PART 1
The context

This section of five chapters paints the big picture for childhood obesity prevention. The problem needs to be well articulated before the solutions, which are the focus for most of the book, can be defined. The rise in obesity has many societal and environmental drivers so the options for solutions to reduce childhood obesity must be multi-dimensional and sustained. The solutions are at once simple, from a behavioral action point of view (eating less and moving more), and highly complex, from a societal, economic and cultural point of view. The solutions must also give primacy to what should be a prevailing societal responsibility to provide safe and healthy environments for children. The human rights approach to childhood obesity, therefore, provides an important frame of reference for solutions to be developed and communicated.

The epidemiology of the childhood obesity epidemic gives us many clues about its determinants and Chapter 1, led by Tim Lobstein from the International Obesity Taskforce, plots the global trends in prevalence rates. The rise has been rapid but varied, and much of the variation in prevalence is likely to be explained by environmental and socio-cultural factors——a neglected area of obesity research. The increasing demands on pediatric health services and the tracking of obesity into adulthood, and thus the future demand on adult health services, are two enormous challenges we face. We need to look widely for the answers to the obesity epidemic and there are many valuable lessons to be learned from the successful control of other epidemics. This important evidence, which is explored in Chapter 2 by Mickey Chopra, is known to many epidemiologists and public health researchers who work across different health issues, but the lessons need to be applied systematically to obesity. The central role of policy is one crucial lesson that has yet to be well applied in obesity prevention.

Terms "life-course", "multi-sector", multi-strategy", "whole-of-society" are often used to describe the approaches to obesity prevention and these are discussed in Chapter 3 by Ricardo Uauy and colleagues. What becomes an inescapable conclusion is that we cannot hope to reduce childhood obesity in the face of the continuing barrage of commercial marketing of "junk" food to children. Something must be done to reduce this overwhelming driver of obesogenic environments as a central plank of childhood obesity prevention. Taking an ethics-based, child rights approach is vital to give gravity to society's response. It also ensures that the ethical dilemmas intrinsic to obesity prevention, such as the potential for risk and the balance between paternalism and individualism, are assessed and managed in the best interests of child health. Chapter 4, led by Marieke ten Have, and Chapter 5, led by Naomi Priest, enter this important territory and, again, food marketing to children arises as a fundamental problem.

CHAPTER 1

The childhood obesity epidemic

Tim Lobstein,[1,2] *Louise A Baur*[3] and *Rachel Jackson-Leach*[1]
[1] International Association for the Study of Obesity, London, UK
[2] SPRU—Science and Technology Policy Research, University of Sussex, Brighton, UK
[3] Discipline of Paediatrics and Child Health, University of Sydney, Sydney, Australia

Summary

- Childhood obesity can be measured in various ways, but applying a single method across all available data shows a rapid rise in the numbers of children affected.
- Very few countries have shown a reversal of this trend, but prevalence levels vary across populations, and according to social demographics.
- The rise in child obesity will almost certainly lead to a rise in adult obesity rates.
- Child obesity is a health concern itself and will increase the demand for pediatric treatment.

Introduction

In many developed economies child obesity levels have doubled in the last two decades.[1] The impending disease burden in these countries has been described by medical professionals as "a public health disaster waiting to happen",[2] "a massive tsunami",[3] and "a health time-bomb".[4] In emerging and in less developed economies, child obesity prevalence levels are also rising,[5] especially among populations in urban areas where there may be less necessity for physical activity, greater opportunities for sedentary behavior and greater access to energy-dense foods and beverages.

This chapter looks at the figures and predictions, and considers the implications in terms of children's obesity-related health problems and the need for policy development for both pediatric treatment services and public health preventive action.

Preventing Childhood Obesity. Edited by
E. Waters, B.A. Swinburn, J.C. Seidell and R. Uauy.

Measuring the prevalence of obesity

Policy-makers will need to evaluate the trends in child obesity and the success of any interventions, but they face an initial problem in agreeing a clear definition of what constitutes excess body weight in a child. Among adults, obesity is generally defined as a BMI greater than 30 kg/m^2, and overweight as a BMI between 25 and 30 kg/m^2, but for children there are difficulties in defining a single standard as normally-growing children show significant fluctuations in the relationship between weight and height. Charts showing weight, height and BMI for children by age and gender are commonly used, but with different cut-off points for overweight and obesity, such as 110% or 120% of ideal weight for height, or weight-for-height greater than 1 or 2 standard deviations above a predefined mean, or a BMI-for-age at the 85th, 90th, 95th or 97th percentiles, based on various reference populations.[1]

For young children, it has been common practice to use "weight-for-height" rather than BMI. This stems from existing definitions used in the assessment of underweight and stunting, where "weight-for-age", "height-for-age" and "weight-for-height" are used to assess infant growth. The measures are still occasionally used for assessing overweight in young children, usually by taking a value of two standard

deviations (Z >+2.0) above a reference population mean as the criteria for excess weight for a given age and gender.

In recent years, BMI has been increasingly accepted as a valid indirect measure of adiposity in older children and adolescents for survey purposes,[1,6] leading to various approaches to selecting appropriate BMI cut-off values to take account of age and gender differences during normal growth.[7–12] A number of different BMI-for-age reference charts have been developed, such as those from the US National Centre for Health Statistics,[9] the United Kingdom[10] and France.[11]

An expert panel convened by the International Obesity TaskForce (IOTF) proposed a set of BMI cut-offs based on pooled data collected from Brazil, Britain, Hong Kong, Singapore, the Netherlands and the USA. The IOTF definitions of overweight and obesity are 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.[12]

The World Health Organization (WHO) has for many years recommended using a set of cut-offs based on a reference population derived from the USA, but more recently the WHO has been reviewing their recommendations. There had been concern that the USA data included large numbers of formula-fed infants with growth patterns that differed from breast-fed infants, and which underestimated the true extent of overweight in younger children. WHO has now published a new "standard" set of growth charts for children aged 0–5 years, based on data from healthy breast-fed babies.[13] It is unclear at this stage what BMI cut-off values should be used from this healthy population to define overweight and obesity, with both centile and Z-score options available in published tables. Further reference charts are available for children aged 5–19 years, based on a revision of US data collected in 1977 adapted to match the standards for 0–5-year-olds.

Care should be taken when looking at published prevalence figures for overweight and obesity. Some authors use "overweight" to define all members of a population above a specified cut-off, while others mean "overweight" to mean those above one cut-off but not above a higher cut-off that defines obesity. Thus, in some reports the prevalence value for "overweight" children includes obese children and in other reports it does not. In this section "overweight" includes obese, so the term should properly be understood to mean "overweight including obese". Readers should also note that prevalence levels using reference curves from the USA sometimes refer to "at risk of overweight" and "overweight" for the top two tiers of adiposity, and sometimes to "overweight" and "obese".

It should also be noted that the definitions are very helpful for making comparisons between different population groups, or monitoring a population over time. However, for the clinical assessment of children, serial plotting of BMI on nationally recommended BMI-for-age charts should be coupled with more careful examination of the child in order to be sure that, for example, a high BMI is not due to extra muscle mass or to stunted linear growth.

In this chapter the prevalence levels will be based on the IOTF international classification scheme, as most survey evidence is available using this approach, and the results tend to be more conservative than some other approaches.[1]

Prevalence levels

Policy-makers face a second hurdle in understanding the circumstances surrounding obesity in children and adolescents, namely, a lack of representative data on what is happening in the population that is of interest. Only in a few countries are children monitored routinely and data on their nutritional status gathered, analysed and reported consistently.

Even where data are available, they need to be examined carefully. Firstly, data may be collected using proper measurement procedures, or may be self-reported, but self-reported measures tend to underestimate BMI, especially among more overweight respondents. Data may come from nationally representative surveys or from smaller surveys—for example, in the more accessible urban areas—which do not represent national populations. And, when comparing two surveys across a period of time, surveys need to be properly comparable in terms of the children's ages, and their ethnic and socio-demographic mix.

The figures presented here are based on the latest and most reliable available, some of which were previ-

Table 1.1 Estimated prevalence of excess bodyweight in school-age children in 2010.

Region[a]	Obese	Overweight (including obese)
Americas	15%	46%
Mid East & N Africa	12%	42%
Europe & former USSR	10%	38%
West Pacific	7%	27%
South East Asia	5%	23%
Africa	>1%	>5%

[a] Countries in each region are according to the World Health Organization.
Source: Wang and Lobstein[5].

ously published in 2006 by Wang and Lobstein.[5] Unless otherwise stated, the IOTF definitions of overweight and obesity in childhood are used.

Global figures

Taking an estimate for the world as a whole, in 2004 some 10% of school-age children (aged 5–17) were defined as overweight, including some 2–3% who were obese. This global average reflects a wide range of prevalence levels in different regions and countries, with the prevalence of overweight in Africa and Asia averaging well below 5% and in the Americas and Europe above 20%. Projections to the year 2010 are shown in Table 1.1.

Region: Americas

The most comprehensive and comparable national representative data on trends in the prevalence of obesity are from the USA, where nationally representative surveys undertaken in the 1960s were followed by the series of National Health and Nutrition Examination Surveys (NHANES) from 1971 onwards. The most recent publications (for surveys conducted in 2003–2004) show that 36% of children aged 6–17 were overweight, including 13% obese. These figures are based on the international (IOTF) criteria for overweight and obesity,[12] and compare with 36% and 18% respectively using US-defined cut-offs.[14]

In Canada 26% of younger children and 29% of older children were found to be overweight in a 2004 survey, almost exactly double the prevalence levels found among children 25 years earlier.[15] In Brazil, the prevalence of overweight among school-aged children was 14% in 1997, compared with 4% in 1974. In Chile, in 2000 the prevalence of overweight among school children was 26%.

There are few data available for schoolchildren in most other South and Central American countries, but some data have been collected for pre-school children. In Bolivia, the prevalence of overweight (defined as one standard deviation above a reference mean) was 23% in 1997, and in the Dominican Republic it was 15% in 1996. In a few countries in the region, obesity prevalence has fallen: in Columbia it fell from 5% to 3% between 1986 and 1995.

Region: Europe

A number of studies have examined childhood overweight and obesity prevalence in European countries. The highest prevalence levels are observed in southern European countries. A survey in 2001 found that 36% of 9-year-olds in central Italy were overweight, including 12% who were obese. In 1991, 21% of school-age children in Greece were overweight or obese, whereas a decade later, in 2000, 26% of boys and 19% of girls in Northern Greece were overweight or obese, while data from Crete in 2002 show 44% of boys aged 15 years to be overweight or obese. In Spain, 35% of boys and 32% of girls aged 13–14 years were overweight in a survey in 2000.

Northern European countries tend to have lower prevalence values. In Sweden in 2000–2001, the prevalence was 18% for children aged 10 years. In the Netherlands the figures are particularly low, with only 10% of children aged 5–17 overweight, including only 2% obese, in a 1997 survey. In France, the figures are a bit higher, at 15% overweight and 3% obese in a northern French survey in 2000, and these figures appear to have remained stable, according to recent preliminary results of surveys in 2007.[16] In England, prevalence rates have climbed to 29% overweight, including 10% obese, in a 2004 survey.

The reasons for a north–south gradient are not clear. Genetic factors are unlikely to be the explanation, as the gradient can be shown even within a single country, such as Italy and virtually all countries have shown a marked increase in prevalence in recent decades. A range of factors influencing regional barriers or promoters of population levels of physical activity may be important. The child's household or family income may be another relevant variable,

possibly mediated through income-related dietary factors such as maternal nutrition during pregnancy, or breast- or bottle-feeding in infancy, as well as the quality of the diet during childhood.

Regions: North Africa, Eastern Mediterranean and Middle East

Several countries in this region appear to be showing high levels of childhood obesity. In Egypt, for example, the prevalence of overweight (based on local reference charts and a z score >1) was over 25% in pre-school children and 14% in adolescents. Similar figures are found in other parts of the region. A fifth of adolescents aged 15–16 years in Saudi Arabia were defined as overweight (based on BMI >120% reference median value). In Bahrain in 2002, 30% of boys and 42% of girls aged 12–17 were overweight, including over 15% obese in both groups (defined by IOTF cut-offs).

Regions: Asia and Pacific

The prevalence of obesity among pre-school children is around 1% or less in many countries in the region, for example Bangladesh (1.1%), the Philippines (0.8%), Vietnam (0.7%) and Nepal (0.3%), but it should be noted that no data are available for some countries in the region (e.g., the Pacific islands) where adult obesity prevalence rates are known to be high.

In more economically developed countries, the prevalence figures for pre-school and school-age children are considerably higher. Among Australian children and adolescents aged 7–15 years, the prevalence of overweight (including obesity) doubled from 11% to 21% between 1985 and 1995, and was found to be 27% in a regional survey of 4–12-year-olds in 2003–4.[17]

In mainland China, whose population accounts for one-fifth of the global population, the prevalence of obesity has been rising in both adults and children during the past two decades. A survey in 1992 showed the prevalence of overweight, including obesity, among schoolchildren to be 4% – this rose to 7% in 2002. In urban areas the prevalence was 10%, and in the largest cities nearly 20% (see Table 1.3).

While the epidemic of obesity has affected a wide range of countries in this region, under-nutrition is still a major problem. In China, the prevalence of underweight (<5th percentile BMI of the US reference) was 9% among children aged 6–9 years, and 15% among children aged 10–18, in 1997. In Indonesia, over 25%, and in Bangladesh and India over 45% of children under 5 years old are underweight. Thus, several of the most populous countries in this region are facing a double burden of continued under-nutrition and rising over-nutrition.

Region: Sub-Saharan Africa

The burden of under-nutrition remains very high in this region, with continuing poverty, war, famine and disease, especially HIV/Aids, and very high rates of child mortality. There are very few surveys from African countries that can provide prevalence figures for childhood obesity, as most public health nutrition programs have been focused on under-nutrition and food safety problems. In general, the prevalence of childhood obesity remains very low in this region, except for countries such as South Africa where obesity has become prevalent in adults, particularly among women, and where childhood obesity is also rising. Data from South Africa show the prevalence of overweight (including obesity) among young people aged 13–19 years to be over 17%, with boys generally less at risk (7%) than girls (25%). Prevalence was highest (over 20% for both boys and girls) in white and Indian population groups.

Trends over time

The prevalence of excess weight among children is increasing in both developed and developing countries, but at different rates and in different patterns. North America and some European countries have the highest prevalence levels, and in recent years have shown high year-on-year increases in prevalence. Data from Brazil and Chile show that rates of increasing overweight among children in some developing countries is comparable to that in the USA or Europe.

Other countries are showing only modest increases. China has shown a small rise in the prevalence of overweight among rural children, but a more marked increase among urban children.[18] The rapid rise in the prevalence of overweight is shown in most developed economies, but an interesting exception is Russia, where the economic downturn in the early 1990s may

explain the decline in the prevalence of overweight children during the period (Table 1.2).

Demographics of child adiposity

If policies to prevent child obesity are to be successful they need to consider the distribution of the problem among different demographic groups within the child population. Some population groups are more easily accessed than others but they may not be those most in need of attention. Treatment may be accessed more easily by some groups, but not necessarily by those that need it most.

Examination of differences in the distribution of overweight and obesity among children coming from different social classes (defined by family income levels or educational levels of the main income earner) shows a complex pattern. In more economically developed, industrialized countries, children in lower socio-economic groups tend to show higher prevalence levels of overweight and obesity. Moreover, programmes to tackle obesity may be assisting better-off families while obesity levels continue to rise among poorer families.

In contrast, in countries that are not economically developed, or are undergoing economic development, overweight and obesity levels tend to be highest among families with the highest incomes or educational attainment. In Brazil, in 1997, 20% of children in higher-income families were overweight or obese, compared with 13% of children in middle-income families and only 6% of children in lower-income families. In China, there is a clear positive association between child overweight and both income level and educational level, and by urban–rural differences (Table 1.3).

These figures need to be considered in developing policies targeting obesity prevention. Economic development in urban and rural areas is likely to be closely related to the development of environments that reduce physical activity, encourage sedentary behavior and encourage the consumption of energy-dense foods and beverages. Physical activity is likely to be highest in rural areas in less developed economies, where there is likely to be only limited access to pre-processed, long-shelf-life, mass-produced products—soft drinks, fatty snack foods, confectionery and fast food outlets—compared with urban areas and among wealthier families. In contrast, in highly-developed economies, the large majority of the population is likely to have less need of physical activity and to have extensive access to processed, energy-dense foods and beverages.

For children, economic development sees a move from agricultural labor and domestic labor to TV watching, while active transport (walking, cycling) is replaced with motorized transport, even for short

Table 1.2 Examples of the rise in the prevalence of overweight children in developed and developing economies.

	Date of survey	Prevalence of overweight
USA	1971–74	14%
	1988–94	25%
	2003–4	36%
Canada	1978–79	14%
	2004	29%
Australia	1985	11%
	1995	21%
New Zealand	1989	13%
	2000	30%
Japan	1976–80	10%
	1992–2000	19%
England	1984	7%
	1994	12%
	2004	29%
Greece (boys)	1991	21%
Greece North (boys)	2000	26%
Greece Crete (boys)	2002	44%
Iceland	1978	12%
	1998	24%
Netherlands	1980	5%
	1996–97	11%
Spain	1980	13%
	1995	19%
	2000–2	34%
Brazil	1974	4%
	1997	14%
Chile	1987	13%
	2000	27%
China rural	1992	4%
	2002	5%
China urban	1992	7%
	2002	10%
Russia	1992	15%
	1998	9%
	2005	12%[a]

[a] Based on self-reported height and weight.

Table 1.3 Prevalence of overweight and obesity (combined) among children aged 7–12 years in rural and urban populations and various income and education levels defined by parental status, China, 2002.

	Boys	Girls
Urban/rural		
Large city	24%	15%
Small city	10%	7%
Village	5%	3%
Family income (yuan/year/person)		
>10,000	22%	13%
5000–10,000	15%	10%
2000–5000	10%	7%
<2000	7%	3%
Education level of father		
College and higher	20%	12%
Senior high school	15%	9%
Junior high school	7%	5%
Primary or less	4%	2%

Source: Li.[18]

journeys such as getting from home to school or to shops. Traditional staple foods give way to highly marketed and promoted branded food and beverage products.

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, child overweight levels may actually show decreasing prevalence, as the data for 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 (1948–49), increasing to the end of the 1970s, and falling again during the recession of the 1980s.[19] When the economy recovers, the prevalence of overweight and obesity may increase sharply, as has been shown in data for East Germany (school-age children) and Croatia (pre-school children) in the years following unification and national independence, respectively.

Child obesity and tracking to adulthood

One of the most pressing considerations to emerge from the dramatic rise in child obesity is the likely impact that this will have on adult disease rates in the next few years. The persistence, or tracking, of obesity from childhood and adolescence to adulthood has been well documented.[20] In the USA, Whitaker et al[21] demonstrated that if a child was obese during childhood, the chance of being obese in young adulthood ranged from 8% for 1- or 2 year-olds without obese parents to 79% for 10–14-year-olds with at least one obese parent. Evidence from a longitudinal study of children, the Bogalusa Heart Study, suggests that children who have overweight onset before the age of 8 are at significantly increased risk of obesity in adulthood.[22] Comparing racial groups, tracking of adiposity was stronger for black compared with white youths, especially for females (Table 1.4).[23]

Table 1.4 Proportion of children who had a BMI >27.5 kg/m^2 as young adults (before age 30 years) according to obesity status in childhood.

Age	BMI normal range for age	BMI >85th centile for age	BMI >95th centile for age
1–2 years	15%	19%	26%
3–5 years	12%	36%	52%
6–9 years	11%	55%	69%
10–14 years	10%	75%	83%
15–17 years	9%	67%	77%

Source: Whitaker et al.[21]

In a review of evidence on child adiposity undertaken by the US Preventive Task Force, persistence of overweight was consistently seen in 19 longitudinal studies of children of both genders and all ages, with the greatest likelihood of overweight persistence seen for older children and those most severely overweight, for both genders.[24] Parental overweight also substantially increases the risk of child obesity and subsequent adult obesity.

Co-morbidities of child obesity

Besides being a risk factor for adult obesity and chronic disease, excess adiposity in childhood raises the risk of a number of adverse physical and psychosocial health outcomes in childhood itself[1,25] summarized in Table 1.5.

Table 1.5 Health problems concurrent with child and adolescent obesity.

Endocrine
Insulin resistance/impaired glucose tolerance
Type 2 diabetes
Menstrual abnormalities
Polycystic ovary syndrome
Hypercorticolism
Cardiovascular
Hypertension
Dyslipidaemia
Fatty streaks
Left ventricular hypertrophy
Gastroenterological
Cholelithiasis
Liver steatosis / non-alcoholic fatty liver
Gastro-oesophageal reflux
Pulmonary
Sleep apnea
Asthma
Pickwickian syndrome
Orthopedic
Slipped capital epiphyses
Blount's disease (tibia vara)
Tibial torsion
Flat feet
Ankle sprains
Increased risk of fractures
Neurological
Idiopathic intracranial hypertension (e.g., pseudotumour cerebri)
Other physical
Systemic inflammation/raised C-reactive protein
Psycho-social
Anxiety
Depression
Low self-esteem
Social discrimination

Figures for the numbers of children affected by co-morbidities are remarkable hard to obtain. BMI or obesity status may not be recorded when diagnoses of ill-health are made in pediatric clinics, while in the population at large the early stages of chronic disease may not be diagnosed among overweight and obese children.

Table 1.6 Estimated prevalence of disease indicators among obese children.

	Mean	95% CI
Raised blood triglycerides	25.7%	21.5%–30.5%
Raised total blood cholesterol	26.7%	22.1%–31.8%
High LDL cholesterol	22.3%	18.9%–26.3%
Low HDL cholesterol	22.6%	18.7%–27.0%
Hypertension	25.8%	21.8%–30.2%
Impaired glucose tolerance	11.9%	8.4%–17.0%
Hyperinsulinaemia	39.8%	33.9%–45.9%
Type 2 diabetes	1.5%	0.5%–4.5%
Metabolic syndrome, 3 factors	29.2%	23.9%–35.3%
Metabolic syndrome, 4 factors	7.6%	4.6%–12.2%
Hepatic steatosis	33.7%	27.9%–41.8%
Raised serum aminotransferase	16.9%	12.8%–22.0%

Note: Definitions of obesity and of the indicators differ between source surveys. Mean and confidence intervals based on weighted averages of survey findings.
Source: Lobstein and Jackson-Leach.[26]

The lack of adequate information can be a significant problem in the planning of pediatric services to respond to the rising levels of child obesity. One estimate, based on clinical surveys in a number of countries, suggests that a substantial proportion of obese children are likely to be affected by one or more concurrent disease indicator, as shown in Table 1.6.

Type 2 diabetes

Obesity in childhood is a major risk factor for the development of Type 2 diabetes – a disease that until recently was considered to occur only later in adulthood. The American Diabetes Association's (ADA) consensus report indicated that up to 85% of children diagnosed with Type 2 diabetes are overweight or obese at diagnosis.[27] Small sample surveys in the USA suggest that up to 3% of clinically obese children may be affected, the majority of them without awareness.[26] These patients may present with glycosuria without ketonuria, and absent or mild polyuria and polydipsia.

Impaired glucose tolerance and insulin resistance

Before Type 2 diabetes develops, there is a period of altered glucose metabolism. Oral glucose tolerance testing (OGTT) appears to be more sensitive than fasting blood glucose to detect the pre-diabetic condition of impaired glucose tolerance (IGT). Children with IGT have elevated insulin levels in the fasting state and in response to OGTT. Around 10% of clinically obese children may be affected.[27] Central adiposity represents an additional independent risk factor.

Metabolic syndrome and cardiovascular disorders

The metabolic syndrome or insulin-resistance syndrome, is a well-known obesity-associated condition found in at least 20% of all adults in the USA[28] and is increasingly observed among obese children and adolescents. The syndrome has a range of definitions, but is usually diagnosed based on the presence of several of the following conditions: abdominal obesity, elevated triglycerides, low high-density lipoprotein (HDL) cholesterol, hypertension and elevated fasting glucose. The overall prevalence among adolescents in the USA in 1999–2000 was estimated to be over 6%,[29] and it increased from less than 1% among normal weight adolescents to 10% among those who were overweight, and to more than 30% among those who were obese.

Approximately 4% of normal-weight US adolescents have high blood pressure, while the prevalence rises to over 25% among obese adolescents. Low levels of circulating HDL cholesterol are found among 18% and 39% or normal weight and obese adolescents, respectively, and high levels of blood triglycerides are found among 17% and 46%, respectively. Results from a study conducted in Hungary suggests that the number of metabolic syndrome components increases with the duration of the obesity.[30]

Evidence from the Bogalusa Heart Study indicates that atherosclerotic changes are present in blood vessels of even very young children.[31] The extent and severity of asymptomatic coronary and aortic disease in young people increases with age, and is strongly correlated with BMI, blood pressure, cholesterol and triglyceride levels.[31] Additionally, very overweight children show signs of severe cardiovascular deconditioning in tests of physical fitness, and some already have left ventricular hypertrophy.[32] These findings suggest that cardiovascular risk factors present in childhood may not only impact long-term risk, but may also have more immediate consequences, further highlighting the importance of addressing cardiovascular risk factors well before adulthood.[31,32]

Hyperandrogenism/polycystic ovary syndrome

Polycystic ovary syndrome (PCOS) is a condition where there is chronic anovulation and evidence of excess androgen, for which there is no other explanation. Although the prevalence of PCOS among adolescents is difficult to determine, girls who are oligomenorrheic and are overweight or obese appear to be at greatest risk for developing PCOS.[33] Insulin resistance may be an important underlying factor.

Cholelithiasis

The increase of total body synthesis of cholesterol that occurs in obesity leads to a higher ratio of cholesterol to solubilizing lipids in bile, and predisposes the individual to gallstone formation.[34] Although cholelithiasis and cholecystitis are relatively uncommon in children, pediatric hospital discharges for gall bladder disease in the USA have tripled in the period 1980 to 1999.[35] Obese children with gall bladder disease may present with non-specific abdominal pain with or without vomiting. Asymptomatic presentations are not uncommon, with gallstones being detected by abdominal ultrasound.

Non-alcoholic fatty liver disease

A further complication of pediatric obesity is non-alcoholic fatty liver disease or liver steatosis. Liver function tests are often abnormal, with greater elevations in aminotransferase (ALT) relative to aspartate aminotransferase (AST). Up to 77% of obese Chinese children referred for medical assessment had radiological evidence of fatty liver disease.[36] In a multicenter review of liver biopsies in Boston area hospitals, all 14 children with varying degrees of hepatosteatosis and steatohepatitis were obese.[37] In a similar study conducted in Australia, 16 of 17 children with steato-

hepatitis were 125–218% of ideal body weight.[38] Liver biopsies in these children generally show inflammation and fibrosis, but there have been occasional reports of cirrhosis.[38,39] As in adults, improvements in liver function tests have been reported among children who lost weight, and both ALT and BMI have been shown to be strong independent predictors of fatty liver disease.[36]

Apnea and Asthma

Obstructive sleep apnea, one part of a spectrum of sleep-disordered breathing, is another potentially dangerous consequence of childhood obesity. Two independent studies of obese US children referred for assessment of sleep-associated breathing disorders reported that 37%[40] to 94%[41] had abnormal polysomnographic findings. All were reported to be snorers and up to 50% had episodes of apnea.

Among US children with asthma, severe obesity is more than twice as prevalent as it is among children without asthma,[42] and asthma is about twice as common in obese children compared with non-obese children in studies conducted in Israel, Germany and the USA.[43–45] Despite this evidence supporting a cross-sectional association between obesity and asthma in children and adolescents, a recent survey in Canada failed to detect a statistically significant association between obesity and asthma in a large population of 4–11-year-olds.[46] Studies differ in their definitions of obesity and/or asthma, and it is plausible that the direction of causation is reversed, with the presence of asthma leading to physical inactivity, which results in weight gain.

Orthopedic/musculoskeletal effects

Excessive body weight in childhood adds mechanical stress to unfused growth plates and bones that are undergoing ossification, making overweight and obese children susceptible to orthopedic abnormalities, namely Blount disease and slipped capital femoral epiphysis. Obese children may also be predisposed to excess fractures, as well as bone and joint pain. Calculations of plantar force and pressure during standing and walking indicate that obese children may be at increased risk of developing foot pain or pathologies.

Psychological effects

Much of the work that has been done in this area is cross-sectional, so that the directionality of the associations is uncertain. However, the stigmatization, bullying and teasing experienced by overweight children may be internalized in feelings of low self-worth, depressive symptoms or suicidal thinking. Whereas one longitudinal study in the USA showed no effect of BMI on self-esteem in adolescents and young adults,[47] a second study identified important racial/ethnic differences in the relationship between changes in self-esteem and overweight in girls.[48] In Hispanic and white girls, but not among black girls, those who were overweight experienced significant decreases in self-esteem compared with their non-obese counterparts.[48] The lack of a similar association for black girls is consistent with an earlier cross-sectional study reporting normal self-esteem among obese inner-city black children, suggesting that, at least in this subgroup, obese children may not be motivated to lose weight by the promise of improved self-esteem.[49]

Psychosocial effects

Possibly the most pervasive consequences of obesity in many Western societies are psychosocial.[50] Cross-sectional associations between obesity risk and bullying, social marginalization and poor academic performance have been documented in studies conducted in Canada, the USA and Sweden.[25] Awareness of the stigma associated with obesity can lead to concerns about weight and fear of obesity even in children as young as 5 or 6.[50]

Adolescent obesity appears to affect socio-economic outcomes: data from the US National Longitudinal Survey of Youth demonstrated that overweight in adolescence and young adulthood may be a significant socio-economic handicap, especially for females.[47] Adolescent and young adult women who were overweight at baseline completed fewer years of school, were 20% less likely to be married, had lower household income and had higher rates of household poverty than non-overweight women when surveyed seven years later. Overweight men were 11% less likely to be married than were non-overweight men in the cohort. A British cohort study

also identified poorer economic outcomes in young women (but not men) independent of parental socioeconomic status and academic ability.[51]

Treatment implications

The impact of child obesity on children's health raises several questions for pediatric 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?

Certainly, some disease 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. However, experience gained so far suggests that weight control interventions organized by pediatric services require a multi-disciplinary team of staff working with both the child and the child's family over an extended period of time, if there is to be a good chance of success.

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 pediatric 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 behavior 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 behavior. 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, with the emphasis moving 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 to tackle obesogenic environments as are needed to support weight control among overweight and obese children. Measures such as those proposed by the World Health Organization[52] and by other expert groups[53–55] include those that are taken "downstream" in the school, home and neighborhood environment, and "upstream" in terms of policies for food supplies, commercial marketing and the encouragement of healthier lifestyles through the creation of health-promoting environments.

References

1 Lobstein T, Baur L, Uauy R: IASO International Obesity TaskForce. Obesity in children and young people: a crisis in public health. *Obes Rev* 2004; **5**(Supp. 1):4–104.

2 Olshansky SJ: University of Illinois. Cited by J Ritter in "Obesity may cut US lifespans", Chicago Sun-Times, 17 March 2005. www.highbeam.com/doc/1P2-1567779.html (accessed 11 June 2008).

3 Ludwig D: Children's Hospital, Boston. Cited by D DeNoon in "Will obesity shorten the American lifespan?" *Medcsape Today*, 16 March 2005. www.medscape.com/viewarticle/527397 (accessed 11 June 2008).

4 Chief Medical Officer, UK Department of Health. Annual: Report of the Chief Medical Officer 2002. London: Department of Health, 2003.

5 Wang Y, Lobstein T: Worldwide trends in childhood overweight and obesity. *Int J Pediatr Obes* 2006; **1**:11–25.

6 Dietz WH, Robinson TN: Use of the body mass index (BMI) as a measure of overweight in children and adolescents. *J Pediatr* 1998; **132**:191–193.

7 Kuczmarski RJ, Ogden CL, Grummer-Strawn LM et al: CDC growth charts: United States. *Adv Data* 2000; **314**:1–27.

8 World Health Organization: Physical status: the use and interpretation of anthropometry. WHO Technical Report Series No. 854. Geneva: WHO, 1995:161–311.

9 Must A, Dallal GE, Dietz WH: Reference data for obesity: 85th and 95th percentiles of body mass index (wt/ht2) and triceps skinfold thickness. *Am J Clin Nutr* 1991; **53**:839–846. Erratum in *Am J Clin Nutr* 1991; 54:773.

10 Cole TJ, Freeman JV, Preece MA: Body mass index reference curves for the UK, 1990. *Arch Dis Child* 1995; **73**:25–29.

11 Rolland-Cachera MF, Cole TJ, Sempe M, Tichet J, Rossignol C, Charraud A: Body Mass Index variations: centiles from birth to 87 years. *Eur J Clin Nutr* 1991; **45**:13–21.

12 Cole TJ, Bellizzi MC, Flegal KM, Dietz WH: Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ* 2000; **320**:1240–1243.

13 World Health Organization: Growth Reference Data for 5-19 Years. Internet publication. Geneva: WHO, 2007. www.who.int/growthref/ (accessed 4 April 2008).

14 Lobstein T, Jackson-Leach R: Child overweight and obesity in the USA: prevalence rates according to IOTF definitions. *Int J Pediatr Obes* 2007; **2**:62–64.

15 Shields M: Overweight and obesity among children and youth. *Statistics Canada Health Report* 2006; **17**:27–42.
16 European Congress on Obesity. Child obesity "levelling off" in France. Media release, 15 May 2008. See abstracts nos: T5: PS.66 and T5: PS.113 at www.nature.com/ijo/journal/v32/n1s/pdf/ijo200847a.pdf (accessed 11 June 2008).
17 Sanigorski AM, Bell AC, Kremer PJ, Swinburn BA: High childhood obesity in an Australian population. *Obesity (Silver Spring)* 2007; **15**:1908–1912.
18 Li Y, Schouten EG, Hu X, Cui Z, Luan D, Ma G: Obesity prevalence and time trend among youngsters in China, 1982–2002. Wageningen: Wageningen University, 2007. *Asia Pac J Clin Nutr* 2008; **17**:131–137.
19 Stolarczyk H, Malinowski A: Secular changes of body height and mass in children and adolescents of Lodz. *Z Morphol Anthropol* 1996; **81**:167–177.
20 Power C, Lake JK, Cole TJ: Body mass index and height from childhood to adulthood in the 1959 British birth cohort. *Am J Clin Nutr* 1997; **66**:1094–1101.
21 Whitaker R, Wright J, Pepe M, Seidel K, Dietz W: Predicting obesity in young adulthood from childhood and parental obesity. *N Engl J Med* 1997; **337**:869–873.
22 Freedman DS, Khan LK, Serdula MK, Dietz WH, Srinivasan SR, Berenson GS: The relation of childhood BMI to adult adiposity: the Bogalusa Heart Study. *Pediatrics* 2005; **115**:22–27.
23 Freedman DS, Khan LK, Serdula MK, Dietz WH, Srinivasan SR, Berenson GS: Racial differences in the tracking of childhood BMI to adulthood. *Obes Res* 2005; **13**:928–935.
24 Whitlock EP, Williams SB, Gold R, Smith PR, Shipman SA: Screening and interventions for childhood overweight: a summary of evidence for the US preventive services task force. *Pediatrics* 2005; **116**:E125–E144.
25 Must A, Hollander SA, Economos CD: Childhood obesity: a growing public health concern. *Expert Rev Endocrinol Metab*, 2006; **1**:233–254.
26 Lobstein T, Jackson-Leach R: Estimated burden of paediatric obesity and co-morbidities in Europe. Part 2. Numbers of children with indicators of obesity-related disease. *Int J Pediatr Obes* 2006; **1**:33–41.
27 American Diabetes Association: Type 2 diabetes in children and adolescents. *Am Diabetes Assoc Diabetes Care* 2000; **23**:381–389.
28 Ford ES, Giles WH, Dietz WH: Prevalence of the metabolic syndrome among US adults. *JAMA* 2002; **287**:356–359.
29 Duncan GE, Li SM, Zhou XH: Prevalence and trends of a metabolic syndrome phenotype among U.S. adolescents, 1999–2000. *Diabetes Care* 2004; **27**:2438–2443.
30 Csabi G, Torok K, Jeges S, Molnar D: Presence of metabolic cardiovascular syndrome in obese children. *Eur. J Pediatr* 2000; **159**:91–94.
31 Berenson GS, Srinivasan SR, Bao W, Newman WP, Tracy RE, Wattigney WA: Association between multiple cardiovascular risk factors and atherosclerosis in children and young adults. *N Engl J Med* 1998; **338**:1650–1656.
32 Gidding SS, Nehgme R, Heise C, Muscar C, Linton A, Hassink S: Severe obesity associated with cardiovascular deconditioning, high prevalence of cardiovascular risk factors, diabetes mellitus/hyperinsulinemia, and respiratory compromise. *J Pediatr* 2004; **144**:766–769.
33 Guttmann-Bauman I: Approach to adolescent polycystic ovary syndrome (PCOS) in the pediatric endocrine community in the USA. *J Pediatr Endocrinol Metab* 2005; **18**:499–506.
34 Grundy SM: Cholesterol gallstones: a fellow traveler with metabolic syndrome? *Am J Clin Nutr* 2004; **80**:1–2.
35 Wang G, Dietz W: Economic burden of obesity in youths aged 6 to 17 years: 1979–1999. *Pediatrics* 2002; **109**:E81.
36 Chan DF, Li AM, Chu WC et al: Hepatic steatosis in obese Chinese children. *Int J Obes* 2004; **28**:1257–1263.
37 Baldridge AD, Perez-Atayde AR, Graeme-Cook F, Higgins L, Lavine JE: Idiopathic steatohepatitis in childhood: a multicenter retrospective study. *J Pediatr* 1995; **127**:700–704.
38 Manton ND, Lipsett J, Moore DJ, Davidson GP, Bourne AJ, Couper RT: Non-alcoholic steatohepatitis in children and adolescents. *Med J Aust* 2000; **173**:476–479.
39 Rashid M, Roberts EA: Nonalcoholic steatohepatitis in children. *J Pediatr Gastroenterol Nutr* 2000; **30**:48–53.
40 Mallory GB, Fiser DH, Jackson R: Sleep-associated breathing disorders in morbidly obese children and adolescents. *J Pediatr* 1989; **115**:892–897.
41 Silvestri JM, Weese-Mayer DE, Bass MT, Kenny AS, Hauptmann SA, Pearsall SM: Polysomnography in obese children with a history of sleep-associated breathing disorders. *Pediatr Pulmonol* 1993; **16**:124–129.
42 Gennuso J, Epstein LH, Paluch RA, Cerny F: The relationship between asthma and obesity in urban minority children and adolescents. *Arch Pediatr Adolesc Med*, 1998; **152**:1197–1200.
43 Bibi H, Shoseyov D, Feigenbaum D et al: The relationship between asthma and obesity in children: is it real or a case of over diagnosis? *J Asthma* 2004; **41**:403–410.
44 von Kries R, Hermann M, Grunert V, von Mutius E: Is obesity a risk factor for childhood asthma? *Allergy* 2001; **56**:318–322.
45 von Mutius E, Schwartz J, Neas LM, Dockery D, Weiss ST: Relation of body mass index to asthma and atopy in children: the National Health and Nutrition Examination Study III. *Thorax* 2001; **56**:835–838.
46 To T, Vydykhan TN, Dell S, Tassoudji M, Harris JK: Is obesity associated with asthma in young children? *J Pediatr* 2004; **144**:162–168.
47 Gortmaker SL, Must A, Perrin JM, Sobol AM, Dietz WH: Social and economic consequences of overweight in adolescence and young adulthood. *N Engl J Med* 1993; **329**:1008–1012.
48 Strauss RS: Childhood obesity and self-esteem. *Pediatrics* 2000; **105**:E15.
49 Kaplan KM, Wadden TA: Childhood obesity and self-esteem. *Pediatrics* 1986; **109**:367–370.
50 Dietz W: Health consequences of obesity in youth: childhood predictors of adult diseases. *Pediatrics* 1998; **101**:518–525.

51 Sargent JD, Blanchflower DG: Obesity and stature in adolescence and earnings in young adulthood: analysis of a British birth cohort. *Arch Pediatr Adolesc Med*, 1994; **148**: 681–687.
52 World Health Organization. Global Strategy on Diet, Physical Activity and Health. Adopted by the World Health Assembly, May 2004. Geneva: WHO, 2004.
53 Lobstein T, Baur LA: Policies to prevent childhood obesity in the European Union. *Eur J Public Health* 2005; **15**: 576–579.
54 Stockley L: Toward public health nutrition strategies in the European Union to implement food based dietary guidelines and to enhance healthier lifestyles. *Public Health Nutr* 2001; **4**:307–324.
55 Swinburn B, Gill T, Kumanyika S: Obesity prevention: a proposed framework for translating evidence into action. *Obes Rev* 2005; **6**:23–33.