

Chapter 11

Epidemiology of Obesity in Children

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Keywords Child • Adolescent • Obesity • Overweight • Body mass index

Key Points

- Childhood obesity has become a serious public health threat worldwide. The prevalence has reached a high level in many countries but large variations exist across countries and population groups within countries.
- The prevalence of childhood obesity is higher in developed countries than developing countries. However, it has been increasing dramatically in many developing countries, particularly in urban settings and among high socioeconomic status groups in the past two decades.
- Various references and standards have been used to define obesity and overweight in children and adolescents over time and across countries although in general most are based on age-sex-specific BMI cut points. They can give different estimates of the rates. The International Obesity Task Force (IOTF) BMI reference. The 2006 WHO Growth Standards for preschool children, and US 85th and 95th BMI percentiles have been used widely.
- Childhood obesity has many immediate, intermediate and long-term health consequences. Overweight and obese children are likely to maintain their status into adulthood and are at higher risks for developing chronic diseases. A good understanding of the childhood obesity epidemic will help guide intervention efforts and develop effective population-based programs and policies.

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Abbreviations

BMI	Body mass index
CDC	Centers for Disease Control and Prevention
NHANES	National Health and Nutrition Examination Survey
WHO	World Health Organization
IOTF	The International Obesity Task Force

Introduction

The rising childhood obesity prevalence is a serious public health problem in many countries worldwide. It becomes a major public health challenge of the twenty-first century [1–3]. Recent studies indicate that approximately 20 % of school age-children in European countries are overweight or obese and 5 % are obese. In North America, these figures are 30 % and 15 %, respectively. It is estimated that 155 million, or one in ten school-age (5–17 years old) children are overweight or obese [4]. During recent years, overweight and obesity have been increasing dramatically in many developed and developing countries [1, 5, 6].

Although current understanding of the health consequences of overweight and obesity is predominately based on adult studies, increasing evidences suggest that childhood obesity has a number of immediate, intermediate, and long-term health consequences. Childhood obesity has long-term effects on mortality and morbidity [7, 8]. Overweight and obese children are likely to maintain their status into adulthood and are at higher risks for developing chronic diseases such as hypertension, dyslipidemia, type 2 diabetes, heart disease, stroke, gallbladder disease, osteoarthritis, sleep apnea and respiratory problems, and certain cancers [9]. A good understanding of the childhood obesity epidemic will help guide intervention efforts and develop effective population-based programs and policies.

Classification of Childhood Overweight and Obesity

Various measures and references have been used to define obesity and overweight in children and adolescents over time and across countries at present. This has affected prevalence estimates across studies and populations. Current consensus is that body mass index ($BMI = \text{weight [kg]} / \text{height [m]}^2$) is a good measure of adiposity in children and adolescents [10–14]. However, BMI varies substantially by age and gender in children. Thus, unlike in adults, BMI cut-off points used to classify obesity in children should be sex-age-specific. For adults, based on the World Health Organization (WHO) recommendations, BMI of 25 and 30 are widely used to defined overweight and obesity, respectively [15].

Different references based on weight-for-height indexes, such as BMI and weight-for-height, have been used to classify body weight status for children. However, application of these measures varies considerably [10–12, 14, 16]. For example, in the USA, the sex-age-specific 85th and 95th BMI percentiles have been used. Other countries, such as China, France, the UK, Singapore, and the Netherlands, have developed their own BMI references using local data. The BMI cut-points in these references differ considerably. A universal reference will help facilitate international comparisons and to monitor the global obesity epidemic. Following are several references that have been used widely.

1. *The International Obesity Task Force (IOTF) reference.* The reference supports a series of sex-age-specific BMI cut-points for children age 2–18 years, which correspond to the BMI cut-points of 25 and 30 for adulthood overweight and obesity, respectively [14]. The cut-points were derived based on sex-specific BMI-age curves with BMI of 25 and 30 at age 18, which were fit based on large data sets from six countries, namely, Brazil, Britain, Hong Kong, the Netherlands, Singapore, and

the USA. The reference has been recommended for international use based on its unique strengths. It is simple to use and is consistent for children and adolescents. However, the reference data sets may not adequately represent non-Western populations, and there are large differences in the prevalence of overweight and obesity across the six source nations [17].

2. *The 2006 WHO Growth Standards for preschool children.* The WHO released new growth standard for children from birth to the age of 60 months in 2006 [18]. These were developed based on the Multicentre Growth Reference Study (MGRS), which recruited affluent, breast-fed, and healthy infants/children whose mothers did not smoke during or after delivery from six cities in Brazil, Ghana, India, Norway, Oman, and the USA. The data showed great similarity in growth across all sites with only about 3 % of the total variation in growth attributable to race/country. Data were pooled to generate cut-off points. These standards include anthropometric indicators such as height-for-age (length-for-age), weight-for-age, weight-for-height (weight-for-length), and BMI-for-age. BMI Z-score ≥ 2 was recommended to classify “obesity” and BMI Z-score ≥ 1 to classify “overweight.” These standards have been widely used.
3. *The 2007 WHO growth reference for school-age children and adolescents.* In 2007, the WHO released another set of growth references for children and adolescents aged 5–19 years [19]. The references were derived based on the same US dataset for the 1978 WHO/National Center for Health Statistics (NCHS) growth references, but used different growth curve smoothing techniques. The references include three indicators: BMI-for-age, weight-for-age, and height-for-age. Overweight and obesity cut-points were based on BMI-for-age Z-scores. A Z-score of 1 was found to be equivalent to a BMI-for-age of 25.4 for boys and 25.0 for girls in 19-year olds. As these values are equal or close to the WHO BMI cut-points of 25 used in adults, it was recommended to use a Z-score of 1 to classify “overweight” and a Z-score ≥ 2 to classify “obesity”. BMI-for-age Z-scores < -2 and < -3 were set as the cut-points for thinness and severe thinness, respectively. The reference is not widely used.
4. *BMI references used in the USA:* In 2000, the US NCHS and the Centers for Disease Control and Prevention (CDC) updated growth charts (including BMI percentiles) using data from five national health examination surveys from 1963 to 1994 including the National Health and Nutrition Examination Survey (NHAENS) [10]. Before the release of the 2000 CDC Growth Charts, 85th and 95th percentiles based on data from the First NHANES (1971–1974) were used in the USA as well as in many other countries to classify childhood obesity and overweight [20, 21]. They recommended the use of sex- and age-specific 95th and 85th BMI percentiles to classify childhood obesity and overweight, respectively, in children over age 2 years old. These cut-points are not directly linked to health risks.

The Global Epidemic of Childhood Overweight and Obesity

1. *Recent and current prevalence of overweight and obesity.* Obesity has become an epidemic in children worldwide, but large regional differences exist. The combined prevalence of overweight and obesity is high in many regions and countries around the world (see Tables 11.1, 11.2, and 11.3). Table 11.1 shows the projected prevalence rates in WHO-defined regions. Our previous work to project combined prevalence for 2006 yielded a range from 17 % in South East Asia to 40 % in the Americas [1]. In general, combined prevalence is much higher in developed countries than in developing countries. There are also considerable age- and gender differences in many populations. Based on our estimations [1] and the findings of others [22–25], approximately 26 % of school-age children in European countries were overweight or obese in 2006, and 5 % were obese. In Americas, these figures were 28 % and 10 %, respectively.

There are large between-country variations in the prevalence across and within world regions (see Fig. 11.1 and Table 11.2). Figure 11.1 shows a worldwide view of combined prevalence of overweight and obesity in childhood. Combined prevalence is high in Western and industrialized countries, such

Table 11.1 Prevalence (%) of overweight and obesity in school-age children based on available data and IOTF criteria, and estimated for 2006 and 2010

WHO region (dates of most recent surveys)	Most recent surveys		Projected 2006 ^a		Projected 2010 ^a	
	Overweight and obesity	Obesity	Overweight and obesity	Obesity	Overweight and obesity	Obesity
Africa (1987–2003)	1.6	0.2	^b	^b	^b	^b
Americas (1988–2002)	27.7	9.6	40.0	13.2	46.4	15.2
Eastern Mediterranean (1992–2001)	23.5	5.9	35.3	9.4	41.7	11.5
Europe (1992–2003)	25.5	5.4	31.8	7.9	38.2	10.0
South East Asia (1997–2002)	10.6	1.5	16.6	3.3	22.9	5.3
West Pacific (1993–2000)	12.0	2.3	20.8	5.0	27.2	7.0

Data source: Wang and Lobstein, 2006

^aBased on population weighted annualized increases in prevalence

^bThere were insufficient data on school age children in the WHO African Region to make estimates of projected prevalence rates

Table 11.2 Combined childhood overweight and obesity prevalence (%) based on data collected since around the year 2000 for selected countries by WHO Region^a

	Year of survey	Age (years)	Boys	Girls	BMI reference
<i>WHO Africa region</i>					
Algeria	2006	6–10	7.4	7.4	IOTF
Seychelles	2004/2005	9–15	16.5	21.0	IOTF
South Africa	2001–2004	6–13	13.6	17.7	IOTF
<i>WHO Americas region</i>					
Brazil	2002	7–10	23.1	21.1	IOTF
Canada	2004	2–19	28.9	26.6	2000 CDC
Chile	2002	6	28.6	27.1	IOTF
Mexico	2006	2–19	28.4	27.3	2000 CDC
USA	2009–2010	2–19	33.0	30.4	2000 CDC
<i>WHO Eastern Mediterranean region</i>					
Egypt	2005	10–17	23.4	29.6	85th percentile
Iran	2003/2004	6–18	14.4	14.0	IOTF
Kuwait	1999–2000	10–14	44.7	44.9	NCHS
Saudi Arabia	2002	1–18	16.7	19.4	IOTF
United Arab Emirates (UAE)	1998–1999	5–17	32.4	32.4	IOTF
<i>WHO European region</i>					
England	2007	5–17	22.7	26.6	IOTF
France	2006/2007	3–17	13.1	14.9	IOTF
Germany	2008	4–16	22.6	17.7	IOTF
Netherlands	2003	5–16	14.7	17.9	IOTF
Switzerland	2007	6–13	16.7	13.1	IOTF
<i>WHO South East Asia region</i>					
India	2007–2008	2–17	20.6	18.3	IOTF
India	2005–2006	<5	1.7	1.4	2006 WHO growth standard
Malaysia	2002	7–10	9.7 (obesity)	7.1 (obesity)	WHO
Sri Lanka	2003	10–15	1.7	2.7	IOTF
Vietnam	2004	11–16	11.7 (boys and girls)		IOTF
<i>WHO Western Pacific region</i>					
Australia	2007	2–16	22.0	24.0	IOTF
China	2005	7–18	14.9	8.9	Chinese ref.
Japan	1996–2000	6–14	16.2	14.3	IOTF
New Zealand	2007	5–14	28.2	28.8	IOTF
South Korea	2005	10–19	21.7	17.1	Korean ref.

^aSome prevalence data was limited by data availability; many rates presented here may not be nationally representative. Only data collected since 2000 were used and we report statistics for those countries with large population sizes within each region as examples. We also added some additional data. (Main data Source: IASO 2012)

Table 11.3 Time trends in the combined prevalence (%) of overweight and obesity in preschool-age children aged 0–5 years for years from 1990 to 2010 and projections for 2015 and 2020, by United Nations (UN) Region^{a–d}

UN region and sub-region	1990	1995	2000	2005	2010	2015	2020
Global	4.2	4.6	5.1	5.8	6.7	7.8	9.1
Developing countries	3.7	4.0	4.5	5.2	6.1	7.2	8.6
Developed countries ^e	7.9	8.8	9.7	10.6	11.7	12.9	14.1
Africa	4.0	4.7	5.7	6.9	8.5	10.4	12.7
Eastern	3.9	4.4	5.1	5.8	6.7	7.6	8.7
Middle	2.5	3.4	4.7	6.4	8.7	11.7	15.5
Northern	6.1	8.0	10.3	13.3	17.0	21.4	26.6
Southern	10.2	9.5	8.8	8.2	7.6	7.0	6.5
Western	2.2	2.9	3.8	4.9	6.4	8.3	10.6
Asia ^f	3.2	3.4	3.7	4.2	4.9	5.7	6.8
Eastern	4.8	4.9	5.0	5.1	5.2	5.3	5.4
South Central	2.3	2.6	2.9	3.2	3.5	3.9	4.3
Southeastern	2.1	2.6	3.1	3.8	4.6	5.6	6.7
Western	3.0	4.5	6.8	10.1	14.7	21.0	29.1
Latin America and Caribbean	6.8	6.8	6.8	6.9	6.9	7.0	7.2
Caribbean	4.6	5.1	5.6	6.2	6.9	7.6	8.3
Central America	4.8	5.3	5.9	6.5	7.2	8.0	8.8
South America	8.0	7.7	7.4	7.1	6.8	6.5	6.3
Oceania ^g	2.9	3.1	3.2	3.3	3.5	3.6	3.8

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Data source: de Onis et al. 2010

^aAll surveys included both boys and girls

^bCross-sectional data on the prevalence of overweight and obesity were obtained from national nutrition surveys. 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. About 38 % of the surveys (171 surveys) were conducted between 1991 and 1999, 16 % (70 surveys) were conducted before 1991, and 46 % (209 surveys) after 1999

^cLinear mixed-effects models were fit to estimate prevalence rates and numbers of affected children by region from 1990 to 2020

^dOverweight and obese statuses were defined based on >2 SDs (standard deviations) from the weight-for-height median

^eIncluding Europe, Northern America, Australia, New Zealand, and Japan

^fExcluding Japan

^gExcluding Australia and New Zealand

as the USA, Canada, some European countries, some countries in South America, some nations in the Middle East, some nations in North Africa, and in the Asia-Pacific region (e.g., Indonesia and in New Zealand) [26]. According to a recent study examining combined prevalence by WHO region [26], the Region of the Americas (approximately 25–30 %) and Eastern Mediterranean Region (approximately 20–40 %) had higher prevalence than the South East Asian and Western Pacific Regions including nations such as India, Malaysia, Vietnam, China, Australia, South Korea, and Japan. Africa had the lowest prevalence (about 10 %). There were also differences between countries within the same WHO region. In the Eastern Mediterranean Region, the combined prevalence in Egypt and Kuwait were about 30 % and 45 % among girls, respectively, while the prevalence was only 14.0 % amongst Iranian girls. Self-reported information in a 2001–2002 international school survey of 11-, 13-, and 15-year-olds from 35 countries in Europe and North America ($N=162,305$) showed large between-country difference in the obesity/overweight prevalence in adolescents, which ranged from 3.5 % in Lithuanian girls to 31.7 % in boys from Malta [27].

The International Association for the Study of Obesity recently reported the combined prevalence of overweight and obesity among childhood based on findings of many researchers by six WHO regions across the world [28]. Some of the data were shown in Table 11.2, which also includes other data. The following countries had the highest combined rate in their respective WHO Region: the USA (32 %), Kuwait (44 %), England (25 %), New Zealand (28 %), India (19 %), Seychelles (18 %).

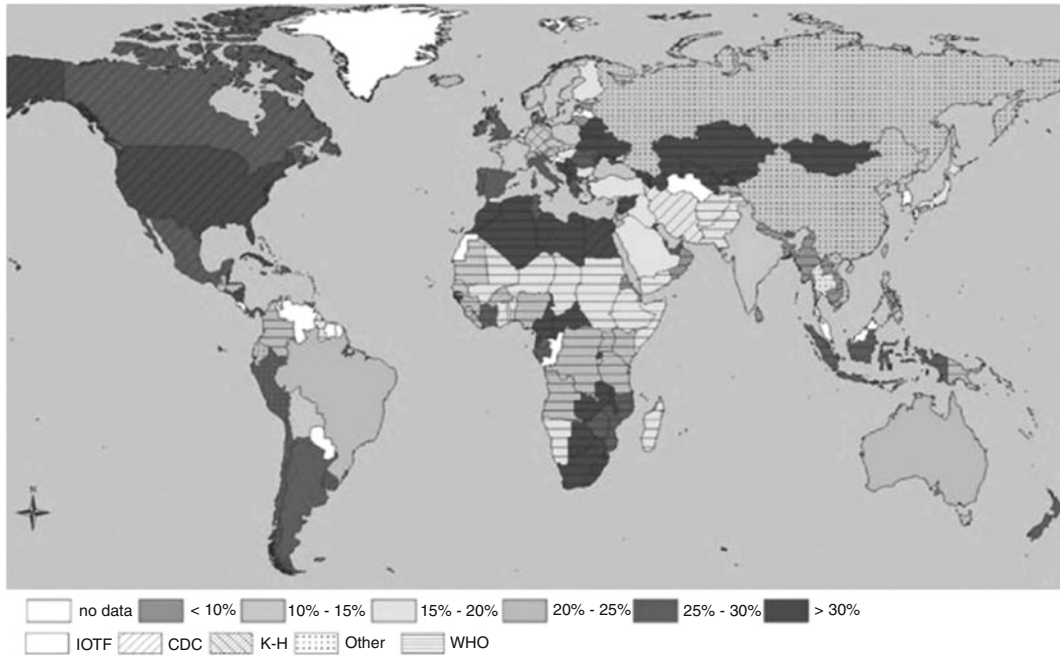


Fig. 11.1 Worldwide combined prevalence of overweight and obesity in children and adolescents. The prevalence estimates were calculated as the arithmetic mean of the age-specific estimates. Difference references (e.g., those recommended by the IOTF, WHO, and US CDC) were used to classify overweight and obesity across countries (Data Source: Pigeot et al. 2011)

2. *Time trends in the prevalence of childhood obesity.* Many countries have data collected over the past two decades allowing for the examination of time trends in obesity in both adults and young people. We studied the global trends in childhood obesity in a comprehensive meta-analysis of studies published between 1980 and 2005 from over 60 countries [1]. The combined prevalence of overweight and obesity increased in almost all countries for which trends data were available. From the 1970s to the end of the 1990s, the combined prevalence doubled or tripled in several large countries in North America (i.e., Canada and the USA), the Western Pacific Region (i.e., Australia), and Europe (i.e., Finland, France, Germany, Italy, and Spain). We estimated the prevalence based on the IOTF BMI cut points (Table 11.1).

One recent study examined trends in the combined prevalence in preschool age children (0–5 years old) between 1990 and 2010, and projected worldwide rates for 2015 and 2020 (Table 11.3) [29]. It estimated 43 million children (35 million in developing countries) were overweight or obese in 2010, and 92 million were at risk of overweight; and the global combined prevalence increased from 4.2 % in 1990 to 6.7 % in 2010. If such trends continue, these numbers may reach 9.1 % (or approximately 60 million children) in 2020. For developing countries alone, the combined prevalence was estimated at 6.1 % in 2010 and is expected to rise, perhaps as high as 8.6 % by 2020. 2010 rates were lower in Asian than in Africa (4.9 % vs. 8.5 %), but a much larger number of children are affected (17.7 million vs. 13.3 million) in Asia compared to Africa. Given the dramatic increases in combined prevalence since 1990, the study concluded that effective interventions starting as early as infancy are necessary to reverse anticipated trends.

Among major industrialized countries, the USA has the highest prevalence and the largest number of overweight and obesity individuals. The prevalence in children has increased for all ages between 2 and 19 years, but the increase in obesity leveled off in recent years. Figure 11.2 shows time trends in the prevalence of obesity (BMI \geq 95th percentile) by age between 1971–1974 and 2009–2010.

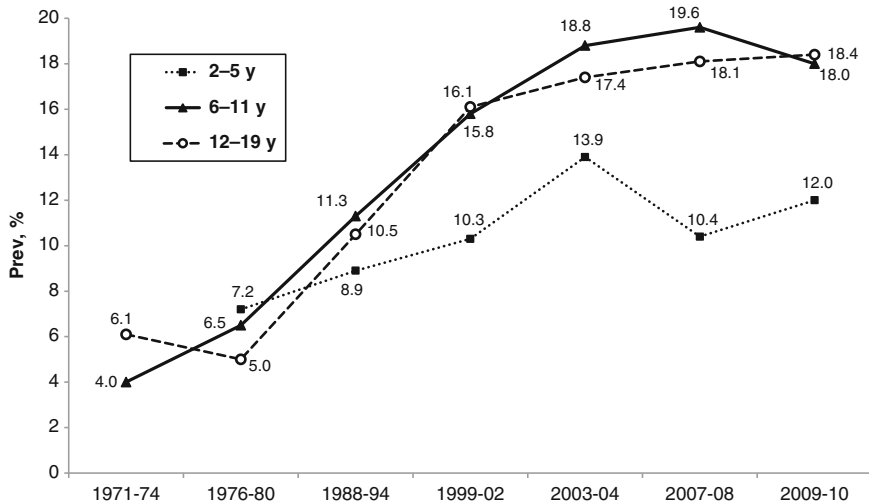


Fig. 11.2 Trends in the prevalence (%) of obesity (BMI \geq 95th Percentile) in US children and adolescents, by age: 1971–1974 to 2009–2010. Based on US national data collected in NHANES (Wang and Lim, 2012). Reprinted, with permission, from the *International Review of Psychiatry*, 2012, 24(3), p. 176

Between NHANES II (1976–1980) and 2003–2004, the average annual rate of increase in obesity prevalence was approximately 0.5 % point in children aged 2–19. However, the NHANES data shows a decrease in the prevalence of obesity among children aged 2–5 years, from 13.9 % in 2003–2004 to 10.4 % in 2007–2008, although the prevalence in both children aged 6–11 years and adolescents was slightly increased [30]. In 2009–2010, the national prevalence of obesity (16.9 %) was similar to that in 2007–2008; and it was 12.0 %, 18.0 %, and 18.4 % in children aged 2–5, 6–11, and 12–19 years, respectively [31].

In some developing countries, the prevalence of child overweight and obesity has increased alarmingly over the past two decades, with the combined prevalence within some sub-regions and population groups being similar to that in some industrialized countries. This is especially the case in countries that are in the midst of rapid social economic transitions (e.g., China, Brazil, and Mexico). China, in particular, is illustrative of dramatic increases in obesity in children and adults [6, 32].

In China, the combined prevalence of obesity and overweight nationwide increased between 1985 and 2005. Figure 11.3 shows overall trends in prevalence based on data collected through a series of representative school-based cross-sectional survey that collected health data amongst school-age children [33]. The combined prevalence has increased approximately tenfold since 1985. The combined prevalence has risen more rapidly (from 2.8 to 19.3 %) in boys than in girls (from 2.4 to 10.8 %), and in the more developed regions and in high income groups.

Nevertheless, our understanding of the current global childhood obesity epidemic and time trend data remains limited due to the lack of up-to-date, comparable and representative data from different countries. In addition, past studies have included dissimilar study samples and used different criteria to define obesity. This makes it difficult to compare findings. Furthermore, there are large within-country differences in many countries for both the prevalence and trends [34].

Discussion

Obesity is a serious threat to global health in the twenty-first century. The prevalence of obesity and overweight in children has tripled in many countries since the 1980s, and the number of people affected is expected to continue to rise. Obesity has many short- and long-term health and financial

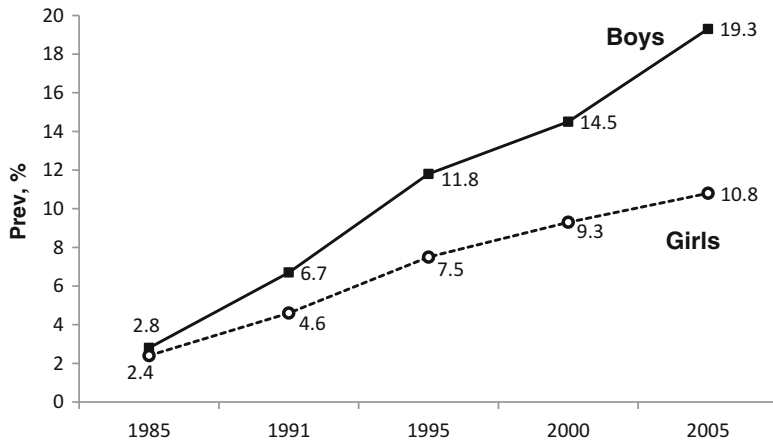


Fig. 11.3 Trends in the combined prevalence (%) of overweight and obesity in Chinese school-age children, by gender: 1985–2005. Overweight and obesity were classified based on Chinese BMI cut points; the prevalence was based on nationwide survey data (Ji and Cheng, 2009). Reprinted, with permission, from the *American Journal of Clinical Nutrition*, 2010, 92(5)

consequences for individuals, families and the society. For example, obesity is already responsible for 2–8 % of health costs and 10–13 % of deaths in parts of Europe, and it was even worse in the USA, may reach 17 % of health costs in 2030 [35]. However, various references and standards have been used over the past two decades and at present to define overweight and obesity in children, although in general most are based on age-sex-specific BMI cut points (percentile or other cut points), and they can give different estimates of the rates.

The prevalence of childhood obesity has reached a very high level in many world regions, but large variations exist across countries and population groups within countries. In general, the prevalence is much higher in developed countries than developing countries. However, overweight and obesity have been increasing dramatically in many developing countries, particularly in urban settings and among high socioeconomic status (SES) groups during recent years. For example, in 2010, the combined prevalence was 31.8 % in US children and adolescents [31], while it was <5 % in many developing countries [29]. Nevertheless, overweight and obesity rates have been increasing dramatically in many countries and population groups. In recent years, the prevalence has increased at a much faster rate in some developing countries, such as China, compared to other industrialized countries. Different from industrialized countries, in developing countries, often urban residents and those of higher SES are more likely to be overweight or obese than their counterparts.

The rising epidemic reflects the profound changes in society and in individuals' behavioral patterns during recent decades. Economic growth, modernization, urbanization and globalization of food markets are some of the forces contributing to the epidemic. The impact of global exchanges of trade, information and culture, made possible by new information technologies, on health-related behaviors such as dietary intakes are likely considerable as well, though are not yet well understood. Obesity is related to SES, however, the associations vary by gender, age, and countries. Previous studies suggest that SES groups with greatest access to energy-rich diets are likely to be at increased risk. In general, low-SES groups in industrialized countries and high-SES groups in developing countries are at higher risk of being overweight than their counterparts. For example, a recent study showed that the prevalence of overweight was higher among children from less affluent families in 21 of 24 Western and 5 of 10 Central European countries compared to children from more affluent

families. However, children from more affluent families were at higher risk of overweight in some countries (i.e., Croatia, Estonia, and Latvia. In Poland, Lithuania, Macedonia, and Finland), girls from less affluent families were more likely to be overweight while the opposite was found for boys [27]. For US children and adolescents, our research shows that the patterns of SES disparity of overweight varied across age, ethnic, and gender groups, and have changed over time [36]. Disparities have decreased since the early 1990s with the rise of the obesity epidemic, but African American children with a high SES were at increased risk. As a result of growing obesity prevalence, it is possible that the association between SES and obesity in some industrialized countries may tend to become weaker even disappear, while may change direction in some developing countries.

Conclusions

In conclusion, we are facing a growing global obesity epidemic that influence both industrialized and developing countries. The growing obesity crisis calls on timely and effective interventions. Obesity as well as the related diseases is largely preventable. The development of effective population-based programs and policies for the prevention of obesity in children should be a priority as obesity is difficult to cure once developed and has many long-term health problems, social and economic consequences. A good understanding of the scope of the childhood obesity problem will help guide intervention efforts.

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