.4	8.7	11.7	15.5
(95% CI)	1.4, 4.4	2.3, 5.2	3.6, 6.2	5.1, 8.0	6.5, 11.5	7.7, 17.2	9.0, 25.5
Northern							
(%)	6.1	8.0	10.3	13.3	17.0	21.4	26.6
(95% CI)	3.4, 10.8	4.8, 13.0	6.7, 15.6	9.3, 18.7	12.8, 22.2	17.2, 26.3	22.6, 31.0
Southern							
(%)	10.2	9.5	8.8	8.2	7.6	7.0	6.5
(95% CI)	6.8, 15.0	6.6, 13.5	6.3, 12.2	6.0, 11.1	5.6, 10.3	5.1, 9.6	4.6, 9.2
Western							
(%)	2.2	2.9	3.8	4.9	6.4	8.3	10.6
(95% CI)	1.5, 3.2	2.2, 3.9	3.0, 4.7	4.1, 6.0	5.2, 7.9	6.3, 10.8	7.4, 14.8
Asia <sup>1</sup>							
(%)	3.2	3.4	3.7	4.2	4.9	5.7	6.8
(95% CI)	1.6, 4.7	2.0, 4.8	2.4, 5.1	2.8, 5.6	3.2, 6.6	3.5, 8.0	3.7, 9.8
Eastern							
(%)	4.8	4.9	5.0	5.1	5.2	5.3	5.4
(95% CI)	2.4, 9.3	2.5, 9.6	2.5, 9.9	2.5, 10.3	2.5, 10.6	2.5, 11.0	2.5, 11.3
South Central							
(%)	2.3	2.6	2.9	3.2	3.5	3.9	4.3
(95% CI)	0.8, 6.5	1.1, 5.8	1.5, 5.4	1.7, 5.7	1.7, 7.0	1.6, 9.3	1.4, 12.8
Southeastern							
(%)	2.1	2.6	3.1	3.8	4.6	5.6	6.7
(95% CI)	1.7, 2.5	2.1, 3.1	2.5, 3.9	2.8, 5.0	3.2, 6.5	3.7, 8.4	4.1, 10.9
Western							
(%)	3.0	4.5	6.8	10.1	14.7	21.0	29.1
(95% CI)	1.7, 5.0	3.1, 6.5	5.1, 8.9	7.4, 13.6	9.8, 21.6	12.3, 33.5	15.3, 48.3
Latin America and Caribbean							
(%)	6.8	6.8	6.8	6.9	6.9	7.0	7.2
(95% CI)	5.6, 8.1	5.7, 7.9	5.8, 7.9	5.8, 7.9	5.9, 8.0	5.9, 8.2	5.8, 8.5
Caribbean							
(%)	4.6	5.1	5.6	6.2	6.9	7.6	8.3
(95% CI)	3.1, 6.9	3.6, 7.1	4.1, 7.6	4.5, 8.5	4.7, 9.9	4.8, 11.7	4.8, 14.0
Central America							
(%)	4.8	5.3	5.9	6.5	7.2	8.0	8.8
(95% CI)	3.5, 6.4	4.2, 6.7	4.8, 7.1	5.3, 7.9	5.6, 9.2	5.8, 10.8	6.0, 12.9
South America							
(%)	8.0	7.7	7.4	7.1	6.8	6.5	6.3
(95% CI)	6.3, 10.1	6.1, 9.6	5.9, 9.1	5.7, 8.8	5.5, 8.4	5.2, 8.1	5.0, 7.8
Oceania <sup>2</sup>							
(%)	2.9	3.1	3.2	3.3	3.5	3.6	3.8
(95% CI)	2.4, 3.6	2.5, 3.7	2.5, 4.0	2.5, 4.4	2.4, 4.9	2.3, 5.6	2.3, 6.3
Developing countries							
(%)	3.7	4.0	4.5	5.2	6.1	7.2	8.6
(95% CI)	2.6, 4.8	3.0, 5.0	3.6, 5.4	4.2, 6.1	5.0, 7.2	5.7, 8.6	6.6, 10.5
Developed countries <sup>3</sup>							
(%)	7.9	8.8	9.7	10.6	11.7	12.9	14.1
(95% CI)	6.0, 10.4	6.6, 11.5	7.3, 12.7	8.1, 13.9	8.9, 15.3	9.7, 16.8	10.7, 18.4
Global							
(%)	4.2	4.6	5.1	5.8	6.7	7.8	9.1
(95% CI)	3.2, 5.2	3.6, 5.5	4.2, 5.9	4.9, 6.6	5.6, 7.7	6.4, 9.1	7.3, 10.9

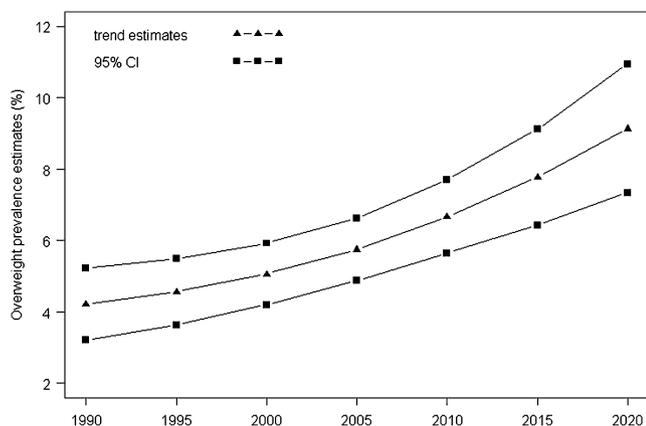
<sup>1</sup> Excluding Japan.<sup>2</sup> Excluding Australia and New Zealand.<sup>3</sup> Including Europe, Northern America, Australia, New Zealand, and Japan.

TABLE 3

Numbers of overweight and obese (&gt;2 SDs from weight-for-height median) children aged 0–5 y with 95% CIs, by United Nations (UN) regions: 1990–2020

UN regions and subregions	No. of overweight and obese children						
	1990	1995	2000	2005	2010	2015	2020
	<i>millions</i>						
Africa							
(n)	4.5	5.7	7.4	9.9	13.3	17.4	22.0
(95% CI)	3.4, 5.5	4.6, 6.8	6.2, 8.6	8.6, 11.2	11.6, 14.9	15.0, 19.7	18.4, 25.6
Eastern							
(n)	1.4	1.7	2.2	2.9	3.7	4.5	5.5
(95% CI)	0.9, 2.0	1.3, 2.3	1.8, 2.8	2.3, 3.6	2.9, 4.7	3.3, 6.1	3.7, 7.9
Middle							
(n)	0.3	0.6	0.8	1.3	1.9	2.8	3.9
(95% CI)	0.2, 0.6	0.4, 0.8	0.6, 1.1	1.1, 1.6	1.4, 2.5	1.9, 4.1	2.3, 6.5
Northern							
(n)	1.4	1.7	2.2	3.0	4.0	5.2	6.4
(95% CI)	0.8, 2.5	1.0, 2.9	1.5, 3.4	2.1, 4.2	3.0, 5.3	4.2, 6.4	5.5, 7.5
Southern							
(n)	0.6	0.6	0.5	0.5	0.5	0.4	0.4
(95% CI)	0.4, 0.9	0.4, 0.8	0.4, 0.7	0.4, 0.7	0.3, 0.6	0.3, 0.6	0.3, 0.5
Western							
(n)	0.7	1.1	1.5	2.2	3.2	4.4	5.8
(95% CI)	0.5, 1.1	0.8, 1.4	1.2, 1.9	1.8, 2.7	2.6, 4.0	3.3, 5.8	4.1, 8.1
Asia <sup>1</sup>							
(n)	12.4	12.9	13.7	15.2	17.7	21.0	24.3
(95% CI)	6.3, 18.5	7.5, 18.4	8.8, 18.7	10.3, 20.2	11.7, 23.7	12.9, 29.1	13.4, 35.2
Eastern							
(n)	6.3	5.6	5.1	4.7	4.8	5.1	5.1
(95% CI)	3.2, 12.2	2.8, 11.0	2.5, 10.0	2.3, 9.5	2.3, 9.8	2.4, 10.5	2.4, 10.6
South Central							
(n)	4.2	4.8	5.4	6.0	6.6	7.4	8.0
(95% CI)	1.5, 11.9	2.1, 10.8	2.8, 10.1	3.3, 10.9	3.3, 13.2	3.0, 17.7	2.5, 24.0
Southeastern							
(n)	1.2	1.4	1.7	2.0	2.5	3.0	3.5
(95% CI)	1.0, 1.4	1.2, 1.7	1.3, 2.1	1.5, 2.7	1.7, 3.5	1.9, 4.5	2.1, 5.6
Western							
(n)	0.6	1.0	1.6	2.4	3.8	5.5	7.7
(95% CI)	0.4, 1.1	0.7, 1.5	1.2, 2.1	1.8, 3.3	2.5, 5.5	3.2, 8.8	4.0, 12.8
Latin America and Caribbean							
(n)	3.8	3.8	3.8	3.8	3.7	3.6	3.5
(95% CI)	3.1, 4.5	3.2, 4.4	3.2, 4.4	3.2, 4.4	3.1, 4.2	3.0, 4.2	2.9, 4.2
Caribbean							
(n)	0.2	0.2	0.2	0.2	0.3	0.3	0.3
(95% CI)	0.1, 0.3	0.1, 0.3	0.2, 0.3	0.2, 0.3	0.2, 0.4	0.2, 0.4	0.2, 0.5
Central America							
(n)	0.7	0.9	0.9	1.0	1.1	1.2	1.2
(95% CI)	0.5, 1.0	0.7, 1.1	0.8, 1.1	0.8, 1.2	0.9, 1.4	0.9, 1.6	0.8, 1.8
South America							
(n)	2.9	2.7	2.7	2.5	2.3	2.1	2.0
(95% CI)	2.3, 3.6	2.2, 3.4	2.1, 3.3	2.1, 3.1	1.9, 2.9	1.7, 2.6	1.6, 2.5
Oceania <sup>2</sup>							
(n)	0.0	0.0	0.0	0.0	0.0	0.0	0.1
(95% CI)	0.0, 0.0	0.0, 0.0	0.0, 0.0	0.0, 0.1	0.0, 0.1	0.0, 0.1	0.0, 0.1
Developing countries							
(n)	20.7	22.4	25.0	28.9	34.7	42.0	49.9
(95% CI)	14.5, 26.9	16.8, 28.0	19.9, 30.1	23.8, 34.1	28.5, 41.0	33.5, 50.5	38.4, 61.4
Developed countries <sup>3</sup>							
(n)	6.2	6.3	6.4	7.1	8.1	8.8	9.5
(95% CI)	4.7, 8.1	4.7, 8.2	4.8, 8.4	5.4, 9.3	6.1, 10.6	6.7, 11.5	7.2, 12.4
Global							
(n)	26.9	28.7	31.4	36.1	42.8	50.8	59.4
(95% CI)	20.4, 33.3	22.9, 34.5	26.0, 36.7	30.6, 41.5	36.2, 49.4	42.0, 59.6	47.7, 71.1

<sup>1</sup> Excluding Japan.<sup>2</sup> Excluding Australia and New Zealand.<sup>3</sup> Including Europe, Northern America, Australia, New Zealand, and Japan.



**FIGURE 1.** Global prevalence and trends of overweight and obesity among preschool children.

obese children, because more than half ( $\approx 18$  million in 2010) of the affected children from developing countries live in this region. Of all the subregions in 2010, Northern Africa has the highest prevalence by far (17%), which is driven mainly by Egypt (20.5% in 2008) and Libya (22.4% in 2007). Translated into the numbers affected, however, Northern Africa contributes only 4 million overweight children. Of the subregions, the greatest numbers of overweight children in 2010 are estimated to live in South Central Asia (6.6 million), where populous countries such as Bangladesh, India, and Pakistan—despite low prevalence rates—contribute considerable numbers of overweight children.

The overall trend in developing countries is noticeably driven by China and India. Both countries have reported a drop (albeit

small) in their latest survey estimates (6). This indicates a need to monitor change in individual countries, because estimates for groups of countries can be affected by the effect of just a few countries because of their large populations.

Worldwide, in the period 1990–2010, there was a relative increase of 21% (first decade) and 31% (second decade) in the prevalence of early childhood overweight and obesity, whereas the forecast for the relative increase in the coming decade (2010–2020) is 36%. Fifty-three of the 111 countries with trend data show a rising trend.

The present analysis has some limitations. First, coverage for developed countries is low (63%). Some have not yet conducted national surveys, and others report results based on national growth standards. For the Caribbean subregion (72% coverage), estimates for overweight have not been published for Cuba (the third-largest population group in the subregion) using the WHO growth standards, and raw data were not accessible.

Second, national surveys were not done randomly across geographic regions. Depending on where and when surveys were conducted, bias may have been introduced in our regional estimates of past and future prevalences.

Third, some regions, despite having large coverage, present wide CIs. This is due either to heterogeneity within the group or to uncertainty resulting from too few data points. Northern Africa (17.0% in 2010; 95% CI: 12.8%, 22.2%), with such nutritionally diverse countries as Egypt (20.5% in 2008) and Sudan (5.3% in 2006), is an example of heterogeneity. Only 9 survey estimates were available for Eastern Asia; thus, the 95% CI around the 2010 estimate (5.2%) ranges from 2.5% to 10.6%.

Finally, as for any forecasting method, the present approach shows increasing uncertainty the further ahead trends are projected. Although CIs partially reflect this uncertainty, trajectories

**TABLE 4**

Estimated prevalence and numbers of children aged 0–5 y at risk of overweight or classified as overweight with 95% CIs, by United Nations (UN) regions: 2010

UN regions and subregions	Risk of overweight (>1 SD and $\leq 2$ SDs from weight-for-height median)		Overweight (>2 SDs from weight-for-height median)	
	Percentage	Millions	Percentage	Millions
Africa	13.8 (12.6, 14.9)	21.6 (19.8, 23.5)	8.5 (7.4, 9.5)	13.3 (11.6, 14.9)
Eastern	13.6 (11.5, 16.0)	7.5 (6.3, 8.8)	6.7 (5.2, 8.5)	3.7 (2.9, 4.7)
Middle	14.2 (11.7, 17.2)	3.1 (2.6, 3.8)	8.7 (6.5, 11.5)	1.9 (1.4, 2.5)
Northern	16.1 (12.8, 20.1)	3.8 (3.0, 4.8)	17.0 (12.8, 22.2)	4.0 (3.0, 5.3)
Southern	17.2 (10.9, 26.2)	1.0 (0.7, 1.6)	7.6 (5.6, 10.3)	0.5 (0.3, 0.6)
Western	12.2 (10.7, 13.9)	6.2 (5.4, 7.0)	6.4 (5.2, 7.9)	3.2 (2.6, 4.0)
Asia <sup>1</sup>	12.2 (8.9, 15.6)	44.2 (32.0, 56.5)	4.9 (3.2, 6.6)	17.7 (11.7, 23.7)
Eastern	21.3 (13.0, 33.1)	19.7 (11.9, 30.5)	5.2 (2.5, 10.6)	4.8 (2.3, 9.8)
South Central	7.6 (4.3, 13.3)	14.5 (8.1, 25.2)	3.5 (1.7, 7.0)	6.6 (3.3, 13.2)
Southeastern	8.1 (5.6, 11.5)	4.3 (3.0, 6.2)	4.6 (3.2, 6.5)	2.5 (1.7, 3.5)
Western	22.5 (17.6, 28.2)	5.8 (4.5, 7.2)	14.7 (9.8, 21.6)	3.8 (2.5, 5.5)
Latin America and Caribbean	21.9 (19.7, 24.1)	11.6 (10.4, 12.8)	6.9 (5.9, 8.0)	3.7 (3.1, 4.2)
Caribbean	16.4 (13.6, 19.6)	0.6 (0.5, 0.7)	6.9 (4.7, 9.9)	0.3 (0.2, 0.4)
Central America	21.9 (20.4, 23.5)	3.3 (3.1, 3.6)	7.2 (5.6, 9.2)	1.1 (0.9, 1.4)
South America	22.5 (19.2, 26.2)	7.7 (6.5, 8.9)	6.8 (5.5, 8.4)	2.3 (1.9, 2.9)
Oceania <sup>2</sup>	11.9 (9.9, 14.1)	0.2 (0.1, 0.2)	3.5 (2.4, 4.9)	0.0 (0.0, 0.1)
Developing countries	13.6 (11.4, 15.7)	77.6 (65.2, 90.1)	6.1 (5.0, 7.2)	34.7 (28.5, 41.0)
Developed countries <sup>3</sup>	21.4 (19.7, 23.1)	14.8 (13.6, 16.0)	11.7 (8.9, 15.3)	8.1 (6.1, 10.6)
Global	14.4 (12.5, 16.3)	92.4 (79.9, 104.9)	6.7 (5.6, 7.7)	42.8 (36.2, 49.4)

<sup>1</sup> Excluding Japan.

<sup>2</sup> Excluding Australia and New Zealand.

<sup>3</sup> Including Europe, Northern America, Australia, New Zealand, and Japan.

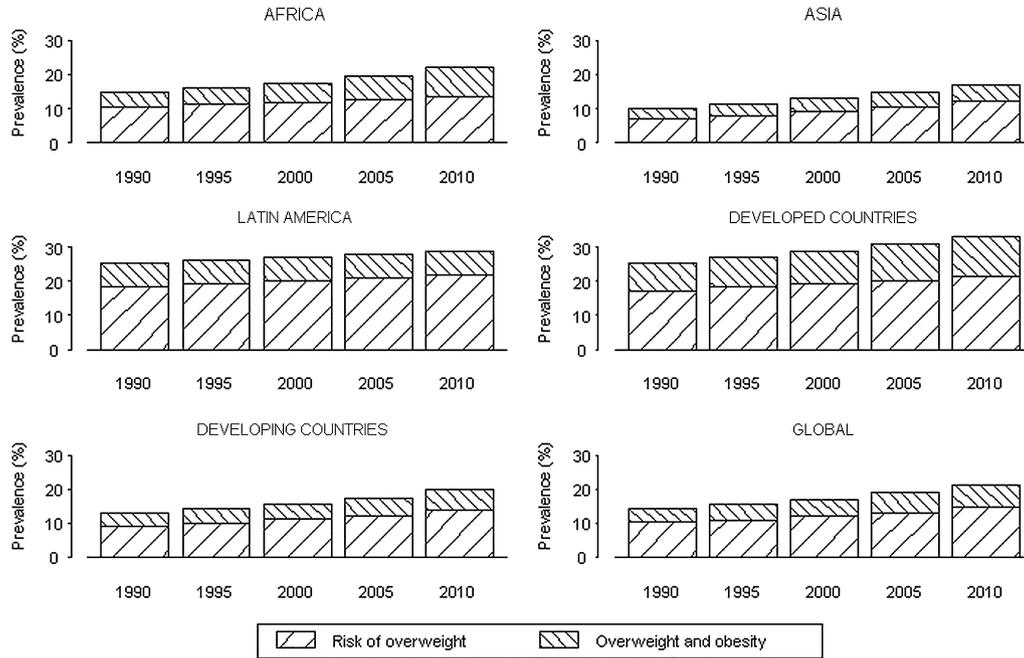


FIGURE 2. Aggregated prevalence, by United Nations region, of children at risk of overweight or classified as overweight or obese.

might change as new estimates become available. In particular, there is a potential for future trends in developed countries to show different rates of change should prevalences stabilize in response to the various programs put in place over the past few years to tackle childhood obesity. Despite these limitations and the inherent speculative nature of extrapolating to 2020, the present estimates provide a useful base for monitoring levels and trends of early childhood overweight and obesity.

For the purpose of these analyses we assessed overweight and obesity based on weight-for-length and -height instead of BMI-for-age. Nevertheless, as shown in Figure 3, weight-for-length and -height and BMI-for-age yield very similar results, which suggests comparability between indicators for assessing overweight and obesity in preschool-age children.

The observed increase in prevalence of early childhood overweight and obesity between 1990 and 2010 is a likely

consequence of a change in nutrition and physical activity patterns overtime. This behavioral change is influenced by multiple social and environmental factors, including interpersonal (family, peers, and social networks), community (school, workplace, and institutions), and governmental (local, state, and national policies), in addition to interaction with biological processes (16). If trends are not reversed, increasing rates of childhood overweight and obesity will have enormous implications not only for future health care expenditures but also for the overall development of nations (17, 18).

The rise in childhood overweight and obesity since 1990 has been dramatic. These findings confirm the need for effective interventions and programs to reverse anticipated trends. The early recognition of excessive weight gain relative to linear growth is essential. Routine assessment of all children needs to become standard clinical practice from very early childhood. Recent studies show that the trend toward childhood obesity starts as early as age 6 mo (19, 20) and that the choice of growth standard is important for identifying the onset of excess weight gain in infants (20). Families of affected infants should be counseled on appropriate feeding practices and other preventive interventions (21). Intrauterine, infant, and preschool periods are considered possible critical periods for programming long-term regulation of energy balance (22–24). Waiting for school programs to address this problem is probably too late.

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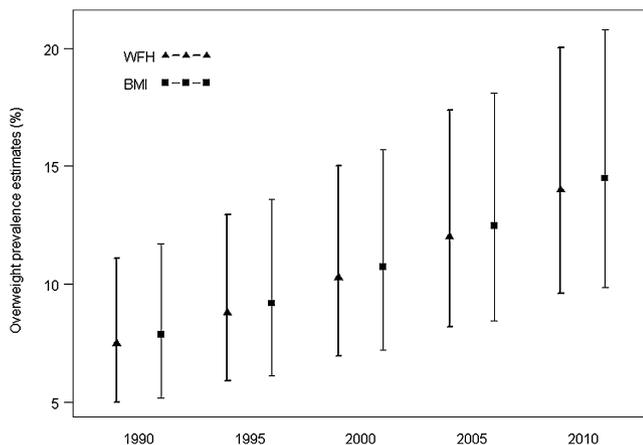


FIGURE 3. Comparison of overweight prevalence estimates in developed countries on the basis of weight-for-height (WFH) >2 SDs and BMI-for-age >2 SDs.

REFERENCES

1. Dietz WH. Health consequences of obesity in youth: childhood predictors of adult disease. *Pediatrics* 1998;101:518–25.

2. de Onis M, Blössner M. Prevalence and trends of overweight among preschool children in developing countries. *Am J Clin Nutr* 2000;72:1032–9.
3. National Center for Health Statistics. NCHS growth curves for children, birth-18 years. Washington, DC: National Center for Health Statistics, Department of Health, Education and Welfare, 1977. [Publication no. (PHS) 78–1650.]
4. WHO Multicentre Growth Reference Study Group. WHO child growth standards based on length/height, weight and age. *Acta Paediatr Suppl* 2006;450:76–85.
5. de Onis M, Onyango AW, Borghi E, Garza C, Yang H, for the WHO Multicentre Growth Reference Study Group. Comparison of the World Health Organization (WHO) Child Growth Standards and the National Center for Health Statistics (NCHS)/WHO international growth reference: implications for child health programmes. *Public Health Nutr* 2006;9:942–7.
6. World Health Organization, Department of Nutrition for Health and Development. WHO global database on child growth and malnutrition. Available from: <http://www.who.int/nutgrowthdb/en/> (cited 30 October 2009).
7. World Health Organization. WHO Anthro for personal computers: software for assessing growth and development of the world's children (version 3). Geneva, Switzerland: 2009. Available from: <http://www.who.int/childgrowth/software/en/> (cited 30 October 2009).
8. Yang H, de Onis M. Algorithms for converting estimates of child malnutrition based on the NCHS reference into estimates based on the WHO Child Growth Standards. *BMC Pediatr* 2008;8:19.
9. de Onis M, Blössner M. The World Health Organization Global Database on Child Growth and Malnutrition: methodology and applications. *Int J Epidemiol* 2003;32:518–26.
10. de Onis M, Blössner M, Borghi E, Frongillo EA, Morris R. Estimates of global prevalence of childhood underweight in 1990 and 2015. *JAMA* 2004;291:2600–6.
11. Black RE, Allen LH, Bhutta ZA, et al. for the Maternal and Child Undernutrition Study Group. Maternal and child undernutrition: global and regional exposures and health consequences. *Lancet* 2008;371:243–60.
12. de Onis M, Blössner M, Borghi E, Morris R, Frongillo EA. Methodology for estimating regional and global trends of child malnutrition. *Int J Epidemiol* 2004;33:1260–70.
13. WHO. Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. *World Health Organ Tech Rep Ser* 1995;854.
14. World Health Organization. Training course on child growth assessment. Module C: interpreting growth indicators. Geneva, Switzerland: World Health Organization, 2008.
15. United Nations, Department of Economic and Social Affairs, UN Population Division. World population prospects, the 2008 revision. New York, NY: United Nations, 2009.
16. Huang TT, Glass TA. Transforming research strategies for understanding and preventing obesity. *JAMA* 2008;300:1811–3.
17. Sherry B, Mei Z, Scanlon K, Mokdad AH, Grummer-Strawn LM. Trends in state-specific prevalence of overweight and underweight in 2-through 4-year-old children from low-income families from 1989 through 2000. *Arch Pediatr Adolesc Med* 2004;158:1116–24.
18. Lee JM, Pilli S, Gebremariam A, et al. Getting heavier, younger: trajectories of obesity over the life course. *Int J Obes (Lond)* 2010;34:614–23.
19. McCormick DP, Sarpong K, Jordan L, Ray LA, Jain S. Infant obesity: are we ready to make this diagnosis? *J Pediatr* 2010;157:15–9.
20. van Dijk CE, Innis SM. Growth-curve standards and the assessment of early excess weight gain in infancy. *Pediatrics* 2009;123:102–8.
21. World Health Organization. Training course on child growth assessment. Module D: counselling on growth and feeding. Geneva, Switzerland: World Health Organization, 2008.
22. Bruce KD, Hanson MA. The developmental origins, mechanisms, and implications of metabolic syndrome. *J Nutr* 2010;140:648–52.
23. Gewa CA. Childhood overweight and obesity among Kenyan pre-school children: association with maternal and early child nutritional factors. *Public Health Nutr* 2010;13:496–503.
24. Griffiths LJ, Hawkins SS, Cole TJ, Dezateux C for the Millennium Cohort Study Child Health Group. Risk factors for rapid weight gain in preschool children: findings from a UK-wide prospective study. *Int J Obes (Lond)* 2010;34:624–32.