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EDITORIAL

The challenge of childhood obesity

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For those of us who complain when another journal is launched, one can fairly ask why do we need yet another? In this case the answer is really straightforward. Not only has the problem of childhood obesity reached epidemic proportions in many parts of the world, but our understanding of why this is happening is rudimentary. This first issue of the journal very appropriately sets out the latest data we have on childhood obesity rates across the globe in the article by Wang and Lobstein (11). Indeed, the whole issue is dominated by an epidemiological perspective which quite rightly sets the scene for future issues and articles dealing with a wide range of related topics.

The long-term implications of childhood obesity

Not only is childhood obesity of immense public health significance (see later) but it poses many challenges which will come to fascinate the molecular biologist, the developmentalist and those interested in organogenesis; experts fascinated by body composition, the analysis of growth rates and the assessment with modern techniques of both intracellular and inter-organ fluxes will also need to be involved. The paper by Ness and his colleagues shows the importance of considering body composition in affluent societies as well as in lower income countries (12). The general clinician, of course, will be concerned with the appropriate indices of adiposity and whether the different fat distributions traditionally assigned to children in what we used to term the developing world, reflect a genetic propensity to small amounts of peripheral fat (e.g. as assessed by triceps skin fold measurement) in different ethnic groups or a programmed redistribution of body fat because of changes in such pathways as the hypothalamic /pituitary/ adrenal regulation of adrenal cortical hormones. Indeed the likelihood of children remaining overweight and entering adulthood at risk will also soon be illuminated by a range of Scandinavian cohort studies currently being analysed. Eriksson's Swedish studies (1) on the predictors of middle aged coronary artery disease in relation to birth weight and early growth patterns are but one example with Danish studies (2) now being used to assess the impact of different BMIs of 7 year olds in predicting premature death from any cause including cardiovascular disease. As these data emerge we are going to be asked whether these reflect the impact of environmental circumstances long passed or whether we should now be applying these results to our current thinking.

New "standard" growth curves

This journal is being started at a time when paediatricians are soon to be confronted by several clinical challenges. For example, later this year the World Health Organization will publish the first ever six-country study of under-6 year old children who have taken part in a mixed cohort analysis to define optimum growth rates. For decades WHO has been attempting to persuade paediatricians and indeed governments throughout the world to apply uniform criteria for specifying both underweight and overweight using the current WHO growth charts. These

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were essentially developed from selected multiple post-war US sources and prove to be very different from the latest CDC growth curves which we all now recognise display body weight changes of a relatively overweight population. The new unpublished growth curves (3) are remarkable in that they will now provide not a reference set of charts but a standard to which all babies should in effect conform! The babies were chosen because they were full-term and normal weight and their mothers did not smoke before, during or after the pregnancy. The babies were also almost exclusively breast fed for up to 6 months with special attention being given to their appropriate weaning and subsequent dietary habits. These babies from California, Norway, Brazil, Ghana, Oman and India apparently grew with an astonishingly consistent pattern (4) so that now it is difficult to argue that there are fundamental ethnic differences in the overall growth pattern of babies and children, at least up to the age of five years. Furthermore, the extraordinary limited distribution of weight for heights or BMIs means that if one takes the usual statistical criterion of +2 SDs as a cut-off point for defining abnormally heavy babies, then this new cut-off point will promptly mean that far more babies and young children will be designated globally as overweight and or obese by WHO than hitherto. We must await the detailed analysis of this work, but it simply reveals how elementary issues in childhood obesity will become the concern of all paediatricians as well as of others involved in public health.

Childhood morbidity

This first edition of the journal is very dependent on a great deal of work already undertaken by a relatively small group of experts, but it fortunately does provide illuminating evidence that the rapidly worsening problem of childhood obesity is not confined to Europe (13) or indeed the western world but to many major economically developing countries, such as China (14). We also see in the paper by Lobstein and Jackson-Leach (15) that we may well be markedly underestimating the morbidity relating to this problem in Europe, but even these figures for associated co-morbidities may still underestimate the problems found elsewhere. Thus Yajnik's analysis (5) of the birth weights, body composition and growth responses of children in India highlights the potentially remarkable synergistic interactions of fetal, or indeed intergenerational, under-nutrition with subsequent positive energy balance. Insulin resistance and increases in blood pressure seem particularly evident in children who are born small but then grow rapidly. This then raises the fundamental paediatric question of whether it is appropriate for us to promote the concepts of catch-up growth as the best option for the future health of these children.

Epigenetics

It is becoming apparent that in different parts of the world babies are being born with very different developmental trajectories and that these may reflect not only the classic effects of early imprinting but also the effects of the epigenetic conditioning of the allelic inheritance that the babies have acquired, not just from their parents, but seemingly also from their grandparents. The work of Reik (6,7) and others is beginning to highlight the care that we need to take before we automatically assume that different responses of children in different ethnic groups are really based on the evolutionary selection of different genes and indeed allelic mutants. If, in fact, the growth of a girl and her nutritional state before, as well as during, pregnancy are going to be important in modifying the DNA methylation and histone changes of her ovarian chromosomes and then her fetus as it progresses through the methylation steps of suppressing the paternal growth genes and modifying the expression of the shuffled inherited genes from both parents, then we may be in a new world where paediatricians need to be working with obstetricians and indeed policy makers concerned with the nutritional as well as general well-being of women. There is also increasing evidence (8) that the behaviour of mothers soon after birth can also imprint, through epigenetic changes, the future responses and the later intellectual capacity of the children.

The new world of metabolome and proteomic profiling and the non-invasive analysis of metabolic fluxes and organ responses to food and activity has not begun to focus on the particular problems of children, but these again will provide fascinating insights into why particular children lay down muscle rather than fat and why some children respond so avidly to particular foods. Indeed, the intrinsic setting of the control of appetite after birth will not only provide answers to fascinating questions, but also again lead to very important advice if it becomes apparent, for example, that breast feeding intrinsically allows a baby to set its appetitive regulatory pathways in such a way as to limit the propensity to overeat. This has parallels with animal and perhaps human evidence that the selected timing of specific nutrient deficiencies in pregnancy predisposes children to violent behaviour which in turn relates to the specific imprinting of the fetal glucocorticosteroid regulatory system in the brain.

Behavioural issues

It would be a pity if this journal did not appeal to the more behaviourally interested paediatricians because we are now entering a world where there are major questions of intense political interest about the capacity of a child to cope with their new environment. The article relating to the socio-economic circumstances of childhood obesity in China (14), provides illuminating evidence of the nutrition transition. For example the extraordinary introduction of deliberate marketing targeted at pre-school children and the commercialization of the whole of children's lives for the first time in the history of any human civilization has not been particularly well documented, particularly in those huge civilisations of greatest numerical significance globally e.g. China, India, Indonesia, Japan, Nigeria, Iran and Brazil. We need to be able to document how this marketing affects our children and what safeguards need to be introduced and at what age. The societal issues are, however, even broader: it is clear that there is now a major demand by governments throughout the world for mothers to work as contributors to the economic welfare of a country. So children are becoming ever more confined to the care of child-miners, playgroups and other home helps. Defining the impact of their more confined and sedentary lives and the effect of such inactivity on their physical as well as mental and social development and well – being is an important issue for the future.

Treating obese children

We seem at present to be very poor at developing coherent and effective methods for helping families with overweight and obese children to grow normally. Is this because, like adults, children's brain mechanisms controlling their body fat are steadily becoming reset so that children also entrain themselves at a new higher weight or is it that in so many countries and societal conditions it is difficult to induce a progressive improvement in the microenvironment within which children live because the pervasive pressures to overeat inappropriate foods and constrain children's activity are so overwhelming? How do we improve on the valuable work of Epstein (9) and develop schemes which can be applied to the 10% of children who, on an IOTF estimate, now need help globally? Are there particular techniques and approaches to diet and physical activity which are particularly useful in children of different ages, and can we extend the interesting approaches of the Lowe's (10) group in North Wales who highlight the importance of particular approaches to changing young children's eating habits and preferences?

The public health challenge

The politicians are also going to be asking us about many of these issues because it has become apparent that obesity is now a high profile issue for Ministers of Health in all regions of the world. It is noticeable that the public and Ministers readily accept the problem of obesity in adults and the fact that this induces premature death. They then often and very conveniently blame the individual for their predicament rather than questioning whether their obesity reflects the impact of deliberate policy and industrial developments over the last few decades. It is striking, however, how Ministers as well as the public and the media immediately focus on the problem of childhood obesity because it is difficult to simply blame the parents. The obvious evidence of an escalating rate of childhood obesity immediately challenges our reflex thinking about the individual reasons for excessive weight gain and poses the question of what coherent policies need to be developed effectively before meaningful reductions in childhood obesity can be realised. Given this perspective, the imminent emergence of the first major WHO report of its Technical Consultation on childhood obesity, held in Kobe, Japan last June will be important. A Global Alliance of five medical societies linking the International Paediatric Association with the International Union of Nutritional Sciences, the World Heart Federation, the International Diabetes Federation and the International Association for the Study of Obesity, all relating formally to WHO, have focused on childhood obesity as their first priority. This Alliance and its planned linking of their national societies to joint action on childhood obesity in every country will soon become evident, particularly as childhood obesity is increasingly accepted as a major amplifier of the top health burden affecting the world – namely chronic disease. The Alliance should therefore ensure that the issue of childhood obesity will be in the top three or five priorities for almost all Health Ministries over the next decade.

The launch of this journal therefore comes at the most opportune time and the Editor should be congratulated on her initiative – the journal can now make an enormous contribution in providing the evidence on how best to tackle the problems which are already confronting the paediatric community and all those concerned with the future health of their country.

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ORIGINAL ARTICLE

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	M: 12.4 →16.4	M: 25.4 →28.0	12–15 y	N	> =110% and > =120% local ideal body weight ref.	73
	1994–96	F: 10.1 →11.1	F: 21.4 →21.3	1980–82: 1980 1994–96: 1366			
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		

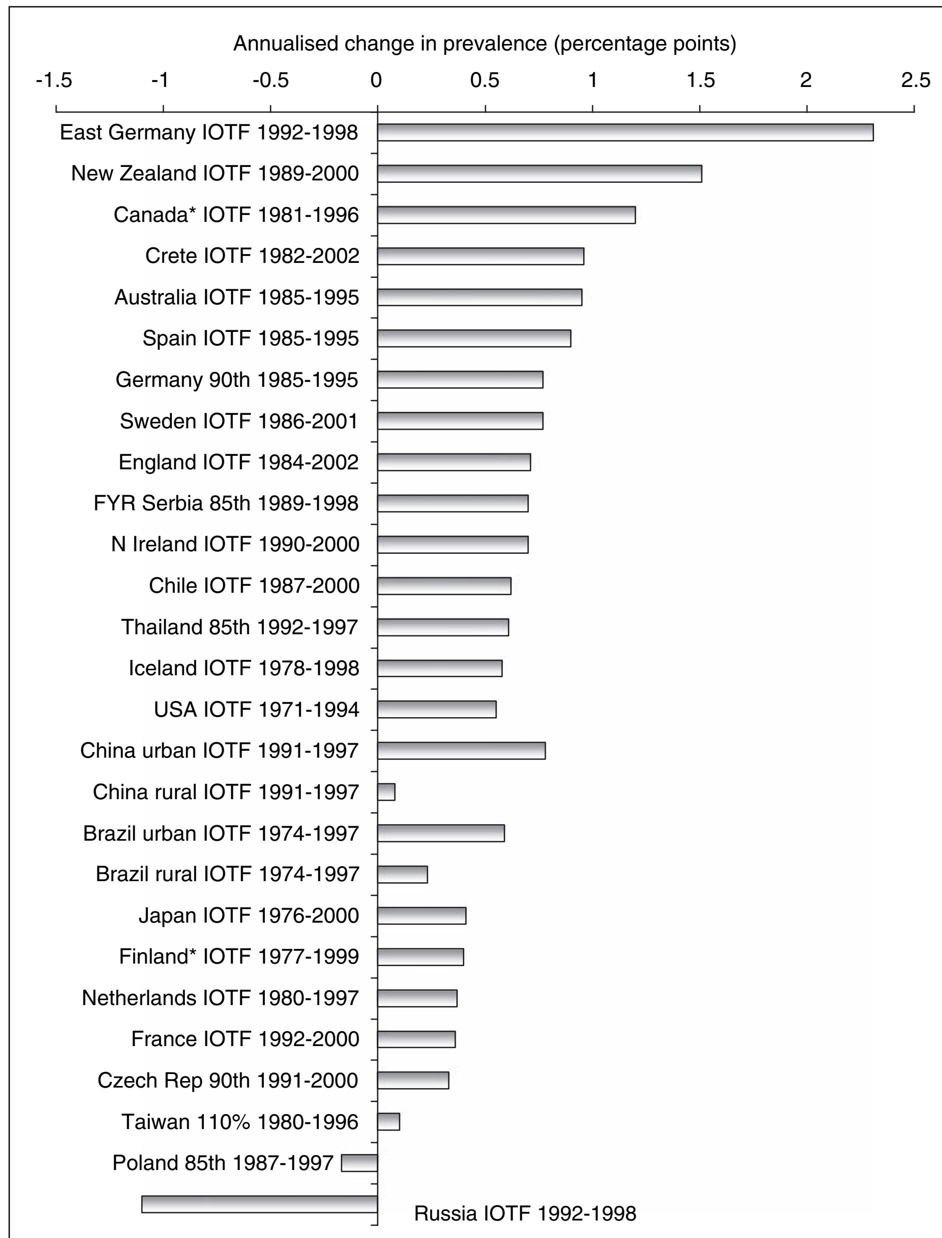
Table 2 (*Continued*)

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-

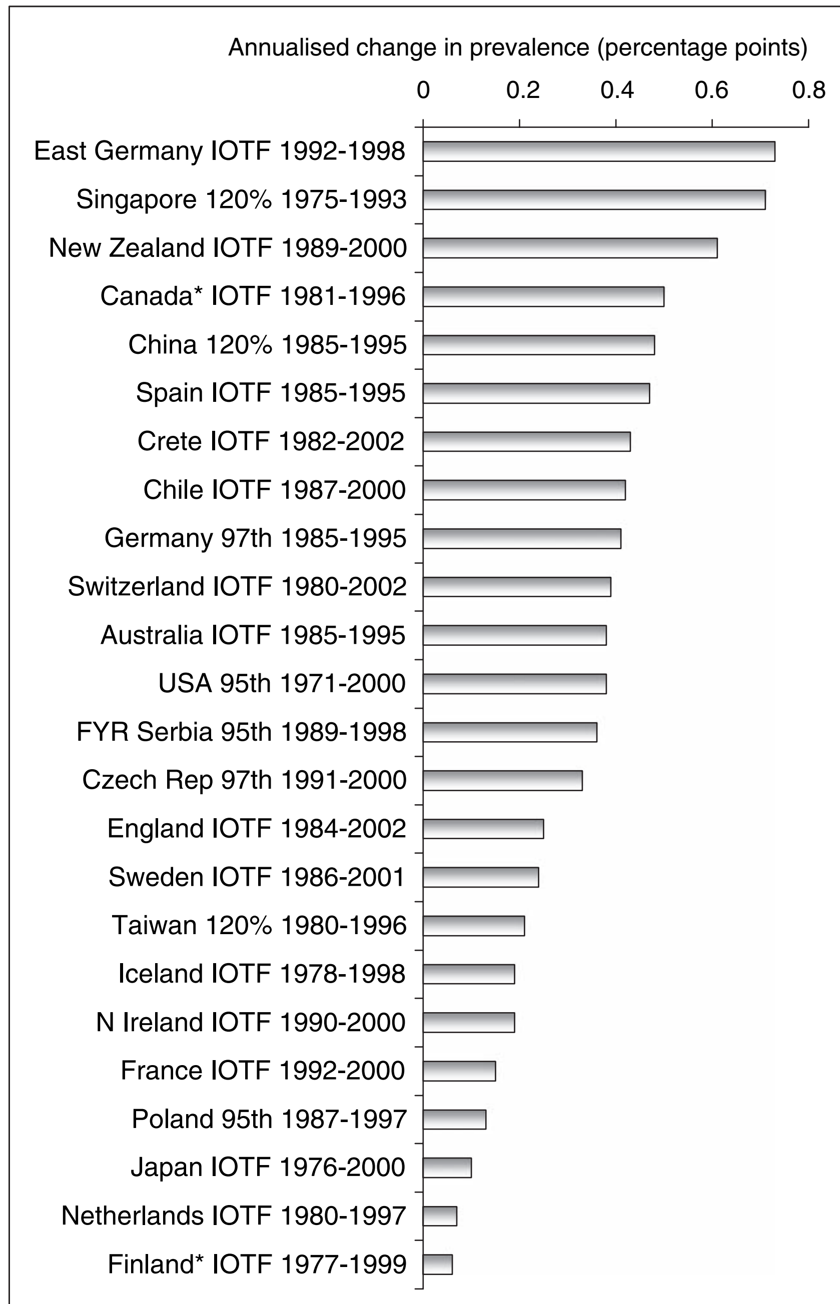


• Self–reported data

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 overnutrition 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

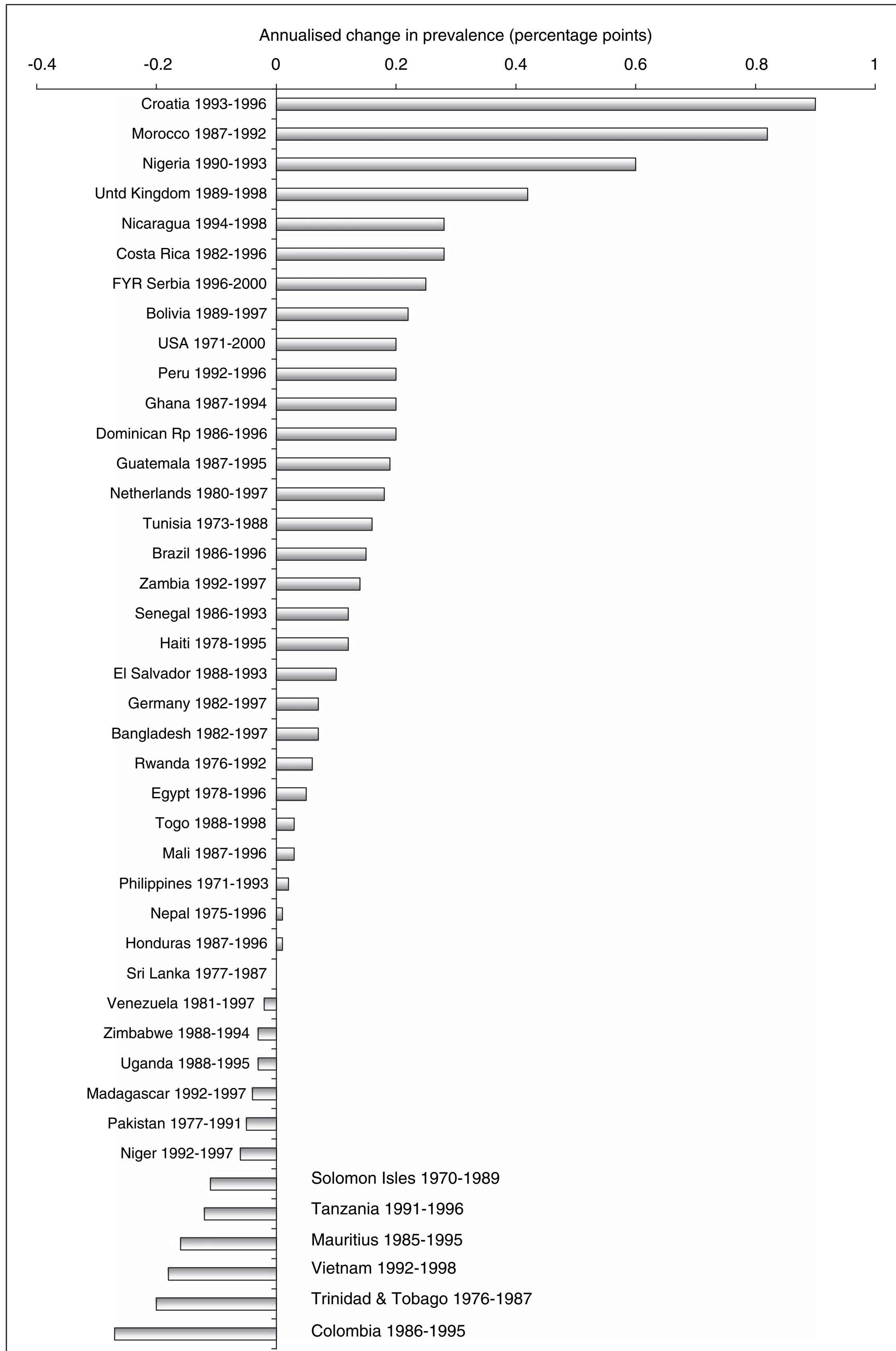


Figure 3. Change in the prevalence of obesity among infants and pre-school children in surveys since 1970. All surveys defined obesity as weight for height Z score >2, except UK and USA which used 95th centile (local reference) and Netherlands, which used 90th centile (local reference) and Germany which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

IOTF benefits from its association with the International Association for the Study of Obesity (IASO), which itself accepts donations from a range of commercial sources conforming with IASO ethical guidelines. The authors declare no other conflicts of interests.

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ORIGINAL ARTICLE

Estimated burden of paediatric obesity and co-morbidities in Europe. Part 1. The increase in the prevalence of child obesity in Europe is itself increasing

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Abstract

Objectives. Surveys have shown the prevalence of overweight among school age children to be as high as 35% in parts of Europe, and several countries have reported prevalence rates increasing year-on-year. The purpose of the present paper is to review the rate of change in prevalence of overweight and obesity among children in the European region. *Methods*. A search of published and unpublished surveys was undertaken to find pairs of surveys that could indicate rates of change of prevalence within comparable population groups using comparable measures. Data from 45 pairs of surveys from 11 countries were analysed. *Results*. Annual increases in prevalence of overweight (including obesity) rose from typically below 0.5 percentage points in the 1980s, to over 1.0 percentage points in the late 1990s. For obesity alone, the annual increase in prevalence was typically below 0.1 percentage points in the 1980s and typically 0.3 percentage points in the late 1990s. *Conclusions*. The prevalence of overweight and obesity among children is rising in the European region, and the annualised rates of increase are themselves increasing. Unless action is taken to counteract these trends, by the year 2010 the European Union can expect to see the numbers of overweight and obese children rising by approximately 1.3 million children per year, of which the numbers of obese children will be rising by over 0.3 million per year.

Key words: *Prevalence, childhood, overweight, obesity, Europe*

Introduction

Several recent surveys have suggested that significant numbers of European school-age children are suffering overweight and obesity (1,2), with one review suggesting that in the region as a whole, in the early part of the present decade some 22% of children aged 5–9 years were overweight (of which 6% were obese), and 16% of children aged 13–17 years were overweight (of which 4% were obese) (2).

Where repeated surveys have been undertaken, the evidence indicates that the prevalence levels are rising. In the UK, for example, the Department of Health has predicted that obesity prevalence (defined by local reference centiles) among children aged 2–11 years will reach over 21% by 2010, having risen from 9.9% in 1995 to 13.7% in 2003 (3). The Department has published a policy statement which states that it will 'halt the year-on-year increase in obesity among children under 11 by 2010' (4). Several other EU member states are also discussing policy measures to prevent further increases in child obesity (5–7), as is the European Commission (8).

In the absence of coordinated monitoring and reporting on child overweight and obesity across the European Region, an overview of trends is difficult to obtain. Such figures may be valuable for monitoring the effects of policies to reduce prevalence. They are also valuable for predicting the burden of disease, which may face paediatric services and the wider community. We have undertaken a review of the literature to identify matched pairs of surveys assessing the extent of child overweight and obesity, which could indicate trends in prevalence.

Methods

An extensive literature search was carried out to identify surveys suitable for use in estimating trends in overweight and obesity in children. Only papers

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using Body Mass Index (BMI; weight/height^2) as the criterion for assessment of obesity were included. Due to the international nature of the study, only studies using the International Obesity TaskForce (IOTF) internationally-based criteria for overweight and obesity were included. The IOTF cut-off points provide a set of BMI thresholds equivalent to BMIs of 25 and 30 at age 18, adjusted for gender and for children's ages down to two years old (9).

Published papers were obtained by searching the Medline®/ PubMed® database (www.ncbi.nlm.nih.gov/entrez/) using search words for child, overweight, obesity and prevalence, and following related links. Conference proceedings in the IOTF archive were also examined. Where data were not published but appeared to exist, authors were contacted by email and available information was requested and generally obtained. From this material a set of 'matched pairs' of surveys was drawn up, according to the following criteria: (a) The interval between a pair of surveys ranged from three to forty years. Any interval of three years or less was excluded as it was deemed too short to determine a trend. (b) Some individual surveys were taken over an extended period. Those single surveys in which sampling extended over a period greater than five years were excluded. (c) Surveys based on self-reported height and weight were excluded. (d) The region for data collection was confined to countries that form the European Union (25 member states: listed at www.eurunion.org/states/home.htm and referred to here as EU25) plus Iceland, Norway and Switzerland. (e) Pairs of surveys were selected if they were sufficiently comparable: i.e. they used similar age categories, used the same methodology for measurement of BMI and assessed children from similar social and ethnic groups living in the same or similar locations within a country. One survey in Eastern Germany was excluded on the basis that the region was undergoing unusual and rapid economic and social changes during the period between surveys.

The pairs of surveys were analysed and the average annual changes in prevalence of overweight and obesity for boys and girls separately were calculated. Each average annual change in prevalence was then listed against the mid year between the two matched surveys. The data were entered into spreadsheets in Excel (Microsoft® Excel 2002, Microsoft Corporation, Seattle, USA) from which linear trend lines were derived and predictions for 2010 estimated.

European population estimates for children were obtained from the United Nations Population Information Network (10). Numbers are based on children aged between 5 and 17.9 years of age.

Results

Suitable data could be found from eleven European countries, resulting in a total of 45 pairs of surveys. These are summarised in Table 1. The pairs of surveys were analysed and the average annual changes in prevalence of overweight and obesity for boys and girls separately were calculated.

Figure 1 shows the annual change in the prevalence of overweight (including obesity) combining both the boys' and girls' data, plotted against the mid-year of each pair of surveys. Particularly high rates of increase in prevalence were noted for both boys and girls during the mid- and late-1990s in surveys in Spain and England, at a time when low rates of increase were found among children in France, Germany and Northern Ireland.

Visual inspection suggests that a second order curve could be a suitable fit. Linear and quadratic models were significant for both boys ($p < 0.05$) and girls ($p < 0.001$). Comparison of the variance explained by a linear model versus a quadratic model showed only a small improvement by using the quadratic model (from 23% explained to 29% explained for boys, and from 43% to 52% for girls), and for the purposes of making forecasts we chose a linear model as offering the more conservative predictions. Using a linear model indicates an average annual increment in the prevalence of overweight and obesity of between 1.3 and 1.7 percentage points in 2006, and between 1.5 and 1.9 percentage points by 2010.

Figure 2 shows the annual change in the prevalence of obesity alone, combining both boys' and girls' data, plotted against the mid-year of each pair of surveys. Particularly high rates of increase in prevalence were noted for both boys and girls during the mid-1990s in surveys in England, at a time when low rates of increase were found among children in France, Germany and Northern Ireland.

Again, visual inspection suggests that a second order curve could be a suitable fit. Linear and quadratic models were significant for both boys ($p < 0.05$) and girls ($p < 0.01$). Comparison of the variance explained by a linear model versus a quadratic model again showed only a small improvement by using the quadratic model (from 26% explained to 29% explained for boys, and from 38% to 42% for girls), and for the purposes of making forecasts we chose a linear model as offering the more conservative predictions. Using a linear model indicates an average annual increment in the prevalence of obesity of between 0.3 and 0.5 percentage points in 2006, and between 0.4 and 0.6 percentage points in 2010.

Table 1. Paired surveys used to estimate annual increases in prevalence. Overweight and obesity defined by IOTF cut-offs (10).

	Survey year	Age group	Prevalence of overweight (%)		Prevalence of obesity (%)		Reference
			Boys	Girls	Boys	Girls	
Greece (Crete)	1982	9–15 yrs	20.6	N/A	4.2	N/A	14
Greece (Crete)	2002	9–15 yrs	39.7	N/A	12.7	N/A	”
England	1974	4–11 yrs	7.8	10.6	1.4	1.5	15
England	1984	4–11 yrs	6	10.6	0.6	1.3	”
England	1994	4–11 yrs	10.7	16.1	1.7	2.6	”
England	1998	5–11 yrs	19.1	21.5	3.7	4.8	16
England	2001/2	5–11 yrs	21.4	28.7	5.7	7.8	17
France (Northern)	1992	5–12 yrs	9	14.1	1.7	1.6	18
France (Northern)	2000	5–12 yrs	10.2	18.6	1.3	4.4	”
France (Northern)	1989	5–6 yrs	7.4	11.9	1.1	2.6	19
France (Northern)	1999	5–6 yrs	14.9	19.1	4.7	5.1	”
Germany	1982	5–6 yrs	7.6	9.5	1.5	2.1	20
Germany	1987	5–6 yrs	8.5	12.4	1.9	2.4	”
Germany	1992	5–6 yrs	9.4	11.6	2.6	2.4	”
Germany	1997	5–6 yrs	11	13.6	2.8	2.8	”
Germany (Brandenburg)	1994/5	6 yrs	N/A	4.6	3.6	4.6	21
Germany (Brandenburg)	2003/4	6 yrs	N/A	5.1	4.3	5.1	”
Iceland	1968	9 yrs	7.1	12.2	1.2	1.5	22
Iceland	1978	9 yrs	12.4	11.9	1.8	0.5	”
Iceland	1988	9 yrs	14.1	16.7	3.1	2.6	”
Iceland	1998	9 yrs	22	25.5	5.8	4.2	”
Ireland (Northern)	1990	12 yrs	16	15.9	4	1.6	23
Ireland (Northern)	2000	12 yrs	19.5	26.3	4.7	4.7	”
Ireland (Northern)	1990	15 yrs	9.1	18.9	0.4	3.9	”
Ireland (Northern)	2000	15 yrs	13.4	19.1	3.1	4.8	”
Netherlands	1980	9 yrs	3.1	6.8	0.1	0.5	24
Netherlands	1997	9 yrs	8.9	13.2	1.1	1.9	”
Scotland	1974	4–11 yrs	7.1	10.7	1.7	1.9	15
Scotland	1984	4–11 yrs	7.3	12.2	0.9	1.8	”
Scotland	1994	4–11 yrs	12.1	19	2.1	3.2	“
Spain	1985/6	6–7 yrs	21	25	N/A	N/A	25
Spain	1995/6	6–7 yrs	34	36	N/A	N/A	”
Spain	1985/6	13–14 yrs	13	16	N/A	N/A	”
Spain	1995/6	13–14 yrs	21	21	N/A	N/A	”
Spain	2000-2	13–14 yrs	35	32	N/A	N/A	26
Sweden	1987	10–16 yrs			7.6		27
Sweden	2001	10–16 yrs			20		”
Sweden	1986	6–11 yrs	13	9.8	2.1	0.2	28
Sweden	2001	6–11 yrs	17.6	27.4	3.3	9	”
Switzerland	1960–65	6–12 yrs	3.5	5.7	0	0	29
Switzerland	2002	6–12 yrs	20.4	22.8	3.8	3.7	”

N/A: not applicable.

Estimates for the prevalence of overweight and obesity in the European Union for the year 2006 were calculated, based on the latest available surveys gathered for the present study in addition to those reported in the published literature (1,2) (8), using the IOTF criteria for defining overweight and obesity, and excluding self-reported measures. The estimates are shown in Table 2. Prevalence figures were adjusted to account for different years of actual surveys, using the average annual increment data obtained from the paired samples (reported below). Where prevalence figures for specific countries were unavailable, estimates were based on data from other countries in the sub-region (shown in Table 2), adjusted for child population characteristics.

The estimated prevalence levels for child overweight and obesity for the European Union (EU25) as a whole are given in Table 3, for the year 2006 and projected to 2010 on the assumption of a continuing linear trend. United Nations population estimates for 2006 indicate a child population (age 5–17.9 years) in excess of 71 million in the European Union (EU25). By 2010 the child population is projected to be nearly 73 million.

Using these figures, almost 22 million children in the European Union are estimated to be overweight

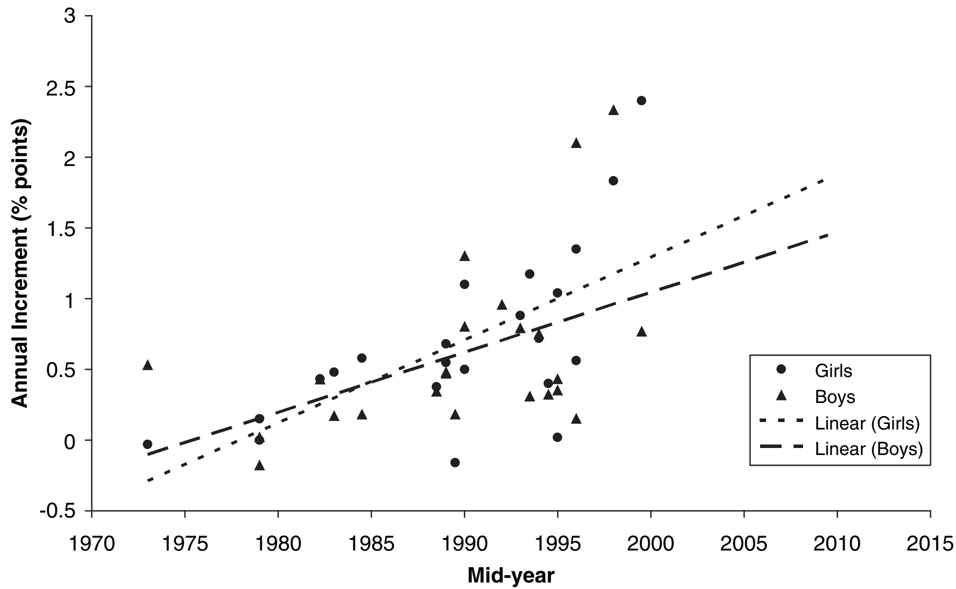

Figure 1. Annualised change in prevalence rates of overweight (including obesity) among children, projected to year 2010.

or obese in 2006, and this figure is rising by over one million children per year. Of the 22 million overweight children, over 5 million are obese, and this figure is rising by over 300 000 children per year.

By the year 2010, based on the conservative linear model and assuming no change in present trends, over 26 million children in the region will be overweight or obese, rising by some 1.3 million children per year. Of the overweight children, 6.4 million will be obese, and that figure will be rising by over 350 000 per year.

Discussion

Overweight and obesity prevalence in children is increasing. Furthermore, the significant linear trends in the annualised increments indicate that the rate of change is itself increasing: i.e., prevalence rates are not rising at a constant rate but are accelerating. Whereas overweight prevalence rates increased annually by less than 0.5 percentage points in the 1980s, they were increasing by over 1.0 percentage points per annum in the late 1990s. Considering obesity alone, the rate of increase in prevalence rose

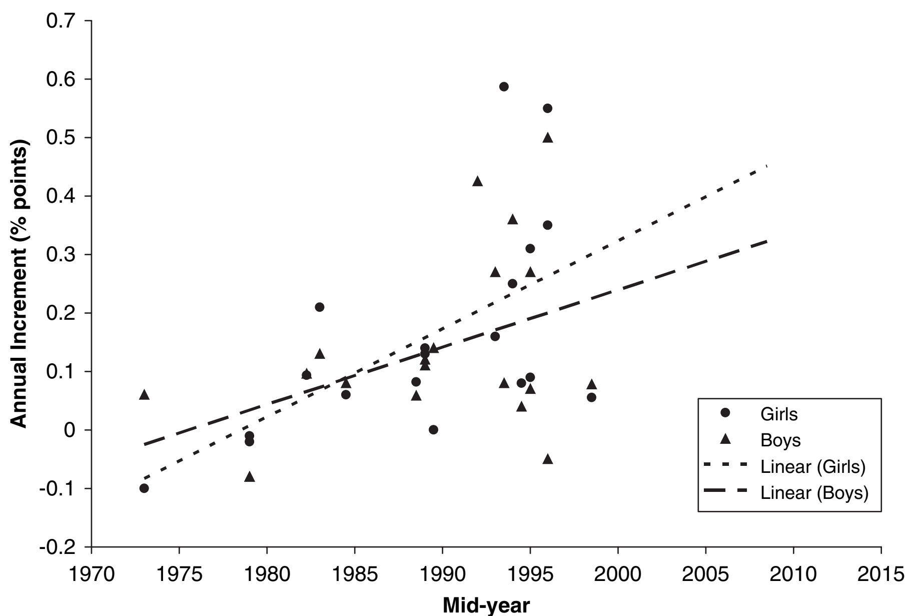

Figure 2. Annualised change in prevalence rates of obesity among children, projected to year 2010.

Table 2. Estimated prevalence in 2006 of overweight and obesity among children aged 5–18 inclusive, in the European Union (EU 25). Overweight and obesity defined by IOTF cut-offs (9).

	Boys		Girls	
	Overweight (including obesity) %	Obesity %	Overweight (including obesity) %	Obesity %
Western Region				
Austria	22.3	8.5	24.1	8.5
Belgium	–	–	–	–
Denmark	25.3	4	29.2	6
Finland	–	–	–	–
France	24.5	4.6	31.9	6.8
Germany	27	5.5	30	6.8
Ireland	–	–	–	–
Luxembourg	–	–	–	–
Netherlands	20	3.4	25.8	5.4
Sweden	24.8	4.9	36.5	11.5
United Kingdom	28.1	6.9	36.1	9.8
Regional estimate	*25.9*	*5.5*	*31.9*	*7.7*
Southern Region				
Cyprus	33.7	8.8	33	8.6
Greece	30.8	10.6	23.6	7.3
Italy	37.8	9.1	38.8	10.8
Malta	–	–	–	–
Portugal	–	–	–	–
Spain	41.4	11.1	30.8	7.4
Regional estimate	*38.4*	*10.0*	*34.0*	*9.1*
Eastern Region				
Czech Republic	21.9	4.3	22.5	4.7
Estonia	–	–	–	–
Hungary	31.5	6.8	32.9	9
Latvia	–	–	–	–
Lithuania	–	–	–	–
Poland	28.8	5.5	28.7	6.3
Slovakia	22.7	3.8	24.3	4.9
Slovenia	–	–	–	–
Regional estimate	*27.7*	*5.3*	*28.0*	*6.3*

– survey data not available for estimate.

from around 0.1 percentage points per annum in the 1980s to around 0.3 percentage points per annum in the late 1990s.

Unless action is taken to counteract these trends, a conservative (linear model) estimate would suggest that the number of children who are either overweight or obese in Europe (EU25) may rise from 22 million in 2006 to reach over 26 million by 2010. Of these, obese children account for a little over 5 million in 2006 and the figure is likely to exceed 6 million by 2010.

A limitation of these conclusions is the possibility that specific subgroups of children are showing increased prevalence in overweight or obesity at a much more rapid rate than other groups, and the data used in the present matched-pair analysis might thus not properly reflect the trends experienced by school-age children as a whole. Specifically, the

Table 3. Estimated levels of overweight and obesity among children in the European Union (EU25).

Year	2006			2010		
Population aged 5–17.9 yrs, inc	71 540 500			72 770 500		
	Prevalence (%)	Number	Annual increment	Prevalence (%)	Number	Annual increment
Overweight or obese	30.4	21 748 312	1 239 615	36.7	26 706 773	1 302 000
Obese	7.1	5 079 376	331 107	8.8	6 403 804	359 000

matched pair data here are mostly from surveys of younger, pre-pubertal children, and it could be argued that the results do not reflect what is occurring among adolescents. We could find no suitable matched-pair data for older children in Europe beyond that given here. In the USA, figures for overweight (IOTF definition) over the period 1976–80 to 1988–94 showed an annualised increase in prevalence of 0.92 percentage points among older children (aged 12–17 years), and 0.53 percentage points for younger children (aged 6–11 years) (11). For obesity (IOTF definition), the annualised increase was 0.35 percentage points for older children and 0.22 percentage points for younger children. From these figures there appears to be no justification for suggesting that overweight and obesity rates are rising more slowly among older children.

It should be noted that changes in prevalence levels are not equivalent to incidence: a year-on-year increase in prevalence reflects the net effect on the population of children who gain weight, as well as children who lose weight. The true incidence level is likely to be significantly higher than the change in prevalence. An example of this can be seen in the monitoring of elementary school children in Kiel, Germany (12), which showed the prevalence of overweight rising from 27% to 47% over a four-year period, an increase in prevalence of five percentage points per year. During the period, 39% of normal-weight children became overweight, a true incidence of very nearly 10% per year.

There are several issues which the present paper highlights. The first is the need to generate better sets of data in order to provide adequate monitoring of Europe's childhood obesity epidemic. We were disappointed at the small number of studies that could be compared to make matched pairs of data for trend analysis, and the limited number of countries they represented. Our projections are likely to have a wide margin of error, which is why we opted for the more conservative, linear model that gives a lower forecast than would a second or possibly higher order polynomial model.

A second limitation is that we have chosen to use the IOTF internationally-based criteria for defining overweight and obesity. Several other methods are used in the literature: some based on locally-constructed centile charts; some using other European countries' centile charts, and some using US centile charts. Because of the continuing change in the prevalence of overweight and obesity, percentile-based cut-offs are dependent on the year when the reference survey data were collected, whereas the IOTF cut-offs are based on a statistical construct that is independent of the level of overweight and obesity in the reference population. The IOTF definitions tend to give more conservative prevalence figures: they give lower estimates compared with the widely-used US 85th and 95th centile definitions for younger age groups, and similar or slightly higher estimates for older age groups (11). The IOTF definitions also give lower estimates of overweight and obesity than some European centile charts: for example, data for English children aged 6–10 years in 2002 show 29% over the 85th centile and 17% over the 95th centile using UK-derived charts, but 25% for overweight with obesity and 7% for obesity alone using IOTF cut-offs (13). For children aged 11–15 years, the figures are 33% and 19% for the UK centile measures, and 26% and 7% for the IOTF cut-offs respectively.

It would have been possible to widen the selection criteria to include matched pairs of surveys using other criteria. We examined several such studies and, although the trends were similar, we found that the numerical values were different and could lead to further error in the predictions, and for this reason we rejected surveys that did not report their findings in terms of IOTF cut-offs, or could not be reanalysed to obtain results in terms of the IOTF cut-offs. We recommend that future surveys ensure that they report IOTF-compatible results along with whatever other measures the researchers choose to report.

We understand that several European countries undertake surveys of school children's health, including their height and weight status, on an annual basis. We recommend that this data is pooled and published, and that the principle of monitoring the status of school children, at least on a sample basis, should be extended to all European member states.

Further issues concerning the rise in the likely prevalence of childhood obesity in Europe are discussed in the second part of this paper.

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ORIGINAL ARTICLE

Estimated burden of paediatric obesity and co-morbidities in Europe. Part 2. Numbers of children with indicators of obesity-related disease

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Abstract

Objectives. Obesity in childhood is associated with the presence of risk factors for later disease and with the early development of these diseases. This paper aims to estimate the numbers of children with obesity-related disease risk factors and co-morbidities in the European Union (EU). *Methods.* A search of the scientific literature identified prevalence rates relating variously to impaired glucose tolerance, hyperinsulinaemia, type 2 diabetes, several cardiovascular risk factors, non-alcoholic fatty liver disease, and the metabolic disease syndrome among obese children. Using the lowest likely prevalence rates for each disease indicator, estimates were made of the expected numbers of obese children within the EU likely to be showing the specified indicator. *Results.* On the most conservative estimate, over 20 000 obese children in the EU have type 2 diabetes, while over 400 000 have impaired glucose tolerance. Over a million obese children are likely to show a range of indicators for cardiovascular disease, including hypertension and raised blood cholesterol levels, and have three or more indicators of the metabolic syndrome. Over 1.4 million may have early stages of liver disorder. *Conclusions.* Although there will be considerable overlap in the numbers of obese children with the various risk factors described, the estimated burden of disease indicators among obese children is high. Paediatric services need to consider their ability to screen and treat children if we are to avoid a substantial rise in chronic obesity-related disease among young adults over the next decade.

Key words: *Childhood, obesity, disease burden, risk factors, Europe*

Introduction

The rising numbers of children suffering from overweight and obesity in Europe has been noted in several papers (1,2) and the rate of increase in prevalence has been discussed in Part 1 of this paper. The consequences of this recent phenomenon have yet to be fully appreciated, but the accumulating evidence of obesity-related disease being suffered in younger age groups led the UK's Chief Medical Officer to describe the problem as 'a health time-bomb' (3). Type 2 diabetes, especially, is being increasingly reported among paediatric populations (4,5), but a range of other disease indicators will also contribute to the likely disease burden experienced by these children in adolescence and early adulthood. As Pinhas-Hamiel and Zeitler have observed (6), "life-style-related diseases are no longer the exclusive domain of adult medicine" (p. 704).

In order to provide some insight into the likely burden of disease, the present paper reviews evidence relating to the presence of co-morbidities and disease indicators in populations of obese children. On the basis of these studies and on the estimated population of obese children in the European Union, we have calculated the numbers of children in the region likely to have obesity-related co-morbidities and disease indicators. It should be noted that due to insufficient data we have not attempted to estimate numbers of children suffering from obesity-related orthopaedic, pulmonary or psychological disorders, nor several other obesity-linked problems.

Methods

A literature search was undertaken to identify papers that estimated the prevalence of disease risk factors linked to obesity in children and adolescents. Published papers were obtained by searching the Medline®/PubMed® database (www.ncbi.nlm.nih.gov/entrez/) for papers published after 1980 using

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search words for: child, adolescent, obesity, and the risk factors and disease indicators linked to obesity identified in reviews (2,7), and by following related links. Only papers with English language text or with sufficiently descriptive summaries in English were used; there was otherwise no geographical limit on the source of the data. However, surveys of specific ethnic groups (such as native Americans) were excluded. Consideration of disease indicators was undertaken only if there were four or more separate surveys and at least one of these was based on a sample from a community population (e.g., school-based) rather than a clinic population. From each of the surveys we took the reported prevalence level and associated confidence intervals, calculated using binomial probability corrected for continuity using VasserStats (8) (© Richard Lowry, Vassar College, Poughkeepsie, NY, USA). For each disease indicator we took the weighted means of the prevalence levels reported and of the upper and lower bounds.

These figures were used in conjunction with estimates of the total numbers of obese children in the European Union (25 member states: listed at www.eurunion.org/states/home.htm and referred to here as EU25), calculated in the companion paper to this one (55), to make estimates of the possible numbers of children with disease risk factors in the paediatric population.

Results

We identified 39 reports that had appropriate data and the results are summarised in Tables 1–3. We were unable to find sufficient information on the prevalence of pulmonary disorders linked to obesity (such as asthma and sleep apnoea); orthopaedic disorders (such as increased risk of fracture, tibial torsion or flat feet), or psychological problems (such as reduced self esteem or suicidal thinking). Information on the metabolic syndrome was inconsistent between different surveys. The syndrome was defined as having a number of the following: hypertension, central adiposity, raised HDL cholesterol, raised triglycerides, raised glucose levels or impaired glucose tolerance, but some papers reported prevalence rates on the basis of three components and others on the basis of four components. These are reported separately in the present paper. Cut-off criteria for the components of the syndrome also differed, but for present purposes the prevalence of the syndrome was taken to be that reported by the authors of the relevant papers.

The surveys summarised in Tables 1–3 provided a range of prevalence estimates for the presence of various disease indicators and risk factors among obese children. Given the potential bias in those samples based on clinical screening rather than community sampling, and given the variation in age ranges and definitions, it was considered appropriate to use the most conservative estimates possible, namely the lowest likely prevalence figures (lower-bound of the 95% confidence interval for each reported prevalence figure) when calculating population statistics. From these lower-bound prevalence figures, and from the estimates for the numbers of obese school-age children in the European Union, it was possible to calculate the numbers of children likely to have the relevant obesity-related disease indicators, and the results are shown in Table 4.

The estimates in Table 4 were calculated according to the populations for which data were available. In the case of the metabolic syndrome (four or more risk factors) studies had only been carried out on children aged 10–17 years, so we did not include children under the age of 10 years in our population estimates.

Discussion

The results indicate that there is a substantial disease burden among obese school age children in Europe. Using the International Obesity TaskForce (IOTF) definition of obesity (56), and using the prevalence estimates for 2006 given in the companion paper to this (55), we estimate that over 27 000 obese children in the European Union have type 2 diabetes, and over 400 000 have impaired glucose tolerance. Over a million obese children are likely to have a range of cardiovascular disease indicators, with an estimated 1.1 million suffering hypertension and a similar number showing raised total blood cholesterol. Approximately 1.2 million obese children are likely to be affected by the metabolic syndrome (three or more components of the syndrome), of which, at least one in ten will be particularly seriously affected (four or more components). Fatty liver (hepatic steatosis) is likely to be found in 1.4 million obese children.

These figures bear comparison with national data from the USA. Based on a sub-sample of the National Health and Nutrition Examination Survey 1999–2000, Duncan et al. (2004) estimate that over 30% of obese adolescents (and a further eight percent of overweight, non-obese adolescents) have three or more risk factors for the metabolic syndrome (9). In total the US adolescent population has an estimated 2.1 million individuals with three or more indicators for the metabolic syndrome. A higher number, approximately 2.6 million, have hypertension.

Table 1. Summary of surveys of the prevalence of cardio-vascular disease indicators among groups of obese children.

Reference, country	Sample features	Obesity definition	Raised triglycerides	Raised total cholesterol	High LDL cholesterol	Low HDL cholesterol	Hypertension	Ref
Chan et al (2004), Hong Kong	n = 84, age 7–18, clinic	BMI obese (IOTF)	19% > 2.0 mmol/l	26% > 5.2 mmol/l	18% > 3.4 mmol/l (n = 83)	56% < 1.2 mmol/l		19
Chu et al (1998), Taiwan	n = 202, age 12–16, community	BMI ≥ 85th centile		31.7% ≥ 90th centile for age, sex			40% ≥ 90th centile for age, sex	20
Cook et al (2003), USA	n = 338, age 12–19, community	BMI ≥ 95th centile	51.8% ≥ 110 mg/dl (1.24 mmol/l)			50% ≤ 40 mg/dl (1.03 mmol/L)	11.2% ≥ 90th centile for age, sex	21
Cruz et al (2004), USA	n = 126, age 8–13 family history of type 2 diabetes, clinic	BMI > 85th centile	26% > 90th centile for age, sex			67% HDL ≤ 10th centile for age, sex	22% SBP > 90th centile for height, age, sex	22
Csabi et al (2000), Hungary	n = 180, age 10–15, clinic	> 120% weight for height	37% above local reference (1.1–1.5 mmol/l by age)	25% > 5.2 mmol/l		5% < 0.9 mmol/l	40.5% > 95th centile for age, sex	23
Davis et al (2005), USA	n = 58, age 7–18, community	BMI ≥ 95th centile	18% > 150 mg/dL	34% > 170 mg/dl	19% > 110 mg/dl	57% < 40 mg/dL (boys), < 50 mg/dL (girls)	45% SBP ≥ 90th centile for height, age, sex	24
Duncan et al (2004), USA	n = ~100, age 12–19, community	BMI > 95th centile	45.5% ≥ 110 mg/dl			39.1% ≤ 40 mg/dl	25.6% ≥ 90th centile for height, age, sex	9
Figueroa-Colon et al (1997), USA, cited in Barlow and Dietz (1998)	n = ~1000, age 5–11, community	> 120% weight for height					25% > 90th centile	25
Freedman et al (2002), USA	n = 356, age 5–10, community	BMI ≥ 95th centile	18% > 130 mg/dl	21% > 200 mg/dl	20% > 130 mg/dl	15% < 35 mg/dl	19% SBP > 95th centile	26
Kotani et al (1997), Japan	n = 1691 (data 1986–1995), age 6–14, community	≥ 140% standardised weight					25.5% SBP ≥ 135 or DBP ≥ 80 mm	27
Invitti et al (2003), Italy	n = 710, age 6–18, clinic	mean BMI 35	17.5% 'above normal range'		18.5% 'above normal range'	17% 'below normal range'	27% > 95th centile for age, height	12
Maffeis et al (2001), Italy	n = 43, age 3–11, community	BMI obese (IOTF)		58% ≥ 180 mg/dl	35% ≥ 130 mg/dl	9% ≤ 35 mg/dl	47% SBP ≥ 120 mm	28
Mohan et al (2004), India	n = 25 urban, n = 21 rural, age 11–17, community	BMI > 30					43.1% (urban), 61.8% (rural) > 95th centile	29
Reich et al (2003), Germany	n = 280, age 8–16, community	BMI > 90th centile					25.5% DBP > 95th centile	30
Reinehr et al (2004), Germany	n = 1004, age 4–18, clinic	BMI > 90th centile	20% > 1.7 mmol/l	27% > 5.1 mmol/l	26% > 3.4 mmol/l	18% < 0.9 mmol/l		31
Verma et al (1995), India	n = ~100, age 5–15, community	'obese'					13.7% > 95th centile for age	32
Viner et al (2005), UK	n = 103, age 2–18, clinic	BMI ≥ 95th centile	20% ≥ 1.75 mM/l	18% ≥ 95th centile		10% < 0.9 mmol/l	32% SBP ≥ 95th centile for age, sex	33

Table 1 (*Continued*)

Reference, country	Sample features	Obesity definition	Raised triglycerides	Raised total cholesterol	High LDL cholesterol	Low HDL cholesterol	Hypertension	Ref
Yoshinaga et al (2005), Japan	n =299, age 6–12, community	BMI obese (IOTF)	35.8% >120 mg/dL fasting level			7% <40 mg/dL	25.4% BP >130/80 (>120/70 age 6–9)	34
Zaborskis et al (2003), Lithuania	n =82, age 3–7, community	BMI ≥18					51% (boys) 41% (girls) >90th centile by age	35
Weighted average prevalence (weighted average 95%CI)			*25.7% (21.5–30.5)*	*26.7% (22.1–31.8)*	*22.3% (18.9–26.3)*	*22.6% (18.7–27.0)*	*25.8% (21.8–30.2)*	

It should be noted that the European figures presented here are based on studies using a variety of definitions of obesity, and sampled children in different settings (clinic or community). If the prevalence of disease indicators is associated with the severity of the obesity, then the definition of obesity would affect the prevalence level: the higher the cut-off or centile used to define obesity, the higher would be the likely prevalence of the disease indicator in the obese group. The studies generally used a cut-off point of 95th centile or the IOTF international cut-off point, but in some instances other cut-off points were taken. For example, in one study a cut-off point of 85th centile was used but it was considered that it would provide an under-estimate rather than an over-estimate so the study was included in the present analysis. When calculating the numbers of children in the population we used the IOTF definition of obesity, which uses a relatively high cut-off, equivalent to the 96th centile or higher on the CDC 2000 Growth Charts (54) for most ages. This should lead to lower estimates of the numbers of obese children in the European population and lower estimates of the absolute numbers suffering disease indicators, as shown in Table 4.

Samples taken from the community are less likely to include more extreme cases of obesity than are samples taken from paediatric clinics specialising in obesity screening. Tables 1–3 indicate whether the surveys were community based (e.g., national populations, school populations) or taken from children attending paediatric clinics. Examination of the results suggests that there is considerable overlap in the prevalence rates found in clinic and community samples, although the figures for measures of hepatic disorder may need to be adjusted downwards to allow for sampling bias. However, the duration of obesity rather than its degree may be a major influence on the progress of liver deterioration (10,11), and a similar observation has been made for the development of the metabolic syndrome (23), which indicates a need to diagnose and treat the problem at an early stage.

The fact that prevalence figures for each of the co-morbidities came from different sampling procedures weakens the ability to make the key assumption that the figures can be combined into one overall estimate. The data from Invitti et al. (12) is an example where, despite a large population (over 700 children) with a high level of obesity (mean BMI 35) in a clinic setting, there was a relatively low prevalence of impaired glucose tolerance and only one case of diabetes, when around seven might have been expected based on other surveys. Such anomalous findings remain to be explained.

Table 2. Summary of surveys of the prevalence of insulin-related and metabolic disease indicators among groups of obese children.

Reference, country	Sample features	Obesity definition[a]	Impaired glucose tolerance	Hyperinsulin-aemia	Type 2 diabetes	Metabolic syndrome[a]	Ref
Cook et al (2003), USA	n = 338, age 12–19, community	BMI $\geq$95th centile				28.7% three or more factors, 5.8% four or more factors	21
Cruz et al (2004), USA	n = 126, age 8–13 family history of type 2 diabetes, clinic	BMI > 85th centile	27% $\geq$140 mg/dl at 2 h			30.2% three or more factors	22
Csabi et al (2000), Hungary	n = 180, age 10–15, clinic	> 120% weight for height	28% 'impaired'	54% > 95th centile local data (> 18.7 mU/l)		15% three or more factors, 8.9% four or more factors	23
Davis et al (2005), USA	n = 58, age 7–18, community	BMI $\geq$95th centile				41% three or more factors	24
Duncan et al (2004), USA	n = ~100, age 12–19, community	BMI > 95th centile				32.1% three or more factors, 4.4% four or more factors	9
Freedman et al (2002), USA	n = 356, age 5–10, community	BMI $\geq$95th centile		22% > 95th centile local data			26
Grey et al (2002), USA, cited by Caprio (2002)	n = 42, age 11–15, community	mean BMI 36.2 ±6	21% 'impaired'		5%		36
Invitti et al (2003), Italy	n = 710, age 6–18, clinic	mean BMI 35	4% $\geq$140 mg/dl at 2 h		0.2%		12
Paulsen et al (1968), USA, cited by Goran (2003)	n = 66, age?, clinic	'obese'	17% 'impaired'		6%		37
Pinhas-Hamiel et al (2004), Israel	n = 101, adolescents, clinic	BMI > 39	8% 'impaired		3%		38
Sinha et al (2002), USA	n = 55, age 4–10, clinic	BMI $\geq$95th centile	25% $\geq$140 mg/dl at 2 h				14
Sinha et al (2002), USA	n = 112 age11–18, clinic	BMI $\geq$95th centile	21% $\geq$140 mg/dl at 2 h		4%		14
Tresaco et al (2003), Spain	n = 95, age 4–16, clinic	'obese'	7.4% 'impaired'		0%		39
Uwaifo et al (2002), USA	n = 48, age?, community	mean BMI 32 ±5	6.3% 'impaired'				40
Viner et al (2005), UK	n = 103, age 2–18, clinic	BMI $\geq$95th centile	11% $\geq$140 mg/dl at 2 h	40% > 15–30 mU/l according to age	0%		32
Wabitsch et al (2004), Germany	n = 520 age 8–20, clinic	BMI > 97th centile	2.1% > 140 mg/dl at 2 h		1.5%		5
Weiss et al (2004), USA	n = 439, age 4–20, clinic	BMI > 97th centile	16.8% > 140 mg/dl at 2 h			41.2% three or more factors	41
Wiegand et al (2004), Germany	n = 102, age 6–17, with abnormal fasting glucose, clinic	BMI > 97th centile	36.3% $\geq$140 mg/dl at 2 h		5.9%		42
Yoshinaga et al (2005), Japan	n = 299, age 6–12, community	BMI obese (IOTF)		52.2% > 90th centile		17.7% three or more factors	33
Weighted average prevalence (weighted average 95%CI)			*11.9% (8.4–17.0)*	*39.8% (33.9–45.9)*	*1.5% (0.54–4.46)*	*Three: 29.2% (23.9–35.3); Four: 7.6% (4.56–12.2)*	

a: Metabolic syndrome was defined as having a number of the following: hypertension, central adiposity, raised HDL blood cholesterol, raised blood triglycerides, raised blood glucose levels or impaired glucose tolerance.

Table 3. Summary of surveys of the prevalence of hepatic disease indicators among groups of obese children.

Reference, country	Sample features	Obesity definition	Hepatic steatosis	Raised serum aminotransferase	Ref
Arslan et al (2005), Turkey	n = 322, age 4–18, clinic	BMI > 120% for age	11.8% (ultrasound)	4.6%	43
Bergomi et al (1998), Italy	n = 175, age 4–20, clinic	BMI > 20	55.4% (ultrasound)	20.3%	44
Chan et al (2004), Hong Kong	n = 84, age 7–18, clinic	IOTF obese	67% (age 7–10); 83% (age 11–18) (ultrasound)	24%	19
Engelmann et al (2004), Germany	n = 182, age 1–9, clinic	BMI Z-score ≥ 1.5		48%	45
Franzese et al (1997), Italy	n = 72, age 6–13, clinic	'obese'	53% (by ultrasound)	18%	46
Iughetti et al (1996), Italy	n = 135, age?, clinic	'obese'	20% (ultrasound or raised ALT)		47
Kinugasa et al (1984), Japan	n = 299, age?, clinic	'obese'		12%	48
Strauss et al (2000), USA, cited in (Lavine 2004)	n = 245, age 12–18, community	BMI > 95th centile		10%	49
Tazawa et al (1997), Japan, cited in Arslan et al (2005)	n = 310, age 6–11, clinic	BMI > 120% for age		24%	50
Tominaga et al (1995), Japan, cited in Arslan et al (2005)	n = ~80, age 4–12, community	BMI > 20	22.5% (by ultrasound)		51
Weiss et al (2004a), USA	n = 282, 'children and adolescents', clinic	'obese'		11% (moderate obesity), 21% (severe obesity)	52
Zhang et al (2001), China	n = 32, age 8–11, clinic	'obese'	93.8% (by ultrasound)		53
Weighted average prevalence (weighted average 95%CI))			*33.7% (27.9–41.8)*	*16.9% (12.8–22.0)*	

It should also be noted that the studies of risk factors were undertaken in many countries, not only in the European region. It could be argued that certain populations – for example, those in Southern Asia – may display higher prevalence rates for disease risk factors at lower levels of obesity, and that these are not applicable to European children. This may be so, although it should be noted that substantial numbers of people with Southern Asian backgrounds now live in Europe, as do many other specific ethnic groups. The large majority of studies reported in Tables 1–3 were undertaken in Europe and North America, perhaps in part because this is where the rising prevalence of obesity has stimulated the most research endeavour. Comparing these two regions, there was no strong evidence of higher prevalence of co-morbidity among obese North American children compared with their European counterparts (see Tables 1–3), although it should be noted that there was a tendency for prevalence rates for some co-morbidities (lowered HDL cholesterol, type 2 diabetes and indicators for the metabolic syndrome) to be higher in North American surveys, while prevalence rates for other co-morbidities (fatty liver indicators and raised LDL cholesterol) tended to be higher in European surveys.

The results shown in Table 4 are likely to be overlapping to some degree, so that children with type 2 diabetes may also, for example, be hypertensive, but it is not possible to say exactly how much overlap has occurred. Clearly, all those children with four or more characteristics of the metabolic syndrome will be included in the figures for the children with three or more such characteristics. Children with hyperinsulinaemia may include those with either impaired glucose tolerance or those with type 2 diabetes.

The figures reported in Table 4 are based on the estimated numbers of obese children among the school-age population in Europe. We have not considered the number of children who are overweight but not obese, and who may also be suffering from weight-related disease. Although the prevalence rates for disease will be lower among the less severely obese children, the absolute number of such children is very much larger, so the total disease burden could be substantial, and these figures would be in addition to those estimated in Table 4.

Lastly, as we noted in the introduction, we have not attempted to estimate numbers of children suffering from obesity-related orthopaedic, pulmonary or psychological disorders, nor several other

Table 4. Minimum estimated numbers of children in EU(25) with obesity-related disease indicators within specified age groups. Estimates are for the year 2006. Age range 5.0–17.9 years, unless otherwise shown.

	Lowest estimated prevalence among obese children	Lowest estimated number of obese children affected in EU25
Raised triglycerides	21.5%	1.09 m
Raised total cholesterol	22.1%	1.12 m
High LDL cholesterol	18.9%	0.96 m
Low HDL	18.7%	0.95 m
Hypertension	21.8%	1.11 m
Impaired glucose tolerance	8.4%	0.42 m
Hyperinsulinaemia	33.9%	1.72 m
Type 2 diabetes	0.5%	27,000
Metabolic syndrome (3+)*	23.9%	1.21 m
Metabolic syndrome (4+)* (age 10–17.9 years)	4.6%	0.13 m
Hepatic steatosis	27.9%	1.42 m
Elevated aminotransferase	12.8%	0.65 m

* Metabolic syndrome was defined as having a number of the following: hypertension, central adiposity, raised HDL blood cholesterol, raised blood triglycerides, raised blood glucose levels.

obesity-linked problems: obese girls, for example, are more likely to experience earlier menarche, menstrual abnormalities, polycystic ovary syndrome and lower fertility rates.

It can be seen from the Tables that there is a considerable potential burden on the paediatric services in communities where child obesity is becoming widespread. Much of it may remain undetected: children are not routinely examined for blood lipid levels, for glucose tolerance or even for blood pressure, at least in most EU countries. Generally, the disorders reported here are virtually symptom-free in their early stages. In six of the eight cases of type 2 diabetes found by Wabitsch et al. (13), and in all four of the cases found by Sinha et al. (14), there had been no previous diagnosis. It is clear that much of the disease burden in the paediatric population may pass unnoticed until the individual experiences a health crisis, by which time many of the children may be young adults.

This raises several questions for paediatric services. Are the services prepared, and adequately resourced, to act as a screening service to prevent later disease? Should screening be offered to children who are overweight as well as those who are obese? If screening leads to the detection of early indications of disease, are there sufficient resources for treatment – and are the treatments used for adults suitable for adolescents, and for even younger children?

Some of the risk factors are likely to improve if the child loses weight, or at least 'grows into' their weight, if they are still showing growth in height. There is thus a case for instituting a weight control intervention for overweight and obese children whether or not co-morbidities are being treated. However, experience gained so far suggests that weight control interventions organised by paediatric services require a multidisciplinary team of staff working with both the child and the child's family over an extended period of time, if they are to have a chance of success. Clinical guidelines have been produced in several EU member states, although the evidence base for effective treatment remains poor.

This leads to two conclusions. The first is that obesity treatment may need to be conducted in a broader context than that currently being discussed. Successful treatment is likely to involve more than just the family and the paediatric services, and will almost certainly require support in the school and the wider community. It may be futile to ask the child to restrain his behaviour in the context of what is increasingly accepted to be an 'obesogenic' environment, with frequent opportunities for the consumption of food (along with its widespread marketing and promotion) and frequent opportunities for sedentary behaviour. This type of environment is a challenge for children and their parents, potentially leading to difficult family dynamics and a sense of personal failure.

The second point is that child obesity is becoming a public health issue rather than a health services issue: the emphasis needs to move from treatment of individuals to prevention in the population at large. Prevention of weight gain among normal weight children will require much the same set of policies as are needed to support weight-control among overweight and obese children. Measures will need to be taken both 'downstream' in the school, home and neighbourhood environment, and 'upstream' in terms of policies for food supplies, commercial marketing and the promotion of healthier lifestyles, through measures such as those proposed by the

World Health Organization (15) and by other expert groups (16–18).

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