5 Child Growth and Development

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5.1 INTRODUCTION

The quality of life of infants and young children, as opposed to mere survival, is becoming increasingly important. Most developing countries have experienced dramatic decreases in their infant and under-5 mortality rates over the last three decades. As greater numbers of children survive, it becomes critical to pay closer attention to children's ability to develop their full physical and mental potentials. This will in turn have important consequences in adult life.

Child growth is internationally recognized as the best global indicator of physical well-being in children because poor feeding practices—in both quantity and quality—and infections, or more often a combination of the two, are major factors that affect physical growth and mental development in children [1]. Poor child growth is the consequence of a range of factors that are closely linked to the overall standard of living and whether a population can meet its basic needs, such as access to food, housing, and health care. Child growth assessment thus not only serves as a means for evaluating the health and nutritional status of children but also provides an excellent measurement of the inequalities in health faced by populations. Based on this principle, internationally set health goals for this century will be assessed on the basis of improvements in the rates of underweight among children younger than 5 years [2].

There is strong evidence that poor physical growth is usually associated with deficient or delayed mental development [3], and a number of studies have demonstrated a relationship between growth status and school performance and intellectual achievement [4, 5]. The precise mechanism linking impaired growth and poor mental development is not known. The association cannot be regarded as a simple causal relationship because of the complex environmental factors that affect both growth and development; many socioeconomic disadvantages that coexist with stunting or underweight may also detrimentally affect mental development. It is possible that more than one mechanism act together. For example, nutritionally deprived children are often described as lethargic, possibly because they reduce their activity as a protective measure to conserve energy [6]. This reduced activity limits the child's ability for exploration and interaction and thus may have negative consequences for children's motor and cognitive development. Children who do not practice their existing skills may be less likely to acquire new skills. At the same time, the apathy these children exhibit could lead adults to treat them

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differently from nonstunted children. Undernutrition could also have a direct effect on children's central nervous system. These complex relationships make it difficult to disentangle the exact mechanisms of the association between deficits in growth and poor mental development.

Impaired growth is ultimately a response to limited nutrient availability or utilization at the cellular level. Although in the past most of the attention has been directed toward the negative consequences associated with inadequate protein-energy intake, there is increasing recognition of the important role that micronutrient deficiency plays in children's growth and development. At severe levels of protein-energy deficiency, linear growth probably stops, and body reserves are used as energy and protein sources to maintain vital functions. At less-severe stages, however, it may be possible to cope by simply slowing the rate of linear growth and other compensatory mechanisms, such as reduced activity. The negative consequences of micronutrient deficiencies range from altered immunity and increased risk of infectious diseases and death to reduced growth and mental development [7].

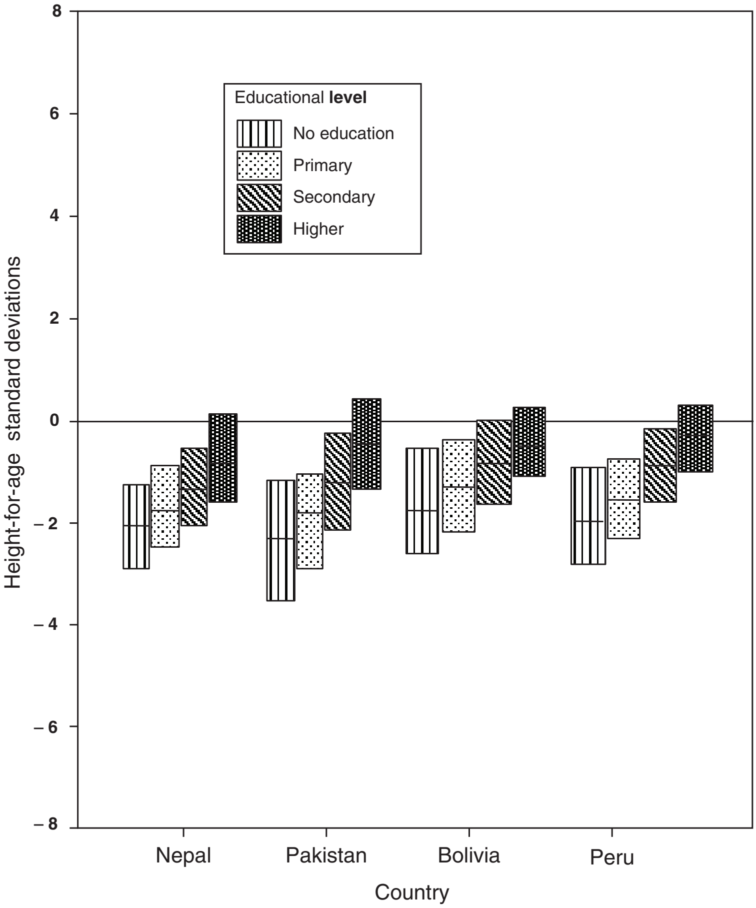

Fig. 5.1. Variation of height for age according to educational level.

Nutritional deficiencies in turn are deeply rooted in poverty and deprivation. Poverty breeds undernutrition, which in turn generates poverty in a vicious cycle that perpetuates across generations. The intrinsic links between poverty and nutrition have been reviewed in detail elsewhere [8]. Based on national-level data, Fig. 5.1 shows the effect of socioeconomic status on stunting (i.e., low height-for-age) for four countries in Asia and Latin America. These associations are consistent across those countries with similar dose-response relationship.

Regardless of the origin, the consequences of impaired growth and development in children can be long lasting and compromise academic performance and the ability to contribute to society. Most growth retardation occurs very early in life; the two periods of highest vulnerability are during intrauterine development and during the transition from reliance on breast milk to addition of other foods to the diet, generally beginning in the second 6 months of life [9]. In fact, almost all of the growth retardation documented in studies carried out in developing countries has its origin in the first 2 or 3 years of life [10]. Once present, growth retardation usually remains for life as growth deficits are generally not recuperated [11].

This chapter reviews concepts and indicators for measuring impaired fetal and child growth; describes the magnitude and geographical distribution of growth retardation in developing countries; discusses the links between fetal and child growth retardation; outlines the main health and social consequences of impaired growth in terms of morbidity, mortality, child development, and adult-life consequences; and reviews interventions aimed at promoting healthy growth and development.

5.2 MEASURING IMPAIRED GROWTH: CONCEPTS AND INDICATORS

Assessing childhood growth remains a mainstay of pediatric care in all settings, that is, in the most advanced health care centers and those faced with severe resource constraints. It is the most widespread approach for assessing body size, weight, composition, and proportions. It can be done inexpensively and noninvasively and is of inherent interest to caretakers responsible for children's welfare. Growth assessment's principal utility to health care stems from its screening value, such as assessing general well-being; identifying growth faltering and excessive growth; managing infant feeding; evaluating maternal lactation performance, the suitability of weaning practices, and related infant behaviours and the follow-up of children with medical conditions known to affect growth adversely (e.g., renal and cardiac patients). It is also useful for population health purposes, such as the assessment of community levels of over- and undernutrition, the prediction and ongoing assessments of feeding emergencies, and assessments of economic resource distribution.

5.2.1 Fetal Growth

Growth failure is a cumulative process that can begin in utero. Various criteria have been used to classify an infant as having experienced normal, subnormal, or supranormal growth in utero. An expert committee from the World Health Organization (WHO) recommended the tenth percentile of a birth-weight-for-gestational-age, sex-specific, single/twins risk curve for the classification of small for gestational age [1]. Strictly speaking, small-for-gestational-age infants are not synonymous to intrauterine growth restriction (IUGR); some small-for-gestational-age infants may merely represent the lower tail of the normal fetal growth distribution. In individual cases, however, it is usually very difficult to determine whether an observed birth weight that is low for gestational age is the result of true in utero growth restriction or represents a "normally small" infant. Classification of IUGR is therefore based on the established cutoff for small for gestational age. The higher the prevalence of infants small for gestational age in a given population, the greater the likelihood that small for gestational age is a result of IUGR [1].

Historically, because valid assessment of gestational age is often not available in developing countries, the incidence of low birth weight (LBW) has been used as a proxy to quantify the magnitude of IUGR in these settings. This approach, however, underestimates considerably the true magnitude of IUGR as it does not take into account those infants whose weight at birth falls below the tenth percentile but who weigh more than 2500 g; many of these infants are likely also to have IUGR [12]. It is thus important to improve the availability and quality of gestational age estimates on a population-wide basis in developing countries. This includes, if feasible, recording early in pregnancy the mother's recall of the date her last normal menstrual period began and the training of birth attendants in the physical assessment of the newborn. In developed countries, early ultrasound examination has improved the validity and reliability of gestational age assessment, although evidence from randomized trials did not demonstrate improvement in maternal or fetal/infant outcomes with routine early ultrasound [13].

The issue of which reference curve to use in assessing growth at birth has been a cause of debate. Based on the observations that children of well-off populations in developing countries experience similar growth patterns as those of healthy, well-nourished children in developed countries and that children of the same genetic background show differing growth performance depending on the environment in which they grow up, there is prevailing international consensus that children of all races have the same growth potential, and that country- or race-specific growth references are not advised [1]. Growth curves should certainly not be adjusted for factors that may be a cause of growth retardation. For example, making adjustments for the height of stunted parents in deprived populations could reinforce the wrong impression that children from these populations are born small for genetic reasons, and that not much can be done about this. On this basis, a group of international experts recommended that an international fetal growth reference curve should be developed based on pooled data from countries in different geographical regions where fetal growth is believed to be optimal [13].

There remain outstanding research questions in the classification and definition of IUGR. Although the use of a single, sex-specific international reference is justifiable, research is needed to assess whether infants of different genetic backgrounds born at a particular weight for gestational age are at substantially different risks for mortality and morbidity. Similarly, it would be important to determine whether infants who are born small because their mothers are primiparous or living at high altitude are at the same risk for adverse outcomes as those of equivalent size who are small because, for instance, their mothers are stunted, have preeclampsia, or are smokers. In addition, research is needed to base the criteria for defining IUGR on evidence of increased risk for important health outcomes, such as perinatal mortality. Because proportionality at birth may be related to adverse health outcomes [13, 14], an attempt should also be made to develop reference data and indicators for the classification of newborns as "wasted" and "stunted" and to quantifying the morbidity and mortality risks associated with these two types of infants.

5.2.2 Child Growth Indicators and Their Interpretation

In children, the three most commonly used indicators to assess growth status are weight-for-age, length/height-for-age, and weight-for-length/height. Weight-for-age is the most commonly applied and, for more than half of the world's countries, the sole anthropometric indicator used [15]. Although it is the easiest indicator to use when children's ages are known, weight-for-age lacks the biological specificity necessary to separate weight- from length/height-related deficits or excesses in growth. Conversely, length/height-for-age and weight-for-length/height permit the distinction of stunted, wasted, and overweight children and allow the appropriate targeting of interventions [16, 17]. The routine collection of length/height measurements (recumbent length up to 2 years of age and standing height for older children) is important because this enables the assessment of not only weight-for-height, but also body mass index (i.e., ratio of weight in kilograms to the square of height in meters), a valuable indicator proposed for monitoring the increasing public health problems of overweight and obesity in childhood [18].

The interpretation of the commonly used anthropometric indicators is as follows:

Low weight-for-age: Weight-for-age reflects body mass relative to chronological age. It is influenced by both the child's height (height-for-age) and weight (weight-for-height). Its composite nature makes interpretation complex. For example, weight-for-age fails to distinguish between short children of adequate body weight and tall, thin children. However, in the absence of significant wasting in a community, similar information is provided by weight-for-age and height-for-age in that both reflect an individual's or population's long-term health and nutritional experiences. Short-term changes, especially reductions in weight-for-age, reveal changes in weight-for-height. In general terms, the worldwide variation of low weight-for-age and its age distribution are similar to those of low height-for-age [19].

Low height-for-age: Stunted growth reflects a process of failure to reach linear growth potential as a result of suboptimal health or nutritional conditions. On a population basis, high levels of stunting are associated with poor socioeconomic conditions (Fig. 5.1) and increased risk of frequent and early exposure to adverse conditions such as illness or inappropriate feeding practices. Similarly, a decrease in the national stunting rate is usually indicative of improvements in overall socioeconomic conditions of a country [20]. The worldwide variation of the prevalence of low height-for-age is considerable, ranging from 5% to 65% among the less-developed countries [21]. In many such settings, prevalence starts to rise at about 3 months of age; the process of stunting slows at around 3 years of age, after which mean heights run parallel to the current international reference [10]. Therefore, the age modifies the interpretation of findings: For children in the age group below 2–3 years, low height-for-age probably reflects a continuing process of "failing to grow" or "stunting"; for older children, it reflects a state of "having failed to grow" or "being stunted." From the point of view of interventions, it is important to differentiate between these two groups.

Low weight-for-height: Wasting or thinness indicates in most cases a recent and severe process of weight loss, which is often associated with acute starvation or severe disease. However, wasting also may be the result of chronic unfavorable conditions. Provided there is no severe food shortage, the prevalence of wasting is usually below 5%, even in poor countries [19]. The Indian subcontinent, where a higher prevalence of wasting is found, is an important exception. A prevalence between 10% and 14% is regarded as serious and above or equal to 15% as critical [1]. Typically, the prevalence of low weight-for-height reaches a peak in the second year of life [19]. Lack of evidence of wasting in a population does not imply the absence of current nutritional problems: Stunting and other deficits may be present [22]. Given these characteristics wasting or thinness demands a careful assessment whenever it is encountered.

High weight-for-height: *Overweight* is the preferred term for describing high weight-for-height [1]. Even though there is a strong correlation between high weight-for-height and obesity as measured by adiposity, greater lean body mass can also contribute to high weight-for-height. On an individual basis, therefore, “fatness” or “obesity” should not be used to describe high weight-for-height. However, on a population-wide basis, high weight-for-height can be considered as an adequate indicator of obesity because the majority of individuals with high weight-for-height are obese. Strictly speaking, the term *obesity* should be used only in the context of adiposity measurements, for example, skinfold thickness.

Other available anthropometric indicators that are used to describe growth status during childhood include mid-upper arm circumference (MUAC), body mass index (BMI), skinfolds, and head circumference; however, none of these has achieved such widespread use as the height- and weight-based indicators mentioned due, in part, to the lack of widely acceptable pediatric reference data for their interpretation. For some of these measurements, technical difficulties result in high intra- and interindividual variation and require skilled individuals to perform the measurements accurately and precisely. For skinfolds, the cost of equipment also has precluded their wide application in children. MUAC-for-age has been proposed as an alternative indicator for use where the collection of height and weight measurements is difficult (e.g., refugee crises); however, its proper application requires the use of age-specific reference data for its accurate interpretation [1]. Its use also requires the ascertainment of age, an important drawback under difficult field conditions.

5.2.3 The International Reference Population

The designation of a child as having impaired growth implies some means of comparison with a “reference” child of the same age and sex. Thus, in practical terms, anthropometric values need to be compared across individuals or populations in relation to an acceptable set of reference values. This need has made the choice of a growth reference population an important issue that has received considerable attention in the last decades.

The international reference growth curves, the so-called National Center for Health Statistics (NCHS)/WHO international reference population, were formulated in the 1970s by combining growth data from two distinct data sets. All samples consisted of healthy, well-nourished US children as the curves were originally planned to serve as a reference for the United States. A detailed account of the historical background of the NCHS/WHO growth charts can be found elsewhere [23].

WHO adopted the reference curves of the NCHS for international use in the late 1970s based on the then-growing evidence that the growth patterns of well-fed, healthy preschool children from diverse ethnic backgrounds are very similar [23]. The adoption by WHO of the NCHS-based growth curves resulted in their wide international dissemination. Throughout the 1980s, several microcomputer-based software versions of the NCHS/WHO international growth reference were developed and supported by the Centers for Disease Control and Prevention (CDC) and WHO. These software-based references have contributed to the wide acceptance of the concept of the international growth reference because they simplified the handling of anthropometric data from surveys, surveillance, and clinical studies.

Although the NCHS/WHO international growth curves have served many useful purposes throughout these years, because of a number of serious drawbacks, the suitability of these curves for international purposes was challenged in the mid-1990s [1, 24]. Work conducted by WHO demonstrated that the NCHS/WHO international reference is sufficiently flawed that it interferes with the sound health and nutritional management of infants and young children. These flaws arise from both technical and biological considerations. In particular, the current international reference may lead to the early introduction of complementary foods in exclusively breast-fed infants, which often has adverse consequences for the health and nutritional well-being of infants [25, 26]. As a result, WHO began planning in 1994 for new references that reflect how children *should* grow in all countries rather than merely describing how they grew at a particular time and place [27, 28].

The WHO Multicentre Growth Reference Study (MGRS) (1997–2003) collected primary growth data and related information from 8,440 affluent children from widely differing ethnic backgrounds and cultural settings (Brazil, Ghana, India, Norway, Oman, and United States) [29]. The MGRS combined a longitudinal study from birth to 24 months with a cross-sectional study of children aged 18 to 71 months. In the longitudinal study, mothers and newborns were screened and enrolled at birth and visited at home a total of 21 times on weeks 1, 2, 4, and 6; monthly from 2 to 12 months; and bimonthly in the second year. Data were collected on anthropometry; motor development; feeding practices; child morbidity; perinatal factors; and socioeconomic, demographic, and environmental characteristics [29]. The new WHO growth curves based on these data represent the best description of physiological growth and establish the breast-fed infant as the biological norm for growth and development.

5.2.4 Issues in the Interpretation of Growth Data

One essential consideration is the appropriate use of the reference data. The way in which a reference is interpreted and the clinical and public health decisions that will be based on it are as important as the choice of the reference. The reference should be used as a general guide for screening and monitoring and not as a fixed standard that can be applied in a rigid fashion to individuals from different ethnic, socioeconomic, and nutritional and health backgrounds. For clinical or individual-based application, reference values should be used as a screening tool to detect individuals at greater risk of health or nutritional disorders, and they should not be viewed as a self-sufficient diagnostic tool.

For population-based application, the reference values should be used for comparison and monitoring purposes. In a given population, a high prevalence of anthropometric deficit will be indicative of significant health and nutritional problems. However, it is not only those individuals below the cutoff point who are at risk; the entire population is at risk, and the cutoff point should be used only to facilitate the application of the indicator [30].

There are three different systems by which a child or a group of children can be compared to the reference population: Z-scores (standard deviation [SD] scores), percentiles, and percent of median. For population-based assessment (including surveys and nutritional surveillance), the Z-score is widely recognized as the best system for analysis and presentation of anthropometric data because of its advantages compared to the other methods [1]. At the individual level, however, although there is substantial recognition that the Z-score is the most appropriate descriptor of malnutrition, health and nutrition centers (e.g., supplementary feeding programmes in refugee camps) have been in practice reluctant to adopt its use for individual assessment. A detailed description of the three systems, including a discussion of their strengths and weaknesses, can be found elsewhere [31].

In clinical applications, children are commonly classified using a cutoff value, often ≤ 2 and ≥ 2 Z-scores. The rationale for this is the statistical definition of the central 95% of a distribution as the "normal" range, which is not necessarily based on the optimal point for predicting functional outcomes. A better approach to classifying individual children would be to base the cutoffs on the relationship between growth deficits and health outcomes, such as mortality, morbidity, and child development [30]. The difficulty of this approach is that these relationships differ according to the prevalence of health and nutritional disorders, and thus it would be more advisable to develop practical methods for identifying local cutoffs that take account of local circumstances.

For population-based applications, a major advantage of the Z-score system is that a group of Z-scores can be subjected to summary statistics such as the mean and SD. The mean Z-score, although less commonly used, has the advantage of describing the nutritional status of the entire population directly without resorting to a subset of individuals below a set cutoff. A mean Z-score significantly lower than zero (the expected value for the reference distribution) usually means that the entire distribution has shifted downward, suggesting that most, if not all, individuals have been affected. Using the mean Z-score as an index of severity for health and nutrition problems results in increased awareness that, if a condition is severe, an intervention is required for the entire community, not just those who are classified as "malnourished" by the cutoff criteria [30, 32]. In addition, the observed SD value of the Z-score distribution is very useful for assessing data quality [1].

Last, experience with population surveillance has contributed to emphasizing the usefulness of identifying prevalence ranges to assess the severity of a situation as the basis for making public health decisions. For example, when 10% of a population is below the −2 SD cutoff for weight-for-height, is that too much, too little, or average? The intention of the so-called trigger levels is to assist in answering this question by giving some kind of guideline for the purpose of establishing levels of public health importance of a situation. Such classifications are very helpful for summarizing prevalence data and can be used for targeting purposes when establishing intervention priorities. It is

Table 5.1
Classification for assessing severity of growth deficits by prevalence ranges among children under 5 years of age

	Severity of growth deficits by prevalence ranges (%)			
Indicator	*Low*	*Medium*	*High*	*Very high*
Stunting	<20	20–29	30–39	≥40
Underweight	<10	10–19	20–29	≥30
Wasting	<5	5–9	10–14	≥15

Source: Adapted with permission from [1].

important to note that the trigger levels vary according to the different anthropometric indicators. The prevalence ranges shown in Table 5.1 are those currently recommended [1] to classify levels of stunting, underweight, and wasting.

5.3. PREVALENCE OF GROWTH RETARDATION IN DEVELOPING COUNTRIES

An analysis using data from the WHO Global Database on Low Birth Weight quantified the magnitude of IUGR in different countries and regions of the world [12]. As summarized in Table 5.2, it is estimated that about 13.7 million babies in developing countries are already malnourished at birth, representing 11% (ranging from 1.9% to 20.9%) of all newborns in these countries. This rate is considerably higher than that estimated for developed countries (approximately 2%). Overall, the incidence of IUGR-LBW is about six times higher in developing than in developed countries [33]. The estimates of IUGR-LBW, however, greatly underestimate the magnitude of fetal growth retardation; the actual incidence of IUGR could be considerably higher. For example, if the rates of infants below the tenth percentile of the birth-weight-for-gestational-age reference curve are considered, 23.8% or approximately 30 million newborns per year would be affected (Table 5.2). There are nevertheless some healthy infants with birth weights below the tenth percentile, who represent the lower tail of a fetal growth distribution. However, in most developing countries a large proportion of newborns suffers from some degree of IUGR, as illustrated by the overall downward shift of the birth weight distribution. Unfortunately, a methodology to disentangle these two groups is not available. The risk of being born malnourished is highest in Asia, followed by Africa. Taking into consideration the number of total live births in each geographical region, nearly 75% of all affected newborns are born in Asia (mainly South-central Asia), 20% in Africa, and about 5% in Latin America [12].

Although there are constraints to deriving these estimates, mainly related to the qualitative and quantitative limitations of the available data, they still represent a valid approximation for descriptive and epidemiological purposes. These estimates confirm that IUGR is a major public health problem worldwide. In many countries, the high rates of impaired fetal growth exceed the recommended levels for triggering public health action [12]. A prevalence of IUGR in excess of 20% has been recommended as the cutoff point; in the absence of information on gestational age, a prevalence above 15% of LBW may be used as a proxy cutoff [1]. Population-wide interventions aimed at preventing fetal growth retardation are urgently needed in these high-prevalence countries.

Table 5.2
Summary estimates of impaired fetal growth in developing countries

Indicator	*Source*	*Rate (%)*	*Total number newborns affected per year*[a] *(in millions)*
IUGR-LBW (<2,500 g; ≥ 37- week gestation)	Live births weighted average using LBW rates from WHO databank and regression model WHO databank and regression model	11.0 (1.9–20.9)[b]	13.699
LBW (<2,500 g; all gestational ages)	Live births weighted average using LBW rates from WHO databank	16.4 (5.8–28.3)	20.423
IUGR (<tenth percentile; all gestational ages)	From WHO Collaborative Study on Maternal Anthropometry and Pregnancy Outcomes	23.8 (9.4–54.2)	29.639

Source: Adapted with permission from [12].

IUGR intrauterine growth restriction, *LBW* low birth weight, *WHO* World Health Organization

[a] Total live births are based on the United Nations World Population Prospects.

[b] Range.

The WHO Global Database on Child Growth and Malnutrition [19] compiles data on height-for-age, weight-for-age, and weight-for-height of preschool children worldwide to monitor global progress in combating childhood malnutrition. The rigorous methodology and large coverage of the Global Database permits an accurate description of the magnitude and geographical distribution of child growth retardation in developing countries. At present, the Global Database covers over 95% of the total population of those under 5 years old (about 510 million children) living in developing countries or 84% of this age group worldwide. Based on this vast amount of data, Fig. 5.2 displays the geographical distribution of countries according to their prevalence of underweight [34]. Prevalences have been grouped according to the recommended trigger levels of public health importance (Table 5.1). The disaggregation by sex shows no consistent differences between male and female; however, prevalence rates are consistently higher in rural than in urban areas and can vary considerably by age and region within countries. Detailed information on national surveys concerning data disaggregated by age, sex, urban/rural residence, and region can be found in the Web site of the Global Database (www.who.int/nutgrowthdb).

Tables 5.3 and 5.4 present regional and global trends (1990–2005) for the prevalence and number of stunted and underweight children under 5 years old, respectively [35]. There was global progress in the reduction of child malnutrition during the 1990s, with stunting and underweight prevalence declining from 34% to 27% and 27% to 22%, respectively (Tables 5.3 and 5.4). The largest decline was achieved in eastern Asia, where stunting and underweight levels decreased by one half between 1990 and 2000.

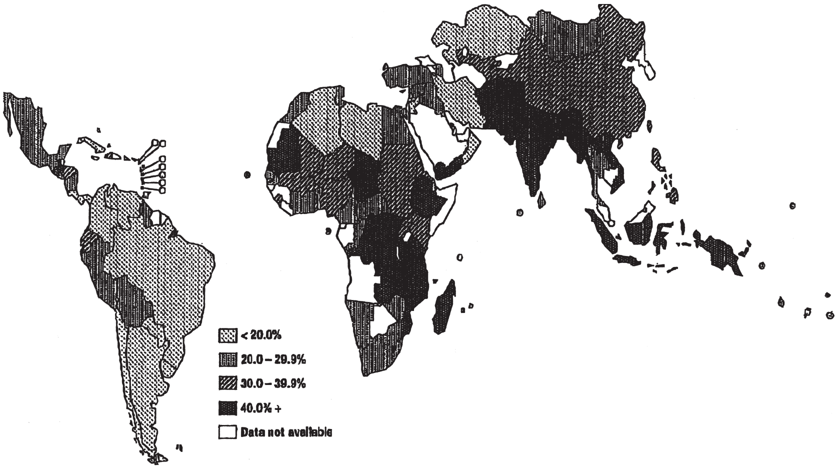

Fig. 5.2. 1 Percent with weight 2 standard deviations below the mean weight-for-age reference population.

Southeastern Asia also experienced substantial improvements, with stunting rates declining from 42% to 32% and underweight from 35% to 27%. South-central Asia continued to suffer from staggeringly high levels of child malnutrition, but rates were showing significant declines in stunting, from 51% to 40% and underweight from 50% to 41% during this period. Substantial improvements were also made in Latin America and the Caribbean, where a relative decrease of 25% in stunting (from 18% to 14%) and one third in underweight (from 9% to 6 %) occurred over the last 10 years of the time period. In Africa, however, there was little or no change in the last decade, and 35% and 24% of all those under 5 remained stunted and underweight, respectively. The actual number of malnourished children in Africa increased between 1990 and 2000, from 40 million to 45 million stunted and 25 million to 31 million underweight. The lack of progress observed in Africa was likely to be partly due to the effect of the HIV/AIDS epidemic. The disease has both direct and indirect effects: Infected children are more likely to be underweight, but also AIDS orphans or children of parents affected by AIDS are at increased risk of becoming malnourished. In sub-Saharan Africa, an estimated 333,000 children below 5 years of age died in 1999 with HIV infection [36], and 11 million were estimated to be orphaned because of AIDS [37]. The predictions of stunting and underweight made for 2005 might have been underestimates if the HIV/AIDS epidemic worsened in Africa or other regions.

An analysis forecasted trends of underweight to identify geographical regions unlikely to achieve the Millennium Development Goal of a 50% decrease in the 1990 prevalence by 2015 [34]. The authors concluded that an overall improvement in the global situation is anticipated; however, neither the world as a whole nor the developing regions are expected to achieve the goal. This is largely due to the deteriorating situation in Africa, where all subregions except northern Africa are expected to fail to meet the goal (Fig. 5.3).

The overall reduction in the prevalence of underweight is consistent with the increasing rates in childhood overweight observed in many developing countries. A global analysis in 1995 showed a rising trend in childhood overweight in 16 of 38 developing countries with more than one national survey [38]. Figure 5.4 presents trends in selected

Table 5.3

Estimated prevalence and numbers of stunted preschool children 1990–2005 with 95% confidence intervals by United Nations (UN) regions and subregions

	Stunting (%)				*Numbers of stunted (in millions)*			
UN regions and subregions	*1990*	*1995*	*2000*	*2005*	*1990*	*1995*	*2000*	*2005*
Africa	36.9	36.1	35.2	34.5	39.6	41.9	45.1	48.5
	33.3–40.5	33.0–39.1	32.5–38.0	31.7–37.4	35.7–43.5	38.4–45.5	41.6–48.7	44.5–52.6
Eastern	44.4	44.4	44.4	44.4	15.8	17.3	19.4	21.6
	36.6–52.4	37.3–51.8	37.6–51.4	37.6–51.4	13.0–18.7	14.5–20.2	16.5–22.5	18.3–25.0
Middle	42.2	40.0	37.8	35.8	5.6	6.3	6.8	7.4
	34.2–50.5	34.0–46.2	33.7–42.1	33.0–38.6	4.5–6.7	5.4–7.3	6.0–7.6	6.9–8.0
Northern	27.4	24.4	21.7	19.1	5.8	5.1	4.6	4.2
	21.1–34.7	18.7–31.2	16.1–28.6	13.5–26.5	4.5–7.4	3.9–6.5	3.4–6.1	2.9–5.8
Southern	25.4	25.0	24.6	24.3	1.5	1.4	1.5	1.4
	23.7–27.1	22.6–27.6	21.5–28.1	20.4–28.6	1.4–1.6	1.3–1.6	1.3–1.7	1.2–1.7
Western	34.7	33.8	32.9	32.0	10.9	11.8	12.7	13.9
	28.7–41.2	29.9–37.9	30.2–35.7	28.4–35.7	9.0–13.0	10.4–13.2	11.7–13.8	12.4–15.5
Asia	41.1	35.4	30.1	25.7	154.6	130.8	109.4	92.4
	38.6–43.6	32.6–38.2	27.1–33.1	22.5–28.9	145.1–164.1	120.5–141.0	98.6–120.2	80.9–103.8
Eastern	30.0	21.5	14.8	10.0	37.5	23.5	15.2	9.5
	28.7–31.3	20.4–22.6	13.9–15.8	9.3–10.7	35.9–39.1	22.3–24.7	14.3–16.1	8.8–10.2
South-central	50.8	45.2	39.7	34.5	88.0	81.0	71.5	63.5
	46.1–55.4	40.2–50.3	34.4–45.3	29.0–40.5	79.9–96.0	72.0–90.2	62.0–81.6	53.3–74.4
Southeastern	41.8	36.8	32.1	27.7	23.9	21.3	18.1	15.3
	33.6–50.4	29.3–44.9	25.2–39.7	21.3–35.1	19.2–28.8	17.0–26.0	14.3–22.5	11.8–19.4
Western	25.0	21.7	18.7	16.1	5.2	5.0	4.5	4.1
	20.2–30.4	15.1–30.1	10.9–30.1	7.8–30.3	4.2–6.3	3.5–6.9	2.7–7.3	2.0–7.8
Latin America and Caribbean	18.3	15.9	13.7	11.8	10.0	8.8	7.6	6.5
	13.6–23.0	11.3–20.5	9.1–18.4	7.0–16.5	7.4–12.6	6.2–11.3	5.0–10.2	3.9–9.2

Caribbean	12.4	9.6	7.4	5.7	0.5	0.4	0.3	0.2
	6.8–21.5	5.1–17.3	3.8–14.1	2.7–11.5	0.3–0.9	0.2–0.7	0.1–0.5	0.1–0.4
Central America	25.9	23.0	20.4	18.0	4.0	3.7	3.3	2.9
	16.3–38.4	14.4–34.8	12.5–31.5	10.8–28.4	2.5–5.9	2.3–5.6	2.0–5.1	1.8–4.6
South America	15.7	13.3	11.3	9.6	5.5	4.7	4.0	3.4
	10.8–22.2	8.6–20.0	6.5–18.9	4.9–18.2	3.8–7.8	3.0–7.1	2.3–6.7	1.7–6.5
Oceania	n/a	n/a	29.3	n/a	n/a	n/a	0.32	n/a
			7.9–66.7				0.09–0.72	
All developing countries	37.9	33.5	29.6	26.5	204.3	181.5	162.1	147.5
	35.9–39.8	31.4–35.6	27.5–31.7	24.2–28.7	193.7–214.9	170.4–192.7	150.4–173.8	135.0–159.9
Developed countries	2.8	2.8	2.7	2.6	2.2	2.0	1.8	1.6
	0.8–9.1	0.8–8.9	0.8–8.7	0.8–8.4	0.7–7.1	0.6–6.4	0.5–5.7	0.5–5.2
Global	33.5	29.9	26.7	24.1	206.5	183.5	163.9	149.1
	29.5–44.9	23.0–40.0	17.4–35.5	12.9–31.4	195.7–217.2	172.2–194.8	152.1–175.7	136.6–161.6

Source: Adapted with permission from [35].
n/a not available due to insufficient data

Table 5.4

Estimated prevalence and numbers of underweight preschool children 1990–2005 with 95% confidence intervals by United Nation (UN) regions and subregions

UN regions and subregions	*Underweight (%)*				*Numbers of underweight (in millions)*			
	1990	*1995*	*2000*	*2005*	*1990*	*1995*	*2000*	*2005*
Africa	23.6	23.9	24.2	24.5	25.3	27.8	30.9	34.5
	21.0–26.2	21.5–26.3	21.9–26.4	22.1–26.8	22.6–28.1	25.0–30.6	28.0–33.8	31.1–37.8
Eastern	26.7	27.9	29.2	30.6	9.5	10.9	12.8	14.8
	22.0–32.0	23.3–33.0	24.6–34.3	25.7–35.8	7.8–11.4	9.1–12.9	10.8–15.0	12.5–17.4
Middle	27.8	26.9	26.1	25.3	3.7	4.2	4.7	5.3
	19.8–37.5	21.0–33.8	21.8–30.8	21.6–29.3	2.6–5.0	3.3–5.3	3.9–5.5	4.5–6.1
Northern	12.3	10.9	9.7	8.6	2.6	2.3	2.1	1.9
	7.4–19.6	5.9–19.4	4.6–19.4	3.6–19.5	1.6–4.1	1.2–4.1	1.0–4.2	0.8–4.3
Southern	14.0	13.9	13.7	13.6	0.8	0.8	0.8	0.8
	9.9–19.5	9.8–19.2	9.7–19.0	9.6–18.8	0.6–1.1	0.6–1.1	0.6–1.2	0.6–1.1
Western	27.8	27.5	27.1	26.8	8.8	9.6	10.5	11.7
	23.6–32.4	24.2–31.0	24.2–30.3	23.6–30.3	7.4–10.2	8.4–10.8	9.4–11.7	10.3–13.2
Asia	35.1	31.5	27.9	24.8	131.9	116.3	101.2	89.2
	31.7–38.5	27.8–35.1	24.0–31.7	20.8–28.8	119.2–144.7	102.7–129.8	87.3–115.0	74.9–103.5
Eastern	18.5	13.2	9.3	6.5	23.1	14.5	9.5	6.1
	17.6–19.4	12.5–13.9	8.8–9.9	6.1–6.9	22.0–24.2	13.7–15.3	9.0–10.1	5.7–6.5
South-central	49.6	45.2	40.8	36.5	86.0	80.9	73.4	67.1
	42.4–56.8	37.9–52.6	33.5–48.5	29.3–44.4	73.5–98.5	67.9–94.3	60.3–87.3	53.9–81.5
Southeastern	35.2	31.2	27.4	23.9	20.2	18.1	15.5	13.2
	30.8–40.0	27.1–35.6	23.4–31.8	19.9–28.5	17.6–22.9	15.7–20.7	13.2–18.0	11.0–15.7
Western	12.9	12.1	11.3	10.6	2.7	2.8	2.8	2.7
	9.9–16.7	7.3–19.4	5.0–23.7	3.3–28.9	2.1–3.5	1.7–4.5	1.2–5.8	0.9–7.5
Latin America and Caribbean	8.7	7.3	6.1	5.0	4.8	4.0	3.4	2.8
	6.1–11.3	5.0–9.6	4.0–8.1	3.2–6.8	3.4–6.2	2.8–5.3	2.2–4.5	1.8–3.8

Caribbean	10.0	7.8	6.1	4.7	0.4	0.3	0.2	0.2
	5.9–16.4	4.5–13.3	3.3–10.8	2.5–8.7	0.2–0.7	0.2–0.5	0.1–0.4	0.1–0.3
Central America	12.4	10.7	9.2	7.9	1.9	1.7	1.5	1.3
	7.5–19.9	6.3–17.6	5.2–15.7	4.3–14.0	1.2–3.1	1.0–2.8	0.9–2.6	0.7–2.3
South America	7.0	5.7	4.6	3.7	2.5	2.0	1.6	1.3
	4.5–10.8	3.6–8.9	2.9–7.4	2.3–6.1	1.6–3.8	1.3–3.1	1.0–2.6	0.8–2.2
Oceania	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
All developing countries	30.1	27.3	24.8	22.7	162.2	148.2	135.5	126.5
	27.6–32.5	24.8–29.9	22.2–27.3	20.1–25.4	149.1–175.3	134.4–162.0	121.3–149.7	111.8–141.2
Developed countries	1.6	1.4	1.3	1.1	1.2	1.0	0.8	0.7
	0.8–3.0	0.6–3.2	0.5–3.5	0.3–3.7	0.6–2.4	0.4–2.3	0.3–2.3	0.2–2.3
Global	26.5	24.3	22.2	20.6	163.4	149.2	136.4	127.2
	24.3–28.6	22.1–26.6	19.9–24.5	18.2–22.9	150.3–176.6	135.3–163.1	122.2–150.6	112.5–141.9

Source: Adapted with permission from [35].

n/a not available due to insufficient data

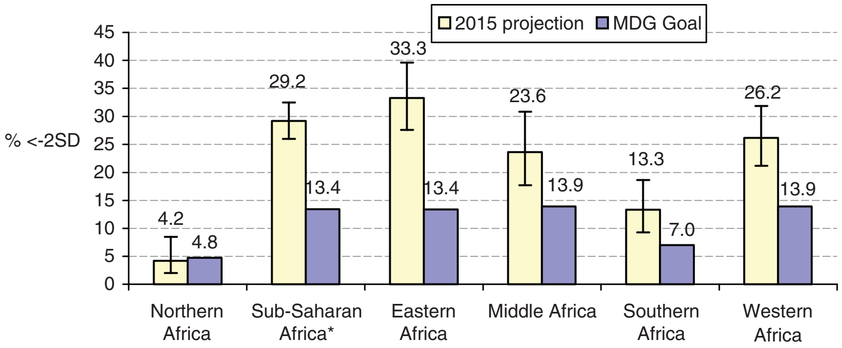

Fig. 5.3. Projections of underweight with 95% confidence intervals in African subregions in 2015 compared to Millennium Development Goal (MDG).

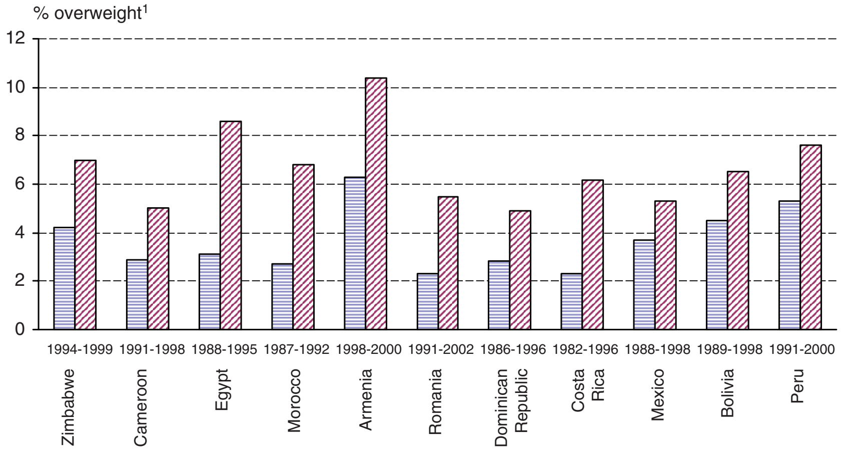

Fig. 5.4. Trends of child overweight in selected developing countries.[1]*Overweight* is defined as weight for height above two standard deviations of the National Center for Health Statistics/World Health Organization reference median value. (Adapted with permission from [39].)

developing countries based on national surveys included in the WHO Global Database on Child Growth and Malnutrition [39]. The comparison of both ends of the weight-for-height distribution suggest a population-wide shift, with overweight replacing wasting as countries undergo the nutrition transition [38]. Because of this transition, indicators of malnutrition based on weight will be more complex to interpret, and stunting will increasingly provide a more accurate indication of undernutrition than will underweight.

5.4 HEALTH AND SOCIAL CONSEQUENCES OF IMPAIRED GROWTH

The health and social consequences of the current high prevalences of fetal and child growth retardation in developing countries are severe. Fetuses suffering from growth retardation have higher perinatal morbidity and mortality [14, 40, 41], are at an increased risk of sudden infant death syndrome [42], and have higher infant mortality and childhood morbidity [43]. During childhood, they are more likely to have poor cognitive development [44, 45] and neurologic impairment [46–48]; in adulthood, they are at increased risk of cardiovascular disease [49], high blood pressure [50], obstructive lung disease [51], diabetes [52], high cholesterol concentrations [53], and renal damage [54]. Newborns with IUGR have lower levels of insulin-like growth factor 1 and higher growth hormone levels [55], indicating an endocrine process that could be related to these long-term impairments.

The major outcomes of poor growth during childhood can be classified in terms of mortality, morbidity (incidence and severity), and psychological and intellectual development. There are also important consequences in adult life in terms of body size, work and reproductive performances, and risk of chronic diseases.

A number of studies have demonstrated the association between increasing severity of anthropometric deficits and mortality [30]. It is now recognized that growth retardation has a far more powerful impact on child mortality than has been traditionally recognized, which in turn has important implications for policy and programs addressing child survival [56]. An analysis documented that the risk of mortality because of low weight-for-age was elevated for each cause of death and for all-cause mortality [57]. Overall, 52.5% of all deaths in young children were attributable to undernutrition, varying from 44.8% for deaths because of measles to 60.7% for deaths due to diarrhea [57]. The majority of deaths were caused by the potentiating effect of mild-to-moderate low weight-for-age as opposed to severe low weight-for-age. Thus, strategies that focus only on severely malnourished children will be insufficient to improve child survival in a meaningful way. The most significant impact can be expected when all grades of severity are targeted. Similarly, children suffering from impaired growth tend to have more severe diarrhoeal episodes and are more susceptible to several infectious diseases frequently seen in developing countries, such as malaria or meningitis [58, 59] (Fig. 5.5). The risk of pneumonia is also increased in these children [60].

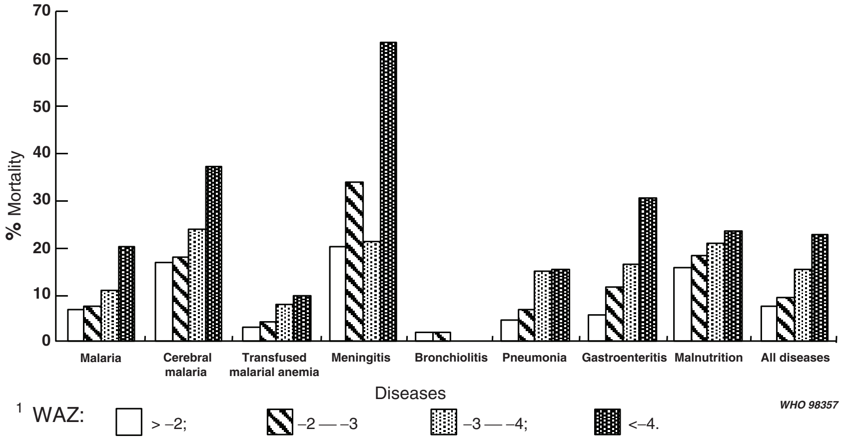

Fig. 5.5. Mortality of malaria, cerebral malaria, transfused malaria anemia, meningitis, bronchiolitis, pneumonia, gastroenteritis, malnutrition, and all diseases combined by weight for age (WAZ) expressed as z-score on admission.[1] (Adapted with permission from [59].)

There is strong evidence that poor growth is associated with impaired development [3, 5], and a number of studies have demonstrated a relationship between growth status and school performance and intellectual achievement [4]. Child stunting leads to significant reduction in adult size [4]; one of the main consequences of small adult size resulting from stunting during childhood is reduced work capacity [61], which in turn has an impact on economic productivity. For women, maternal size is associated with specific reproductive outcomes. Data from the Guatemalan Longitudinal Study [4] showed how the percentage of women with short stature varies strikingly according to the degree of stunting at 3 years of age. As shown in Fig. 5.6, 65% of the girls severely stunted at age of 3 had short stature when they became adults. Short women are at a greater risk for obstetric complications because of smaller pelvic size [1]. There is also a strong association between maternal height and birth weight [62]. This results in an intergenerational effect since LBW babies are themselves likely to have anthropometric deficits at later ages [63, 64]. These LBW babies, born to stunted mothers, contribute to closing the intergenerational cycle by which low maternal size and anemia predispose to LBW babies, which in turn predisposes to growth failure of children, leading back to small adults (Fig. 5.7). Also, the occurrence of early pregnancy will contribute both in terms of LBW and inducing premature cessation of growth in the mother. The implications of this vicious cycle are enormous for the human and socioeconomic development of the affected populations.

In summary, the magnitude of the problem and the severity of the health and social consequences associated with impaired growth cannot be overemphasized. Child growth is a major determinant of human development. There is thus an urgent need to develop or identify effective community-based interventions for improving child growth and development. Population-wide interventions aimed at preventing IUGR are also urgently

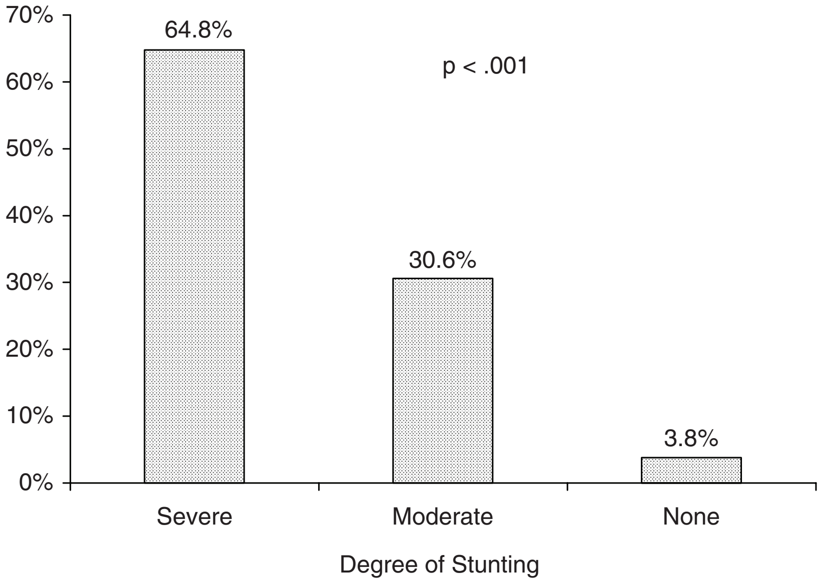

Fig. 5.6. Prevalence of short stature (<149 cm) in Guatemalan women (≥18 years) by degree of stunting at 3 years of age. (Adapted with permission from [4].)

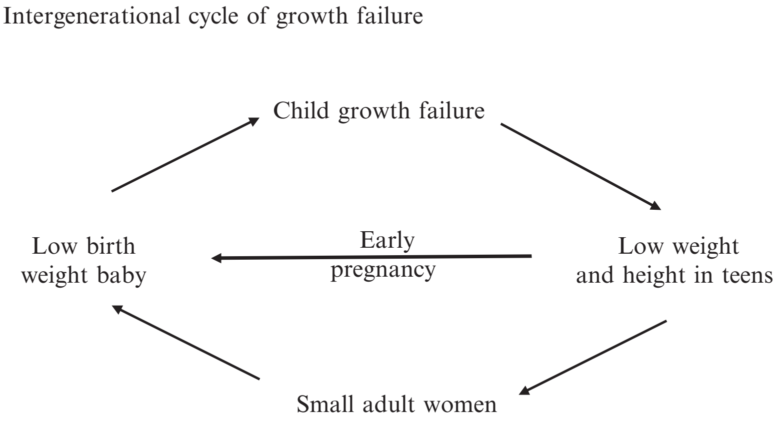

Fig. 5.7. Intergenerational cycle of growth failure.

required given the strong association between pre- and postnatal growth and the magnitude of fetal growth retardation in developing countries.

5.5 INTERVENTIONS AIMED AT PROMOTING HEALTHY GROWTH AND DEVELOPMENT

A comprehensive review of the evidence from 126 randomized controlled trials (RCTs) evaluating 36 prenatal interventions aimed at preventing or treating impaired fetal growth was carried out by Gülmezoglu et al. [65]. The same authors provided an in-depth analysis of nutritional interventions evaluated in RCTs [66]. RCTs are widely recognized as the most objective and rigorous available method to evaluate the effectiveness of health care interventions. Systematic reviews of RCTs provide an excellent tool for summarizing the results of interventions. By following a rigorous methodology, they reduce bias, improve reliability and accuracy of conclusions, and can establish if trial results are consistent and generalizable across populations, settings, and treatment variations. The strategies evaluated by Gülmezoglu et al. [65] included care and advice during pregnancy (e.g., social support for women at risk, strategies to stop smoking, nutritional advice); nutrition supplementation (e.g., protein-energy, vitamin and minerals, antianemic supplements, fish oil supplementation); and prevention/treatment of hypertensive disorders, fetal compromise, and infections.

Based on this review, only 2 of 24 nonnutritional interventions (i.e., strategies to reduce maternal smoking and antimalarial chemoprophylaxis in primigravidae) provided evidence they were beneficial (Table 5.5). Strategies to reduce smoking during pregnancy were associated with increased birth weight and lower rate of term LBW (typical odds ratio 0.80; 95% confidence interval [CI] 0.65–0.98). These effects have been greater in more compliant groups, and those groups who were more successful in stopping smoking showed the highest mean birth weight gains. The systematic review of the use of antimalarial drug chemoprophylaxis showed that malaria chemoprophylaxis was associated with higher maternal hemoglobin levels and birth weights. These effects were more prominent in primigravidae, who are known to be more susceptible.

Only 1 of the 12 nutritional interventions (i.e., balanced protein-energy supplementation) showed a reduction in the incidence of IUGR [65, 66]. Supplementation was

Table 5.5

Forms of care likely to be beneficial and forms of care of unknown effectiveness that merit further research for the prevention or treatment of impaired fetal growth

Intervention	*IFG outcome*	*Effect*[a]	*Comments*
Forms of care likely to be beneficial			
Smoking cessation	Term LBW	0.80 (0.65–0.98)	Effect stronger in more compliant women; intervention in agreement with overall health advise
Antimalarials—primigravidae	MBW	112 g (41–183 g)[b]	Four trials of small sample size
Balanced protein-energy supplementation	SGA	0.76 (0.58–1.01)	Borderline significance but does not include the new positive Gambia trial; lack of effective method to select women who will benefit the most
Forms of care of unknown effectiveness that merit further research			
Routine zinc	Term LBW	0.77 (0.54–1.11)	Only the most recent trial showed positive effect
Routine folate	Term LBW	0.60 (0.37–0.97)	Populations poorly defined and limitations in randomization procedures
Routine magnesium	Term LBW	0.59 (0.37–0.93)	Trials have high numbers of exclusions and limitations in the randomization procedures
Abdominal decompression (for suspected IFG)	Term LBW	0.21 (0.13–0.34)	Possibility of selection, observer, and analysis bias in the two RCTs; safety unknown; the large effect observed makes further exploration of this technique worthwhile

Source: Adapted with permission from [65].

[a] Typical odds ratios (ORs) and 95 % confidence intervals (an OR < 1 indicates that the intervention resulted in favourable outcomes).

[b] Weighted mean difference between intervention and control groups.

IFG impaired fetal growth, *LBW* low birth weight, *MBW* mean birth weight, *RCT* randomized controlled trial, *SGA* small for gestational age

associated with increases in maternal weight gain and mean birth weight and a decrease of borderline statistical significance in the number of IUGR babies (Table 5.5). A community-based trial in rural Gambia, not included in the calculations of the typical odds ratio in Table 5.4, showed that supplementation significantly increased birth weight by 136 g [67]. The odds ratio for LBW babies in supplemented women was 0.61 (95% CI 0.47–0.79), supporting the results of the systematic review [66].

Overall, it is surprising how limited data are supporting the effectiveness of nutritional interventions during pregnancy, some of which are of widespread use even in women without nutritional deficiencies. However, it is obvious that women manifesting nutritional deficits can only benefit from reversing such a situation. On this basis, efforts to improve women's nutrition should be a priority, especially in developing countries, although the expected effect of maternal nutrition supplementation on birth weight may be modest (about 100 g). Similarly, the average effect associated with some interventions suggests a potential effect of considerable magnitude (Table 5.5). Zinc, folate, and magnesium supplementation should be rigorously evaluated. Trials to evaluate these and other promising interventions should target populations at risk for IUGR, should be based on sound epidemiological or basic science background information, and should follow rigorous methods, including adequate sample sizes to detect any impact on substantial outcomes [65, 66]. In countries where multiple pathologies coexist, it may be difficult to achieve beneficial results by testing a single intervention. Malaria and other parasites, malnutrition, and anemia coexist in many developing countries, and the presence of such a combination of conditions is probably worse than each one of them alone. Appropriate combinations of interventions (e.g., a combination of antianemic [iron-folate] and antimicrobial/antiparasite agents tested in population-based trials) should be rigorously evaluated since it is very unlikely that the intergenerational and intragenerational effect of deprivation and poverty on maternal and fetal health can be overcome by a single intervention or treatment. Simple solutions will not resolve the problem of fetal malnutrition and its associated outcomes [68].

The World Health Organization recently conducted a comprehensive review evaluating the effectiveness of interventions aimed at improving physical growth or psychological development during childhood [69]. The review concluded the following:

Nutrition interventions significantly improve physical growth in poor and malnourished populations. Balanced protein-energy supplementation during pregnancy improve birth weight and reduce the incidence of IUGR. Food supplementation for infants and young children has documented impacts on physical growth. Other types of effective nutrition interventions include caregiver education about feeding practices for young children, breast-feeding promotion, and zinc supplementation in zinc-deficient areas. Programmes that include education, food supplementation, or micronutrient supplementation can result in reductions in the prevalence of moderate and severe growth retardation.

Nutrition interventions significantly improve psychological development in disadvantaged populations. Increased intake of nutrients and energy during the first 2 years of life, and prenatally through supplements to mothers, have significant positive impacts on cognitive and motor development. For example, interventions to prevent iodine deficiency have dramatic effects on cognitive development as well as preventing the physical stunting that accompanies iodine deficiency.

Psychosocial interventions significantly improve psychological development. For example, children attending preschool center-based programmes gain an average of about 8 IQ points by the time they are ready to start school. They are also less likely to repeat primary school grades or be placed in special education classes.

Combined interventions to improve both physical growth and psychological development have even greater impact in disadvantaged populations at risk of malnutrition. The combination of supplementation and stimulation interventions appears to have a greater effect on cognitive development than either alone. These combined nutrition and psychological interventions had significant impacts on both growth and development in every study that tested this relationship.

There are a number of conditions under which the impact on growth and development is most likely to be seen. Interventions during the earliest periods of life (i.e., prenatally and during infancy and early childhood) are likely to have the greatest impact. The children at higher risk are generally the ones who show the greatest response to growth and development interventions. Growth and development programmes that utilize several types of interventions and more than one delivery channel are more efficacious than those that are more restricted in scope. Types of interventions include nutrition education on diet and feeding practices, providing supplementary food or micronutrient supplements, and demonstrating cognitive stimulation activities or other activities to improve parenting skills. Types of delivery channels are home visits, group counselling, child care centers, and mass media. Program efficacy and effectiveness appear to be greater when parents are more involved.

When discussing combined interventions, a number of challenges arise. Many potential models for combined interventions to promote physical growth and psychological development of infants and young children have not yet been implemented. Others have been implemented but not systematically evaluated, which is essential. There is a need to develop and evaluate a model of combined interventions that could reach a large proportion of children who are at risk of growth and development faltering. An example could be a culturally adaptable counselling package that combines nutrition counselling on complementary feeding (with food supplementation if necessary) with counselling on psychosocial care (e.g., warmth, attentive listening, proactive stimulation, and support for exploration and autonomy). There is also an urgent need to evaluate the effectiveness of different content, programme venues, and delivery channels.

Poor growth is part of a vicious cycle that includes poverty and disease. These three factors are interlinked in such a way that each contributes to the presence and permanence of the others. Given the complexity of the underlying causes of the problem, new efforts must also be made to understand the specific economic, behavioural, dietary, and other factors affecting child growth and development. A good technical package has proved to be insufficient by itself; a distinguishing feature of successful programmes has been community involvement in identifying the problems and mobilizing action to resolve them. Future interventions should thus be strongly community based. Special effort should be made to improve the situation of women as primary child caregivers, with particular attention to their health and nutrition throughout the life cycle. Similarly, a focus on complementary feeding combined with continued attention to the protection and promotion of breast-feeding remain key for tackling the problem.

5.6 CONCLUSIONS

The future of human societies relies on the ability of children to achieve their optimal physical growth and mental development. Never before has there been so much knowledge to assist families and societies in their desire to raise children to reach their full potential. A fundamental need is to focus the attention of policymakers on nutritional status as one of the main indicators of development and as a precondition for the socioeconomic advancement of societies in any significant long-term sense. A good start in life will pay off, in terms of both human capital and economic development.

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