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Worldwide trends in childhood overweight and obesity

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Abstract
Objectives. Obesity has become a global epidemic but our understanding of the problem in children is limited due to lack of comparable representative data from different countries, and varying criteria for defining obesity. This paper summarises the available information on recent trends in child overweight and obesity prevalence. *Methods.* PubMed was searched for data relating to trends over time, in papers published between January 1980 and October 2005. Additional studies identified by citations in retrieved papers and by consultation with experts were included. Data for trends over time were found for school-age populations in 25 countries and for pre-school populations in 42 countries. Using these reports, and data collected for the World Health Organization's Burden of Disease Program, we estimated the global prevalence of overweight and obesity among school-age children for 2006 and likely prevalence levels for 2010. *Results.* The prevalence of childhood overweight has increased in almost all countries for which data are available. Exceptions are found among school-age children in Russia and to some extent Poland during the 1990s. Exceptions are also found among infant and pre-school children in some lower-income countries. Obesity and overweight has increased more dramatically in economically developed countries and in urbanized populations. *Conclusions.* There is a growing global childhood obesity epidemic, with a large variation in secular trends across countries. Effective programs and policies are needed at global, regional and national levels to limit the problem among children.

Key words: *Child, adolescent, obesity, overweight, prevalence, trends*

Introduction

Obesity has become an epidemic in many parts of the world, according to numerous studies conducted in adults and in the much more limited data collected from young people (1–4). Currently our understanding of the global circumstances surrounding obesity in children and adolescents is limited due to a number of factors. The two main challenges are the lack of comparable representative data from different countries, and the use of varying criteria for defining obesity among different countries and researchers. This methodological problem of inconsistency between classifications of childhood obesity is a major obstacle in studying global secular trends for younger age groups (3,5). A good understanding of the global situation can provide useful insights on the causes of the current obesity epidemic and will assist the planning and development of international collaborations and programs to address this growing public health crisis.

Obesity increases the risk of a number of chronic diseases (2, 3, 6–8). In some countries, it has become a very serious public health problem. For instance, in the United States, obesity is the second leading cause of preventable disease and death, surpassed only by smoking. The direct and indirect costs attributed to obesity in the year 2000 were 117 billion US dollars (9). Childhood and adolescence have been proposed as critical periods for the development of this condition (10). Obesity in early life is of particular concern due to its associated health consequences and its influence on young people's psychosocial development (6–8). Once people develop obesity, it is difficult and costly to cure and there are tremendous challenges for patients to maintain a healthy body weight (8). Overweight children are more likely to become

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overweight in adulthood than are lean children. Approximately one half of overweight adolescents and over one-third of overweight children remain obese as adults (7,11). Childhood obesity also confers long-term effects on mortality and morbidity (6,7). Therefore, prevention of obesity in children and adolescents has been argued as a public health priority to combat the obesity epidemic (2, 3, 9,10).

In the present study, we examined the recent trends in overweight and obesity prevalence in more than sixty countries from different regions worldwide. The goal was to provide an overview of the worldwide trends in childhood obesity over the past two decades and to estimate current global prevalence levels.

Methods

Study inclusion criteria

Cross-sectional and longitudinal studies that examined the prevalence of overweight or obesity in children and adolescents up to 18 years of age were examined. Papers were limited to those published after 1980, which reported prevalence levels for obesity based on weight for height or body mass index (BMI), and which contained trend data or which could be compared with surveys based on similar population groups at an earlier or later time. In many countries, especially low- or middle-income countries, national representative data were not available and studies based on small, regional surveys were included where these were considered to provide a useful indication of the situation in these countries. In countries where national or large-scale studies were available, other small-scale studies were excluded to simplify the analysis.

Search strategy

PubMed (www.ncbi.nlm.nih.gov/entrez) was searched for studies published from January 1980 to October 2005. Several concepts were incorporated in the search process, including: child, adolescent, overweight, obesity, body mass index (BMI), trend, prevalence, and country name. Titles and abstracts of studies uncovered by the electronic searches were examined on screen. Papers, which could not be excluded on the basis of the abstract, were obtained in full and reviewed for suitability for inclusion. In addition, a number of studies identified in the course of reading, or brought to the authors' attention by colleagues and experts consulted, were included. Where it appeared that data were available from unpublished sources, this was sought and, generally, obtained. Where essential information was lacking (such as time of data collection), authors were requested to provide this and were generally able to do so.

Classifications of obesity and overweight in children and adolescents

At present, there is still no widely agreed standard for classifying overweight and obesity in children and adolescents (3). Results can vary considerably when using different reference populations (3, 12,13). The use of universal classifications for childhood obesity (e.g., an international reference) can help facilitate international comparisons, but such a practice may also raise some serious concerns (12,14). Different measures and references have been used, with cut-off points for overweight and obesity, such as 110% or 120% of ideal weight for height; weight-for-height Z-scores of >1 and >2, and BMI at the 85th, 90th, 95th and 97th percentiles (based on various reference populations (3).

Previously, many researchers chose to use weight-for-height to classify obesity, especially for children under 10 years. In recent years, BMI has been increasingly accepted as a valid indirect measure of adipose tissue in both children and adolescents for survey purposes (3,15). Age- and gender-specific BMI cut-off points are needed when classifying overweight and obesity in young people (16–21). A number of different BMI references have been developed such as those from the US National Centre for Health Statistics (NCHS (18), the United Kingdom (19) and France (20). Currently there are two international references, the WHO and the International Obesity TaskForce (IOTF) references (17,21). The latter was developed in response to concerns that the WHO reference cut-off points were based on a US reference population that did not reflect healthy growth and which used arbitrary statistical cut-off points at the 85th and 95th centiles. An IOTF expert panel used internationally pooled data collected from Brazil, Britain, Hong Kong, Singapore, the Netherlands, and the USA, and developed definitions of overweight and obesity based on BMI centile curves that passed through the adult cut-off points of BMI 25 and 30. The resulting set of age- and gender-specific BMI cut-off points for children was published in 2000 (21).

However, in addition to their strengths, international reference sets have disadvantages (12, 14, 17, 22,23). Some researchers have argued that population-specific references should be used for certain ethnic groups, on the grounds that the WHO-defined thresholds for overweight and obesity in adults may be inappropriate in terms of health outcomes for these ethnic groups (24–26) and

therefore should not be used as a basis for child cut-off points. It is also argued that local population references should be used in screening programs and to make clinical judgments about individual children (3,14).

Data presentation and comparison of secular trends across countries

Previous comprehensive reviews have looked at prevalence levels of obesity in pre-school children (27–29) and in school-age children (3), but have not looked expressly at trends over time. To facilitate comparisons of the trends across countries based on data gathered over different survey periods, average annual change in prevalence levels were calculated (=[prevalence at time 2-prevalence at time 1]/number of years between the two surveys). An annualised change in prevalence was only calculated when the two surveys measured prevalence levels among similar age groups. Where a choice of classification method was available, preference was given to classifications using the IOTF cut-off points.

Results

A summary of the material collected is given in Tables 1 and 2. The countries represented in these tables constitute 60 of the 191 member countries of the World Health Organization, and the total population in the countries presented here represents over half of the world population in 2000 (30). The Tables are sectioned according to WHO regions (membership of WHO regions can be found by visiting the regional office sites at http://www.who.int/about/en/).

Secular trends for school-age children are presented in Figure 1 and 2, which show the annualized changes in the prevalence of overweight (including obesity) and for the prevalence of obesity alone, respectively, for those countries where data are available. It can be seen that for both classifications, prevalence levels are increasing in virtually all countries. The exceptions are Russia and to a lesser extent Poland, where the prevalence of overweight showed a decline across the period indicated. The prevalence of overweight and obesity had increased in all other countries. For some countries, such as the former East Germany, New Zealand, the Netherlands and Canada, the prevalence of overweight has been rising by more than one percentage point each year.

Data for trends in overweight prevalence among children in China and Brazil were available for urban and rural populations separately, as shown in Figure 1, and indicate a greater change in the prevalence of overweight among urban children than rural children.

Results for changes in the prevalence of obesity among pre-school children are shown in Figure 3. Although several of the countries surveyed showed a reduction in obesity levels among this younger age group over the relevant periods, the majority showed an increase in prevalence over the period, with some countries reporting average increases in obesity prevalence greater than a quarter of one percentage point each year.

IOTF has previously published estimates of the prevalence of overweight and obesity among children on a global and regional basis (3), based to a large extent on the present authors' collated materials. The organization maintains a collection of data on prevalence rates on behalf of the International Association for the Study of Obesity (31). The figures for changing prevalence rates among school-age children presented here were applied to the most recent survey data held in the data collection, resulting in estimates of the prevalence of overweight and obesity for 2006, and further projected to 2010, assuming that the annualised increments in prevalence continue increasing on a linear basis. These estimates are shown in Table 3.

Discussion

Based on surveys of child overweight and obesity spanning the last forty years, this paper reports evidence for a growing global obesity epidemic among school-age children, which may also be affecting pre-school children in some parts of the world.

A number of conclusions can be drawn. First, the prevalence of childhood obesity is increasing in almost all industrialized countries for which data are available, and in several lower-income countries. The Figures indicate that the changes have been taking place at very different speeds and in different patterns. Obesity appears to have spread more dramatically in industrialized countries over the past 2–3 decades than in less economically developed countries. In several industrialized countries and in societies that have been undergoing rapid socioeconomic transitions, obesity has increased at an accelerated rate. From the 1970s to the end of the 1990s, the prevalence of overweight or obesity in school-age children doubled or tripled in several large countries in most regions, such as Canada and the United States in North America; Brazil and Chile in South America; Australia and Japan in the Western Pacific region, and Finland, Germany, Greece, Spain and the UK in Europe.

Table 1. Worldwide trends of overweight and obesity in school-age children

Country	Date of survey	Prevalence of obesity (%)	Prevalence of overweight and obesity (%)	Age/ sample size	National or local survey	Definition	Ref
Americas							
Brazil	1974 1997	INA	4.1 →13.9 Urban: 4.9 →18.4 Rural: 3.1 →8.4	6–18 y 1974: 56,295 1997: 4875	N	IOTF	1
Canada	1981 1996	M: 2.0 →10.0 F: 2.0 →9.0	M: 11.0 →33.0 F: 13.0 →27.0	7–13 y, 1981: 2879 1996: 6277	N	IOTF	46 47
Chile	1987 2000	M: 1.8 →7.2 F: 2.1 →7.5	M: 10.6 →18.8 F: 11.6 →19.6	6 y, 1987: 166,891 2000: 199,444	N	IOTF	49
United States	1971–74 1988–94	INA	15.4 →25.6	6–18 y, 1971–74: 4472 1988–94: 6108	N	IOTF	1
United States	1971–74 1999–2000	6–11 y: 4.0 →15.3 12–19 y: 6.1 →15.5	INA	6–19 y, (NHANES data) 1971–74: INA 1999–2000: 3298	N	2000 CDC BMI 95th	48
Europe							
Czech Rep.	1991 2000	3.0 →6.0	10.0 →13.0	1991, (national reference) 2000, 7–11 y, 3345	N	Czech 90th/97th percentiles	50
Finland	1977 1999	M: 1.1 →2.7 F: 0.4 →1.4	M: 8.3 →19.4 F: 4.5 →11.2	12–18 y 1977: 2832 1997: 66,211	N	IOTF	51
France	1980 1990	2.5 →3.2	10.0 →11.7	4–17 y 1980: 6697 1990: 5795	N	French BMI 90th and 97th	52
France (North)	1992 2000	M: 1.7 →1.3 F: 1.6 →4.4	M: 9 →10.2 F: 14.1 →18.6	5–12 y 1992: 804 2000: 601	L	IOTF	66
Germany	1985 1995	M: 5.3 →8.2 F: 4.7 →9.9	M: 10.0 →16.3 F: 11.7 →20.7	7–14 y 1985: 2002 1995: 1901	L	French 90th and 97th BMI	53
Germany (East)	1992–3 1998–9	M: 2.8 →7.1 F: 3.5 →7.9	M: 16.7 →32.7 F: 19.0 →30.7	11–14 y 1992:798 1998:950	L	IOTF	55
Greece (Crete)	1982	M: 4.2 →12.7	M: 20.6 →39.7	11–13 y 1982:528 2002:620	L	IOTF	64
Iceland	1978 1998	M: 1.8 →5.8 F: 0.5 →4.2	M: 12.4 →22.0 F: 11.9 →25.5	9 y 1978: 418 1998::601	N	IOTF	67
Netherlands	1980 1996–97	M: 0.1 →1.1 F: 0.5 →1.9	M: 3.3 →9.0 F: 6.8 →13.2	9 y, (approx 700)	N	IOTF	57, 69

Table 1 (*Continued*)

Country	Date of survey	Prevalence of obesity (%)	Prevalence of overweight and obesity (%)	Age/ sample size	National or local survey	Definition	Ref
Poland	1987 1997	8.4 →9.7	23.8 →22.1	14 y, 1987: 3165 1997: 1014	L	Local BMI 85th and 95th percentile	56
Russia	1992 1998	INA	15.6 →9.0	6–18 y, 1992: 6883 1998: 2152	N	IOTF	1
Spain	1985 1995	Children: M: 6.5 →14.2 F:10.0 →17.7 Adolescents: M: 3.1 →6.0 F: 1.1 →1.5	Children: M: 21 →34 F:25 →36 Adolescents: M: 13 →21 F: 16 →21	6–7 and 13–14 y, 1985: 90997 1995: 106284	L	IOTF	70
Sweden	1986 2001	1.2 →4.8	11.5 →23.1	1986: 6–11 y, 507 2001: 6–13 y, 1115	L	IOTF	58
Switzerland	1980 1990	M: 3.7 →9.1 F: 2.7 →5.1	INA	15–16 y 1980: 1866 1990: 1212	L	French BMI 97th	60
United Kingdom England	1984 2002	M: 1.7 →5.4 F: 2.6 →7.8	M: 9.0 →20.7 F: 13.5 →27.4	1984:4–11 y, 5874 2002:2–10 y, 9982	N	IOTF	61, 62, 65
N Ireland	1990 2000	M: 4.0 →4.7 F: 1.6 →4.7	M: 16.0 →19.5 F: 15.9 →26.3	12 y 1990: 509, 2000: 1047	N	IOTF	68
FYR Serbia	1989 1998	M: 3.6 →7.2 F: 3.6 →6.4	M: 12.4 →18.7 F: 11.1 →17.4	8–14 y 1989: 12380 1998:6692	L	85th and 95th NHANES I	59
SE Asia							
Thailand	1992 1997	INA	M: 12.4 →21.1 F: 15.2 →12.6	5–16y, 2252	L	WHO/NCHS	79
Western Pacific							
Australia	1985 1995	7–15 y: M: 1.4 →4.7 F: 1.2 →5.5	7–15 y: M: 10.7 →20.0 F: 11.8 →21.5	1985: 7–15 y, 8492 1995: 2–18 y, 2962	N	IOTF	76
New Zealand	1989 2000	2.4 →9.1	13.4 →30.0	11–12 y, 1989: 871 2000: 894	L	IOTF	77
China							
Mainland	1985 1995	M: 2.6 →8.2 F: 3.3 →7.3	INA	6–18 y 264,000	N	120% wt-for-ht	71
	1991 1997	INA	All: 6.4 →7.7 Urban: 7.7 →12.4 Rural: 5.9 →6.4	6–18 y 1991: 3014 1997: 2688	N	IOTF	1

Table 1 (*Continued*)

Country	Date of survey	Prevalence of obesity (%)	Prevalence of overweight and obesity (%)	Age/ sample size	National or local survey	Definition	Ref
	1985 2000	Urban M: 1.1 →10.4 F: 0.2 →2.3 Rural M: 0.04 →1.5 F: 0.06 →0.9	Urban: M: 1.3 →14.8 F: 1.7 →8.3 Rural: M: 0.5 →5.8 F: 1.7 →4.7	7–22y, 1985: 471115 2000: 266431	N	China BMI ref.	72
Taiwan	1980–82 1994–96	M: 12.4 →16.4 F: 10.1 →11.1	M: 25.4 →28.0 F: 21.4 →21.3	12–15 y 1980–82: 1980 1994–96: 1366	N	> =110% and > =120% local ideal body weight ref.	73
Japan	1976–80 1996–2000	M: 6.1 →11.1 F: 7.1 →10.2	INA	6–14 y 1976–80: 15,677 1996–2000: 6079	N	> =120% local wt-for-ht ref.	74
	1976–80 1996–2000	M: 1.5 →3.8 F: 1.2 →2.9	M:10.7 →20.0 F: 10.1 →17.2	6–14 y 1976–80: 15,677 1996–2000: 6079	N	IOTF	74
Singapore	1975 1993	M: 1.6 →15.2 F: 1.1 →12..9	INA	6–16 y, INA	N	> =120% ideal wt-for-ht	75

WHO/NCHS WHZ = The WHO Reference based on the US 1977 Growth Charts, weight-for-height Z-score (WHZ).
WHO/NCHS = Age- and sex-specific BMI 85th and 95th percentiles, developed based on the US NHANES I data collected in 1971–74, were used to classify overweight and obesity, respectively.
IOTF = The IOTF age- and sex-specific BMI cutoffs that correspond to a BMI of 25 and 30 at age 18.
INA = Information not available.
M = males; F = females.
N = National or nationwide; L = local.

Table 2. Worldwide trends of obesity* in pre-school children

Country	Date of surveys	Prevalence of obesity (%)	Age/sample size	National or local survey	Ref
Americas					
Bolivia	1989	4.5	0–5 y, INA	N	28
	1998	6.5	0–5 y, 5773		
Brazil	1986	2.6	2–5 y, INA	INA	27
	1996	4.1	2–5 y, INA		
Columbia	1986	4.2	2–5 y, INA	INA	27
	1995	1.8	2–5 y, INA		
Costa Rica	1982	2.3	0–6 y, INA	N	28
	1996	6.2	1–7 y, 1008		
Dominican Rep.	1986	2.6	2–5 y, INA	INA	27
	1996	4.6	2–5 y, INA		
El Salvador	1988	1.2	2–5 y, INA	INA	27
	1993	1.7	2–5 y, INA		
Guatemala	1987	0.5	2–5 y, INA	INA	27
	1995	2.0	2–5 y, INA		
Haiti	1978	0.8	0–5 y, INA	INA	28
	1994–95	2.8	0–5 y, 2794		
Honduras	1987	1.3	2–5 y, INA	INA	27
	1996	1.4	2–5 y, INA		
Nicaragua	1994	2.2	2–5 y, INA	INA	27
	1998	3.3	2–5 y, INA		
Peru	1992	3.9	2–5 y, INA	INA	27
	1996	4.7	2–5 y, INA		
Trinidad & Tobago	1976	5.2	0–5 y, INA	INA	28
	1987	3.0	0–3 y, 840		
United States	1971–74	5.0	2–5 y, 1971–74: INA	N	48
	1999–2000	10.4	1999–2000: 739		
Venezuela	1981–82	3.3	0–5 y, INA	INA	28
	1997	3.0	0–5 y, 291,749		
Europe					
Croatia	1993–94	4.1	1–6 y, INA	N	28
	1995–96	5.9	1–6 y, 6036		
Germany	1982	1.8	5–6 y, 95806	L	54
	1997	2.8			
Netherlands	1980	10	1–5 y	N	57
	1996–97	12.9	INA		
United Kingdom	1989	5.4	3–4y: 28,768	L	63
	1998	9.2			
FYR Serbia	1996	13.0	0–5 y, 3228	N	78
	2000	14.0	0–5 y, 1647		
South East Asia					
Bangladesh	1982–83	0.1	0–5 y, INA	INA	28
	1996–97	1.1	0–5 y, 4787		
Nepal	1975	0.1	0–5 y, INA	N	28
	1996	0.3	0–5 y, 3705		
Sri Lanka	1977–78	0.1	0–5 y, INA	N	28
	1987	0.1	0–5 y, 1994		
Western Pacific					
Philippines	1971–75	0.4	0–6 y, INA	N	28
	1993	0.8	0–5 y, 4229		
Solomon Islands	1970	3.1	0–5 y, INA	N	28
	1989	1.1	0–5 y, 3981		
Vietnam	1992–93	1.7	0–5 y, INA	N	28
	1998	0.7	0–5 y, 12,919		
Eastern Mediterranean					
Egypt	1978	2.2	0–5 y, INA	N	28
	1995–96	3.1	0–5 y, 9766		
Morocco	1987	2.7	0–5 y, INA	N	28
	1992	6.8	0–5 y, 4532		

Table 2 (*Continued*)

Country	Date of surveys	Prevalence of obesity (%)	Age/sample size	National or local survey	Ref
Pakistan	1977	3.8	0–5 y, INA	N	28
	1990–91	3.1	0–5 y, 4056		
Tunisia	1973–75	1.3	0–6 y, INA	N	28
	1988	3.5	0–3 y, 1996		
Africa					
Ghana	1987–88	0.7	0–5 y, INA	N	28
	1993–94	1.9	0–3 y, 1819		
Madagascar	1992	0.4	2–5 y, INA	INA	27
	1997	0.2	2–5 y, INA		
Mali	1987	0.3	2–5 y, INA	INA	27
	1996	0.6	2–5 y, INA		
Mauritius	1985	5.6	0–5 y, INA	N	28
	1995	4.0	0–5 y, 1537		
Niger	1992	0.6	2–5 y, INA	INA	27
	1997	0.3	2–5 y, INA		
Nigeria	1990	1.5	0–5 y, INA	N	28
	1993	3.3	0–6 y, 2664		
Rwanda	1976	1.2	0–5 y, INA		28
	1992	2.1	0–5 y, 4386		
Senegal	1986	1.8	0–3 y, INA		28
	1992–93	2.6	0–5 y, 3865		
Tanzania	1991	2.1	2–5 y, INA	N	27
	1996	1.5	2–5 y, INA		
Togo	1988	0.2	2–5 y, INA	N	27
	1998	0.5	2–5 y, INA		
Uganda	1988	1.8	2–5 y, INA	INA	27
	1995	1.6	2–5 y, INA		
Zambia	1992	1.5	2–5 y, INA	INA	27
	1997	2.2	2–5 y, INA		
Zimbabwe	1988	4.4	0–5 y, INA	N	28
	1994	4.2	0–3 y, 2014		

* All surveys defined overweight as weight-for-height Z > 2 using the WHO/NCHS 1977 Growth Charts, with the exceptions of:
USA (95th centile of the CDC 2000 reference charts), United Kingdom (95th centile, local reference charts), Germany (IOTF cut-off points) and Netherlands (90th centile, local reference charts).
INA = Information not available.
M = males; F = females.
N = National or nationwide; L = local.

As has been shown previously (3), the current prevalence of overweight and obesity varies considerably worldwide. North America, Europe, and parts of the Western Pacific have the highest prevalence of overweight among children (approximately 20–30%). Parts of South East Asia and much of sub-Saharan Africa appear to have the lowest prevalence. South and Central America, Northern Africa and Middle Eastern countries fall in between. Importantly, the prevalence of overweight among school-age children in several countries undergoing economic growth, such as Brazil, Chile, Mexico and Egypt, has reached a level comparable to those in fully industrialized countries. One child in every eight among urban Chinese was overweight in 1997, and based on recent trends, this figure is likely to be one in five urban children before 2010. Rural Chinese children show far lower rates of overweight, with less than one child in 14 likely to be overweight by 2010. Similar differences between urban and rural populations are seen for Brazil but there appear to be no such differences in the USA (1).

Based on the secular trends reported here, and assuming they continue on a linear basis, we estimate that over 46% of school-age children will be overweight (IOTF criteria) in the Americas by 2010; along with approximately 41% of children in the Eastern Mediterranean region, and 38% of children in the European region (which includes the countries of the former Soviet Union); 27% in the Western Pacific region, and 22% in South East Asia. Data for sub-Saharan Africa are not adequate to make predictions. By 2010, one in seven children in the Americas is predicted to be obese (IOTF criteria), as is about one in every ten children in the Eastern Mediterranean and European regions. The implica-

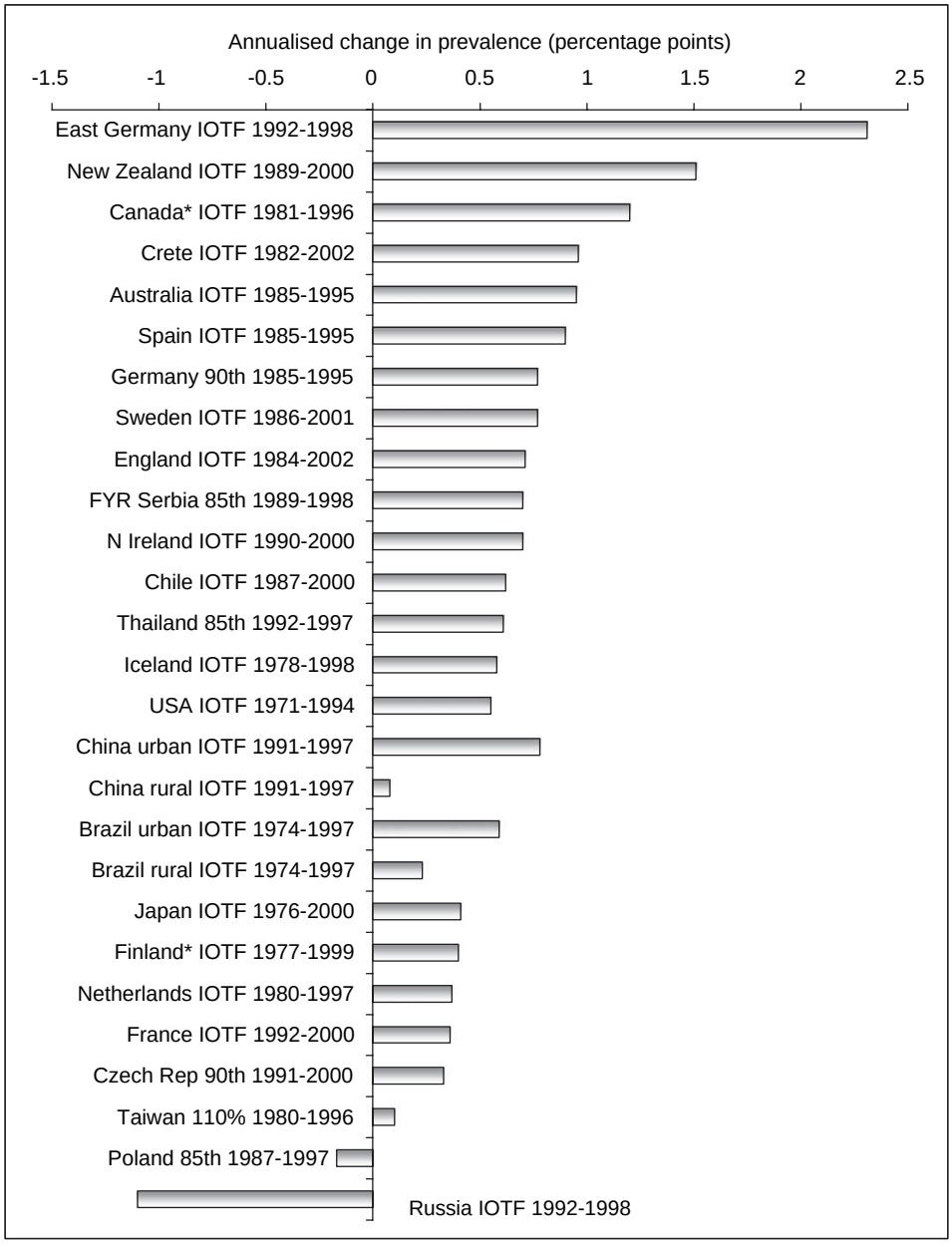
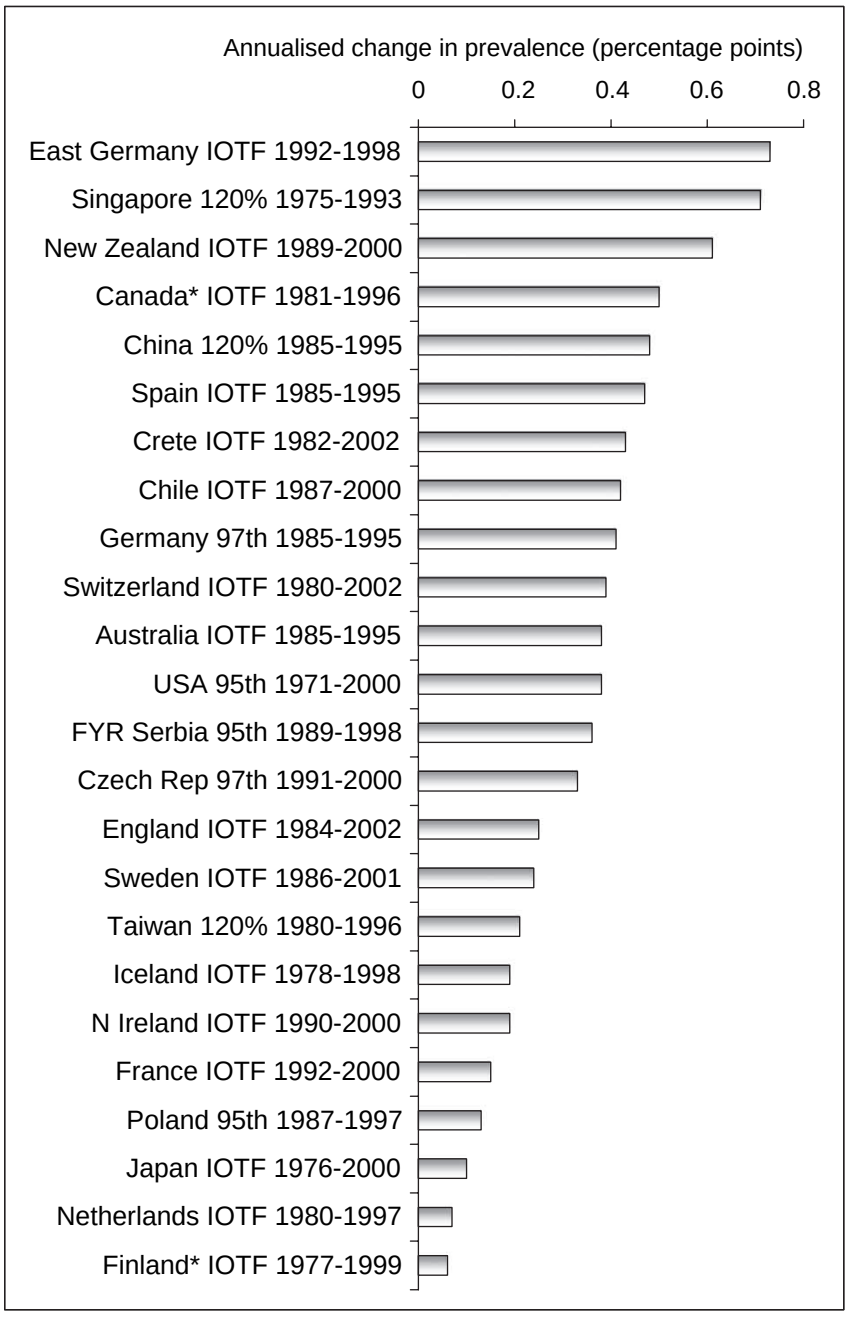


Figure 1. Change in the combined prevalence of overweight and obesity among school-age children in surveys since 1970. The chart shows country, method of measurement and period of assessment for prevalence change. Methods of measurement: IOTF = International Obesity TaskForce recommended cut-off point for overweight, 85th and 90th = centiles for local or WHO BMI reference charts, 110% = percent of ideal body weight (locally defined).

tions for local health services as these children develop obesity-related chronic diseases in later adolescence and early adulthood, are difficult to estimate, but planning for this disease burden needs to be undertaken urgently. For some countries the costs may not be easily absorbed into the domestic economy, and health outcomes may be correspondingly poor.

A number of lower- and middle-income countries have experienced a transition from under- to over-nutrition problems or, quite frequently, a double burden of both malnutrition and obesity. For example, in Brazil between 1974 and 1997, the prevalence of overweight among children aged 6–18 years more than tripled (4.1% to 13.9%), while the prevalence of underweight decreased from 14.8% to 8.6% (1). There is increasing evidence that underweight and overweight may exist among family members within the same household, especially as low income, urbanized populations adopt westernized diets (32). Infants who are born small are at greatest risk of stunting: thus stunting is very



* Self-reported data.

Figure 2. Change in the prevalence of obesity among school children in surveys since 1970. The chart shows country, method of measurement and period of assessment for prevalence change. Methods of measurement: IOTF = International Obesity TaskForce recommended cut-off point for obesity, 95th and 97th = centiles for local or WHO BMI reference charts, 120% = percent of ideal body weight (locally defined).

common in countries with a high prevalence of low birth weights, such as the less developed regions of Asia (33). Children whose linear growth is compromised through early malnutrition may respond to subsequent availability of food by increasing their body weight but not their height proportionately, leading to a raised risk of central adiposity and below average height (34). With several low-income countries experiencing prevalence rates for stunting of over 50% among infants (33), large numbers of children may be at risk of central adiposity and related chronic diseases. For these children, interventions in early infancy are needed to promote catch-up growth while minimising the risk of central obesity.

Socioeconomic status (SES) and ethnicity can affect overweight and obesity prevalence among adults and children, and these influences may vary

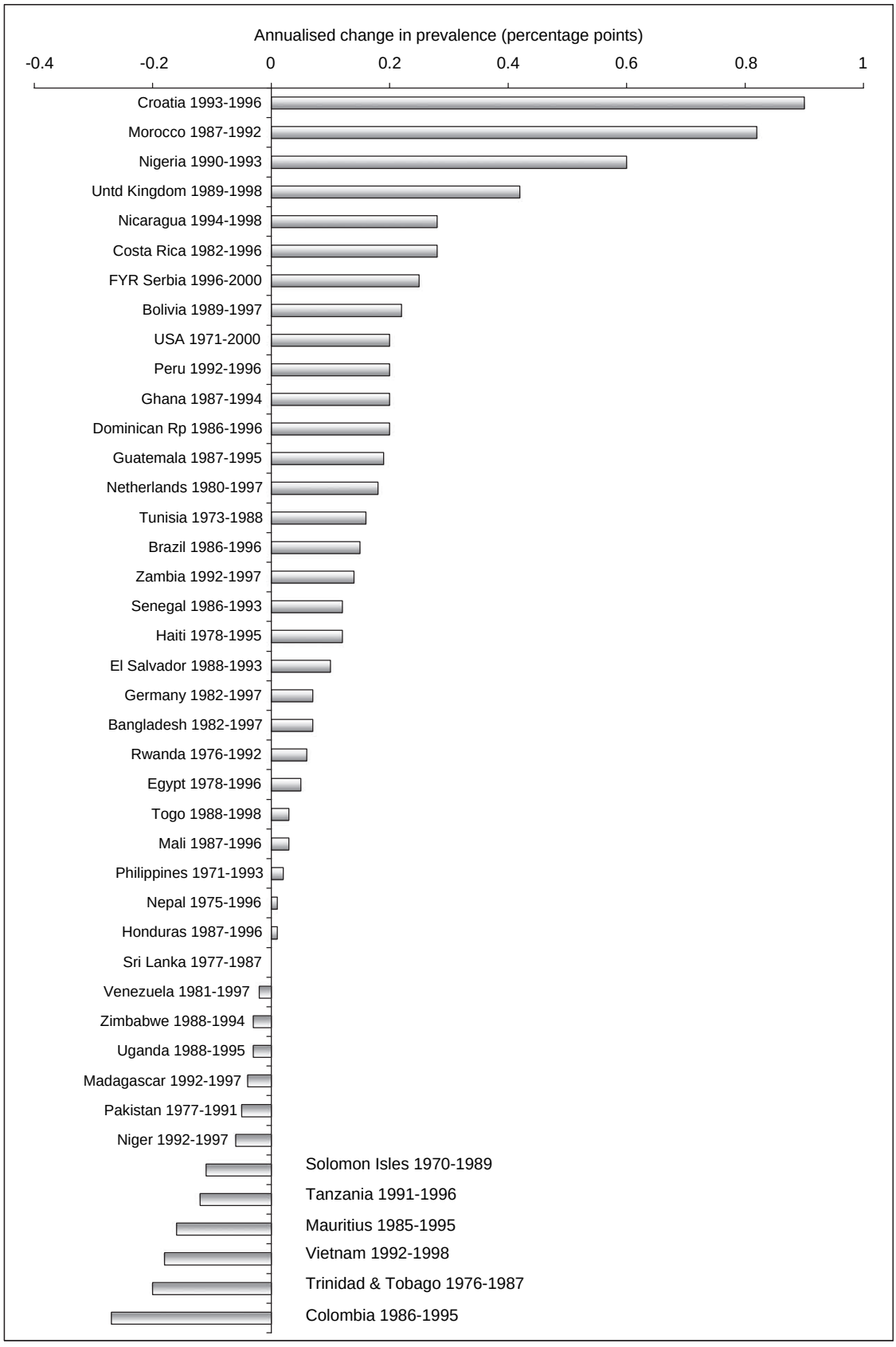


Figure 3. Change in the prevalence of obesity among infants and pre-school children in surveys since 1970. All surveys defined obesity as weight for height Z score >2, except UK and USA which used 95th centile (local reference) and Netherlands, which used 90th centile (local reference) and Germany which used IOTF cut-off points for obesity.

Table 3. Prevalence of overweight and obesity in school-age children based on latest available data and the IOTF criteria, and estimated for 2006 and 2010 based on population-weighted annualised increases in prevalence

	Most recent surveys		Projected 2006		Projected 2010	
WHO Region (dates of most recent surveys)	Overweight (inc obesity)%	Obesity%	Overweight (inc obesity)%	Obesity%	Overweight (inc obesity)%	Obesity%
Africa (1987–2003)	1.6	0.2	*	*	*	*
Americas (1988–2002)	27.7	9.6	40.0	13.2	46.4	15.2
Eastern Med (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

* There were insufficient data on school-age children in the WHO African Region to make estimates of projected prevalence rates.
* inc, including.

according to the economic context. For example, in middle-income countries, members of better-off households are more likely to be at risk of adiposity compared with members of poorer households, and urban residents may be more at risk than rural ones. In South Africa, the highest prevalence levels for overweight were found among young white (23%) and Indian populations (25%) compared with young Africans (17% (35). As the economies develop, the pattern changes to one where higher obesity levels are found among lower income groups (36). In industrialized, economically developed countries, children in the lowest SES groups may be at greatest risk, as may be children in specific racial or ethnic groups (1, 37–40).

When economic development suffers a reversal, as was witnessed in some Eastern European economies and in the Russian Federation during the late 1980s and early 1990s, then child overweight levels may actually show decreasing prevalence, as the data for Poland and Russia indicate here. A study of children's body height and mass in Poland from 1930 until 1994 indicated that the lowest values for both traits were found immediately post-war (1948–9), increasing to the end of the 1970s, and falling again during the recession of the 1980s (41). When the economy recovers, the prevalence of overweight and obesity may increase sharply, as shown in the data for East Germany (school-age children) and Croatia (pre-school children).

The prevalence of overweight and obesity remains low in many lower-income countries, in particular those in Asia and sub-Saharan Africa where undernutrition is still a major public health problem. Two recent comprehensive studies examined the obesity problem in pre-school children worldwide (27,28). The overall prevalence of obesity (defined as weight for height Z score >2) was estimated to be 3% in lower-income countries in the 1990s. It should be noted, however, that the low levels of overweight and obesity observed in some countries might be due to a shortage of recent representative data.

Energy balance is determined by a number of complex biological, behavioural, cultural, social, and environmental factors and the interactions between them (2,42). On a population basis, obesity rates appear linked to socio-economic development; changes in environmental factors such as people's working, living and school environments; changes in people's eating and physical activity patterns, as well as demographic transitions in developing countries (80–85). Strategies to tackle the obesogenic elements of economic development and social progress – for example, increasing use of active transport (e.g., walking or cycling to school) instead of motorized transport, and reducing the promotion to children of energy-dense foods – present a challenge which transcends local and even national boundaries. The protection and promotion of health-enhancing traditions can be undermined by the attraction of 'western' lifestyles, which are promoted and marketed by commercial interests and may be subsidized by agriculture and fuel pricing policies (43–45).

It is worth noting a number of issues when interpreting the results presented in this report. First, different references have been used in the classifications of obesity in different studies. This limits the comparability of the findings (12). Further, even if the same reference (e.g., the IOTF reference) is used, it is still debatable whether the findings are comparable across populations: it has been argued that population-specific references should be used due to between-population biological differences in body composition, body build, sexual maturation status, and the relationships between BMI and health outcomes (24–26).

Second, some of the results presented are based on nationally representative data, but others are small, non-representative studies. Nationally repre-

sentative surveys, repeated across time, are more likely to be available in developed countries, while only smaller, indicative surveys may be run in developing countries, and may be linked to nutrition supplementation programmes among more deprived or vulnerable population groups. Thus many of the surveys for pre-school children were in developing countries, and those for school-age children were in developed economies. It should also be noted that the data for Canada and Finland were based on self-reported height and weight, which might not be as reliable as data obtained from physical measurement, and may underestimate the prevalence of overweight (86).

There are several areas in which further research should be undertaken. Collection of national representative and longitudinal data in developing countries, especially for older children (>5 years) is urgently needed to monitor secular trends. Well-designed prospective follow-up studies are needed to examine the health and psychosocial consequences of childhood obesity, especially in non-Caucasian populations. The usefulness of most of the current anthropometric references in predicting long-term health consequences needs to be clarified. Lastly, child obesity prevention will require much greater understanding of various environmental obesogens, which influence behaviour, and the social and cultural drivers, which shape these obesogens and which can be used in anti-obesity strategies.

In conclusion, our findings indicate that the developed countries face a significant and rapidly growing childhood obesity epidemic. Children in lower- and middle-income countries are also at risk, especially those growing up in urban environments and able to afford a western lifestyle. In countries where childhood obesity has become an epidemic, population-based strategies should be emphasized. In countries undergoing rapid socioeconomic and nutrition transitions, with a double burden of over- and under-nutrition, public-health programs and policies should be developed or adjusted to promote healthy growth and prevent stunting-related central adiposity. In low-income countries where the prevalence of childhood obesity remains very low and the prevalence of under-nutrition is high, health-enhancing traditional practices need to be protected, attention needs to be focused on addressing under-nutrition problems while also avoiding raising the risk of central adiposity linked to stunted growth. In all countries, there is a need to monitor children's nutritional status in order to evaluate progress towards a healthier population, and we urge continuing international collaboration and cooperation to ensure that such monitoring can be undertaken in all communities.

Acknowledgements and Conflict of Interest

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Part of this study was conducted in 2002 when Dr. Wang was invited by the International Obesity TaskForce (IOTF) to review the global situation of childhood obesity as part of their report to the World Health Organization. The review was submitted to the IOTF at the end of 2002 and some of the findings published in 2004 (3). The present paper provides additional analyses on prevalence trends, including more recent survey data, and gives details of literature search strategies and study inclusion criteria, which have not been previously published.

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