SHOULD ADOLESCENTS BE SPECIFICALLY TARGETED FOR NUTRITION IN DEVELOPING COUNTRIES? TO ADDRESS WHICH PROBLEMS, AND HOW?

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ABSTRACT

Concern for nutrition in adolescence has been rather limited, except in relation to pregnancy. This paper reviews adolescent-specific nutritional problems, and discusses priority issues for the health sector, particularly in developing countries. Chronic malnutrition in earlier years is responsible for widespread stunting and adverse consequences at adolescence in many areas, but it is best prevented in childhood. Iron deficiency and anaemia are the main problem of adolescents world-wide; other micronutrient deficiencies may also affect adolescent girls. Improving their nutrition before they enter pregnancy (and delaying it), could help to reduce maternal and infant mortality, and contribute to break the vicious cycle of intergenerational malnutrition, poverty, and even chronic disease. Food-based and health approaches will oftentimes need to be complemented by micronutrient supplementation using various channels. Promoting healthy eating and lifestyles among adolescents, particularly through the urban school system, is critical to halt the rapid progression of obesity and other nutrition-related chronic disease risks. There are pressing research needs, notably to develop adolescent-specific anthropometric reference data, to better document adolescents' nutritional and micronutrient status, and to assess the cost-effectiveness of multinutrient dietary improvement (or supplements) in adolescent girls. Our view is that specific policies are needed at country level for adolescent nutrition, but not specific programmes.

1. Introduction

Adolescents[1] are tomorrow's adults, and 85% of them live in developing countries (*1)*. They are relatively healthy compared to other lifecycle groups, and they show roughly similar morbidity and mortality trends in developed and developing countries (*2-3*). As adolescents have a low prevalence of infection compared with under-five children, and of chronic disease compared with ageing people, they have generally been given little health and nutrition attention (*4*), except for reproductive health concerns. Traditionally, preschool-age children and women of reproductive age have been targeted as nutritionally vulnerable groups in developing countries, whereas in industrialised countries, the focus tends to be on nutrition-related chronic diseases of the ageing population. Adolescents are an in-between group, with some nutrition problem commonalties with children, and with adults. However, there may be adolescent-specific priority issues, calling for specific strategies and approaches.

A review and discussion paper was prepared for WHO to examine nutrition issues in adolescence and to make recommendations that can feed into WHO's action and research agendas. The main findings are highlighted in this article Answers to the following basic questions were attempted:

1) Are there nutrition problems or risks that are best tackled at adolescence, and therefore, call for targeted action;
2) What could be the overall strategic approach, and the priorities, for the health sector to address these adolescent nutrition issues.

The main focus is developing countries, although this dichotomy of developed versus developing countries is becoming irrelevant with urbanisation and globalisation, particularly among adolescents. Those living in cities anywhere tend to have a common liking for fast food, and they increasingly have access to the same commercial outlets world-wide. Obesity among young people is a growing problem in most countries owing to eating patterns and sedentary lifestyles. Teen pregnancy is a problem anywhere. Furthermore, micronutrient intake inadequacies are not only to be found in developing country adolescent girls. Deficiencies or poor diets may be associated with poverty; they may also result from unhealthy eating behaviours, which are observed in well-off and not so well-off groups.

[1] WHO has defined « adolescents » as people in the 10-19 years age range, and « youth », as those between 15 and 24 years of age.

Broadly speaking, adolescents' problems are malnutrition, micronutrient deficiencies, and nutrition-related chronic diseases. Wide disparities in the relative magnitude of these problems are likely even within a given region or country, with a direct bearing on priorities.

The paper focuses on what the health sector can, and should do for adolescents' nutrition. Health programmes may as such have a substantive nutritional impact, for instance, control of infections and reproductive health care. However, while nutritional problems are health problems, their prevention and control lies to a large extent outside the health sector. There is widespread recognition of the critical role that economic constraints and food system bottlenecks play in contributing to poor nutritional health, in addition to socio-cultural pressures and lack of education. Nutrition cuts across many sectors, and nutrition action calls for strong inter-sectoral links, particularly among health, education, and agriculture.

Adolescence may represent a window of opportunity to prepare nutritionally for a healthy adult life. Some nutritional problems originating earlier in life can potentially be corrected, in addition to addressing current ones. It may also be a timely period to shape and consolidate healthy eating and lifestyle behaviours, thereby preventing or postponing the onset of nutrition-related chronic diseases in adulthood. Through adolescents, younger siblings, families, and other community members may be reached.

2. Prominent nutrition issues in adolescence

Adolescence is a period of intense physiological, psychological, and social change. The transition from childhood to adulthood may extend over variable periods of time, depending upon socio-cultural and economic factors. Even in a given culture, adolescents are not a homogeneous group, with wide variations in development, maturity, and lifestyle. It is interesting, however, that a study conducted in 1996 on 25,000 middle-class high-school students aged 15-18 years on five continents found them to be more similar than different in their values and concerns[2]. Boys express more self-confidence, more happiness and well-being, and less vulnerability than girls, who tend to be less satisfied with their body, their personality, and their health. A majority of adolescents think that they are in good health, and

[2] Web site : www.un.org/events/youth98/backinfo/yreport.html, 18/04/99

they show little concern for protecting their health "capital" for the future *(5)*. Nonetheless, caution is needed before generalising problems and approaches.

The main nutritional problems of adolescents are micronutrient deficiencies, iron deficiency anaemia in particular, and depending on the context, undernutrition or obesity and co-morbidity. Like in any other age group, poor nutrition is usually the result of dietary inadequacies, often combined with unhealthy lifestyles or infections, which further compromise nutritional status. Dietary inadequacies are likely more of a threat among adolescents because of erratic eating patterns and specific psycho-social factors underlying these, combined with the particularly high nutritional requirements for rapid growth. However, there is a dearth of data on adolescents' nutrition in developing countries, other than the eleven studies of the International Centre for Research on Women (ICRW) in the 1990s *(6)*. Adolescent pregnancy is a well-documented nutritional risk factor, in addition to potential health and socio-economic consequences.

A conceptual framework is proposed for analysing adolescents' nutritional problems irrespective of geographic area or income level (Figure 1). The following sets of issues will be discussed: iron and other micronutrient deficiencies; malnutrition and stunting; obesity and other nutrition-related chronic disease risks; adolescents' eating patterns and lifestyles; and early pregnancy. There is no attempt at ranking the issues, which ought to be area-specific.

2.1. Iron-deficiency anaemia and other micronutrient deficiencies

Anaemia is generally recognised as the greatest nutritional problem among adolescents, and diet is likely a major factor. In a review of 32 studies from developing countries *(7)*, the overall prevalence was of the order of 27%, and prevalence was higher in boys. In the ICRW studies, rates ranged from 16% (Ecuador) to 55% in India *(6)*. A higher prevalence in boys was only observed in one study. The physiological significance of anaemia in adolescent boys is not fully understood, but it is only transient and subsides as growth slows down. Iron deficiency as a result of chronic urinary and gastrointestinal blood loss, and intravascular hemolysis, is associated with strenuous exercise and endurance events in athletes *(8)*. It is not known whether very heavy physical work could have similar effects and therefore contribute to iron deficiency anaemia in adolescent boys (and girls). What is quite well established is that iron deficiency affects physical work capacity, in men and in women *(9-10)*, although studies have not specifically focused on adolescents. Even mild anaemia may also interfere

with leisure physical activity *(11)*. Iron deficiency was also shown to be associated with impaired cognitive processes in adolescents as suggested by improved performance following supplementation in South-east Asia *(11)*. Similarly, anaemia was independently associated with lower school achievement in adolescent girls *(12).*

Iron deficiency associated with poor intakes, or secondary to infections *(13)*, is likely the major cause of anaemia among adolescents, but other factors may be involved and need to be better documented, including multiple micronutrient deficiencies involving folate and vitamin A. Furthermore, menorrhagia may be a contributing factor, as suggested by data in Nigerian girls *(14)*, and vitamin A deficiency may be implicated in this heavy menstrual blood loss observed in 12% of nulliparous under the age of 20. Vitamin A and iron deficiency are indeed interrelated. In Bangladesh school adolescents, it was found that low serum retinol was associated with low hemoglobin (Hb) and poor iron status *(15)*. Controlled studies on the range of blood loss in malnourished adolescents are still awaited. In addition to well-established obstetric risks, anaemia in pregnancy may be associated with a higher risk of hypertension and heart disease in the offspring, according to Barker's hypothesis *(16-17)*

Vitamin A deficiency is not only a problem in young children. It has been reported in pregnant women, and it is associated with excess maternal mortality *(18)*. Sub-clinical vitamin A deficiency may also be widespread among adolescents. In Malawi, low serum retinol was observed in 27% of rural adolescent girls, and 74% of the pregnant ones *(19).*

Where iodine deficiency is endemic, women are most affected, but it seems that the whole community suffers. In a study in India, 9-15 year-old school boys from severely deficient villages showed not only neural impairment, but also a lack of motivation to learn owing to limited socio-psychological stimulation in the environment, compared to matched groups from only mildly deficient sites *(20).*

Calcium requirements are greater during adolescence, since it is the period of peak bone mass increase*(21)*; up to 37% may be accumulated during the growth spurt of adolescence *(22).* There is some evidence of continuing bone acquisition after the adolescent growth spurt, and calcium intake could make a difference, at least in Caucasians *(23-24).* Bone demineralisation in lactating adolescents has been ascribed to calcium deficiency, as it was reversed with increased calcium intake *(25).* Consumption of dairy products was reported to be associated with higher bone mass and density in Caucasian adolescent girls *(26-27).* High post-

menopausal bone loss has also been associated with low calcium intake in earlier years, and milk conferred some protection, according to a retrospective study in American women *(28)*. Adolescent diets are often inadequate in calcium in USA, particularly in girls *(22)*. However, many factors other than diet determine bone status and osteoporosis, including body mass and physical activity level, as observed in Mexican women *(29)*. Furthermore, calcium nutriture in developing countries and in population groups other than Caucasians is still poorly understood, and this should be a priority area for research. Although osteoporosis was considered as a relatively unimportant problem in developing *(30)*, data now indicate that it is a growing problem among Asian *(31)* and even African *(32)* women, but whether it may be modulated by calcium (and other micronutrients) intake during childhood or adolescence is unknown.

Evidence from supplementation trials suggests that marginal zinc status may be common in adolescents and limit skeletal growth, much the same as in younger children. This is further discussed below, together with stunting. Observations in older women also suggest that it may prevent bone loss *(33)*.

2.2. Malnutrition and stunting, and assessment issues

Stunting is commonly observed among adolescents in populations with a high rate of malnutrition: it was highly prevalent in 9 of the 11 ICRW studies, ranging from 27% to 65% *(6)*. Chronic undernutrition that results in stunting is responsible at adolescence for delayed growth and maturation, magnified obstetric risk, and reduced work capacity. In 9 of the 11 ICRW studies, stunting was highly prevalent in adolescent boys and girls, ranging from 32% in India to 65% in the Philippines *(34)*. In contrast, the rate of low body mass index (BMI) indicative of current undernutrition was relatively low, and exceeded 20% in only 3 sites.

A still debated question is the extent of catch-up growth that is achievable in adolescence. Delayed growth and maturation as a result of chronic malnutrition in children allows for some spontaneous catch-up growth in adolescence, since the growing period is thereby extended *(35)*. However, this catch-up is not complete, particularly for those remaining in the same (adverse) environment *(36)*. Furthermore, nutritional improvement may increase the velocity of adolescence growth spurt, but at the same time, accelerate maturation and as a result reduce the period of fast growth, with little change in the final achieved height. Potential benefits of gaining a few centimetres more in adolescence, if at all feasible, are reduced obstetric risk in

girls *(37)*, and improved physical work capacity, as suggested by observations in Guatemalan adolescent boys *(38)*. However, certain direct negative effects of chronic malnutrition may not be reversed, notably altered cognitive development *(36).* Furthermore, nutritional improvement through food supplementation may bring about some catch-up growth, but it may also increase the risk of obesity, as seen in adolescents who have an accelerated maturation *(39-40),* and as suggested by the observed association of overweight with *(41-42).* At growth spurt of adolescence, it is further reported that children who were growth retarded at birth tended to gain more weight than those with normal birth weight *(43)*

There is some evidence that micronutrients may enhance statural growth in adolescents, even after the growth spurt, but further research is needed. Height gain was observed, for instance, in pregnant Nigerian adolescents, and it was associated with iron and folate supplementation (Harrison et al, 1985). There is also evidence from supplementation trials that marginal zinc status may limit skeletal growth in adolescents *(44).* In Chile, zinc supplements increased height in stunted pre-adolescent and adolescent boys, but not girls *(45).* Nonetheless, existing evidence does not suggest that interventions for catch-up growth in adolescents should have a high priority at this time.

Wasting, based on low body mass index (BMI) is not widespread among adolescents, according to available data. However, the situation may be very different in emergency settings. Particularly when the crisis situation extends over long periods of time, adolescents may be seriously affected by malnutrition and yet, have little access to supplementary or therapeutic feeding programmes. Preliminary results of a recent survey among adolescent refugees from Bhutan *(46)* reveal a 34% rate of low BMI, much the same as in adults. However, these findings do not allow firm conclusions because of uncertainties regarding the validity of the reference BMI cut-offs for these populations.

There is at this time no truly appropriate anthropometric reference data set available at the international level to assess nutritional status of adolescents, whether undernutrition or obesity is the prevailing concern. Anthropometric assessment is more complex in adolescence than in childhood because of changes in body composition, and of the variable timing of the growth spurt. Height and BMI cut-off points based on reference percentiles from USA adolescents' data collected in the NHANES II survey in 1976-80 *(47)* has been suggested by WHO *(48)* for comparison purposes until more appropriate reference data become available. These

values and cut-offs may not be appropriate for individual assessment of adolescents' undernutrition irrespective of ethnicity, for wide variations of leg length are observed and make a difference. The overweight cut-off points may not either apply without confirmatory evidence of excess fat to all populations, in particular those with a high rate of stunting, although stunting may itself increase susceptibility to obesity *(41-42)*Furthermore, anthropometric data have to be age-adjusted for maturity status in adolescents *(48).* Practical indicators are age at menarche in girls, and of adult voice in boys. BMI for age was validated against other measures of body fat in adolescents, for instance in Italy *(49),* but this needs to be done in different adolescent populations. Another limitation is that in adolescents in particular, levels of morbidity and mortality risk associated with various degrees of "overweight" and "obesity" based on BMI are unknown.

2.3. Obesity and other nutrition-related chronic disease risks

Obesity has become a pandemic, and it is today's principal neglected public health problem *(50).* There is still very little data on obesity world-wide, particularly in developing countries. Only patchy data are available on obesity in adolescence, and in the absence of consistent cut-off points and reference values, comparisons are uneasy. While existing information is sufficient to show that obesity is increasing everywhere, and in all age groups, obesity should be monitored world-wide. In countries undergoing rapid urbanisation and economic growth, nutrition transition is observed, with a rise in obesity and other nutrition-related chronic diseases. In China, for instance, overweight is only emerging, but it is a problem associated with urban living, high income, and adolescence *(51).* There are many reports on spreading obesity among young people in the Middle-East, but using different criteria. Changes in the structure of diets and level of physical activity obviously have to be incriminated, even if a genetic predisposition may be present. Furthermore, foetal malnutrition as evidenced by low birth weight may be an additional risk factor for obesity and associated co-morbidity in later *(52)*. A study in France showed that adolescents who were small at birth tended to put on more weight during the growth spurt *(43).*

Obesity at adolescence is an issue because it tends to persist in adulthood *(53-55),* and the longer its duration, the higher the associated mortality and morbidity *(56).* Abdominal obesity in particular (high waist-hip ratio) is already associated with adverse blood lipid profiles in adolescents, as shown in the longitudinal study of Bogalusa *(57).* Obesity imposes a heavy health and social burden, and it is widely recognised that treatment is not only costly, but

remarkably ineffective. Prevention is now crucial, and adolescents should be a priority target, even in developing countries, particularly in urban settings because of conducive eating patterns and lifestyles. An additional reason is that obesity programmes appear more successful in adolescents than adults, as suggested in a few studies *(58-59).*

2.4. Adolescents' eating patterns and lifestyles

Eating patterns are frequently erratic in adolescents, and this may be a common factor of nutritional risk irrespective of the area. When there are no major economic or food security constraints, food choices are primarily determined by psycho-social factors. Personal preferences take precedence over eating habits learned at home as adolescents progressively take control of what they eat, where and how *(60).* The following features are quite typical of adolescents, and have a bearing on diets: search for identity; struggle for independence and acceptance; concern about appearance; vulnerability to commercial and peer pressure; and limited concern for health *(61).* Girls may be more exposed than boys to inadequate intakes because of dieting, lower energy intake, social discrimination, and pregnancy *(62).* Some dietary patterns appear quite common among adolescents, at least in industrialised countries, and to mention a few: snacking, usually on energy-dense foods; meal skipping, particularly breakfast, or irregular meals; wide use of fast food, even in Europe; low consumption of fruits and vegetables, and of dairy products in some instances; faulty dieting practices in girls; and unconventional dietary practices *(63-69).* Even in developing countries, particularly in cities, some of these patterns are also likely common among adolescents, but very little information is available. In Nepal, a study among school children revealed that fast food (ready to eat snacks, chips...) were preferred by more than two-thirds, and that advertising influenced preferences in 80% of them *(70).* Adolescents may be seen as 'early adopters' of new products or ideas, if we consider the overwhelming influence that the medias have upon them *(71).* All this makes adolescents an ideal target for nutrition education.

In many industrialised countries, eating disturbances and disorders have become a leading chronic illness among adolescent girls *(72).* Anorexia and bulimia are only the extreme of a broad spectrum of disordered eating, which also includes frequent dieting; partial syndromes. However, eating disorders are still rare in societies where obesity is not widespread or stigmatised by society *(50).* The problem is not described in developing countries, but in USA, it is increasingly observed at a younger age, in males, in not so affluent groups, and in non-Caucasians *(73-76).* In a study in New-England school adolescents *(77),* it was found that

disordered eating was less prevalent among Hispanic and African-American girls than in Caucasians. In contrast, it tended to be more frequent among non-Caucasian boys, although overall it was less common in boys than in girls. Body image is important in adolescence, and disturbances are in relation with obesity, dietary disorders, and psychological discontent *(78).* Many theories have been proposed to explain the relationship between body image disturbances and eating disorders, but the socio-cultural factor is the theory which is best supported by available data *(78).* As part of nutrition promotion and obesity prevention, it is therefore important to develop a positive body image and self-esteem among adolescents, as will be further discussed below.

It is interesting to note that healthy eating and other healthy behaviours are oftentimes strongly related, and that conversely drinking, smoking, lack of physical activity, overeating, and poor dietary choices tend to cluster *(79-81).* In high income societies, it is observed that physical activity tends to fall during adolescence *(82),* and girls are less active than boys *(83).* Self-efficacy, social support, and enjoyment have been found to be important determinants of leisure time physical activity *(84-85).* In contrast, in poorer societies of developing countries, adolescent boys and girls may be expected to engage in heavy physical work many hours a day, as observed, for instance, in Malawi *(19)*. This impinges on energy requirements and likely also on weight status. Poor access to food as a result of poverty may further exacerbate the gap between food energy requirements and intake of adolescents, as suggested by the frequency of reported household food insecurity in the ICRW studies among adolescents, notably 86% of households in Benin *(86).* However, no gender difference in dietary adequacy was observed overall in the ICRW studies in adolescents *(6).* Thus, livelihoods may impose high physical work and energy demands among adolescents of poorer societies, while sedentary lifestyles are increasingly observed with urbanisation in others. In one case, household food security needs to be improved for adolescents to have more adequate diets, and in the other case, a higher level of physical energy expenditure is required, in combination with healthier eating. This shows how contrasting adolescent nutrition problems can be.

2.5. Adolescent pregnancy

It is world-wide problem, with 25% of women having their first child before the age of 20 *(4)*The proportion may reach two-thirds, for instance in Bangladesh and in some African countries *(87),* while there is a declining trend in USA *(88).* Risks are for both mother and child. Young age by itself may not have much of an independent effect, but those factors that

are associated with poor pregnancy outcomes are more often observed in pregnant adolescents, including primiparity, poor nutritional status, low SES *(89-90)*. Controlled studies in several sites show that adolescent mothers have a higher incidence of prematurity, low birth weight, and complicated labour. Delayed maturation due to chronic malnutrition further increases the risk of early pregnancy, because biological age lags behind chronological age *(91)*.

Two years post menarche, nutritional requirements of pregnant adolescents are theoretically similar to adult pregnant women's *(92)*. However, adolescents may enter pregnancy with poor nutritional status and low nutrient stores. Furthermore, until maternal growth is completed, competition for nutrients between mother and child may have adverse consequences, as suggested by many observations. Improving nutritional status of adolescent pregnant girls who are still growing through food may affect birth weight, as it seems that the extra nutrients are diverted for maternal growth, at the expense of fœtal growth. This was observed in pregnant ewes *(93),* and in a high protein supplementation trial in pregnant women including a good proportion of adolescents *(94)*. Lower birth-weights were reported in adolescent mothers who grew in height during pregnancy *(95)*. There are also reports of lower milk secretion in adolescent than adult mothers *(96),* which cannot be explained by infant feeding practices.

Offspring of adolescent mothers may be at higher nutritional risk because of size and nutrient stores at birth, but also of breastfeeding and child-care practices (and perhaps less than optimal breast-milk production). However, nutritional risk was only increased among children of poor adolescent mothers in the ICRW studies *(97)*. In the Latin American region, 70% of early pregnancies occur in low income groups, according to PAHO[3] (1997). Small baby girls tend to become small mothers, with higher obstetric risk. Adolescent mothers tend to beget adolescent mothers. Socio-economic consequences of adolescent pregnancy are not to be overlooked. Early pregnancy may have more economic than social drawbacks: it disrupts schooling, and this may be one way whereby it perpetuates poverty. It also tends to be associated with larger family size, and to perpetuate poverty of low income women. These socio-economic consequences have been observed in ICRW studies in Latin America *(97),* and in Nordeste, Brazil *(98)*.

[3] http://www.paho.org

So, postponing the first pregnancy (keeping girls in schools is a good way), and improving nutritional status of adolescent girls (school again is a good entry point) is important. This may contribute to breaking the intergenerational vicious cycle of malnutrition and poverty and chronic disease as well. There is accumulating evidence supporting the hypothesis of early programming of chronic diseases. Intra-uterine growth retardation as a result of foetal malnutrition has been found to be associated with coronary heart disease, hypertension, and metabolic disease in various adult populations *(99)*. Maternal anaemia was also found to be a risk factor for hypertension *(100-101)*. Maternal malnutrition is a primary factor of foetal growth retardation in poorer population groups, and pregnant adolescents are at even higher risk. This provides additional justification for improving nutritional status of girls before (and during) their first pregnancy, in parallel with attempts to delay this first pregnancy.

3. Suggested overall strategy to address priority issues

In adolescents in particular, there is evidence that programmes are more effective when multi-focused *(6)*. This is the approach of joint WHO/UNFPA/UNICEF agenda for adolescent health, which is intended to provide accurate knowledge, build skills, provide counselling, improve access to health services, and ensure safe and supportive environments *(102)*. This paper deals with nutrition, but its integration into more global programmes is implicit.

For adolescent nutrition to be specifically addressed by the health sector, an integrated approach somewhat comparable to the IMCI programme of WHO *(103)* is proposed, with promotion, prevention, and treatment components. However, there have to be multiple entry points rather than only health care, since contacts of adolescents with health services are scarce, except perhaps in pregnancy. The approach involves 3 components, as shown in Figure 2, and schools would have a major role, particularly for the first two:

1) Nutrition promotion, as part of health promotion
2) Prevention (and management) of main nutritional problems
3) Nutritional management of clinical conditions in adolescents.

As depicted in Figure 2, nutrition promotion is the major component, and it should be in the background of all nutrition-related activities anywhere. Promotion and prevention are more critical than clinical care for adolescents' present and future nutritional health, as for health in general. The model is incomplete, however, as it is primarily directed at health care providers.

It does not include other essential components such as advocacy, training, and surveillance. For a relevant strategy, context-specific priority issues have to be identified, but addressing malnutrition, micronutrient deficiencies, and nutrition-related chronic diseases in an integrated manner is nearly always required. Halting the rapid increase of obesity and associated chronic disease should not wait until these get to the top of the list of death causes *(104)*.

3.1. Primary focus on nutrition promotion, and the central role of the school

WHO's global school health initiative and the 'health promoting schools' programme *(105)* provide an appropriate framework for enhancing nutrition among adolescents, at least for those who are in school. School-based programmes may also encourage children and adolescents to remain in school, school-feeding programmes, for instance *(106-107)*. This is particularly important for girls *(108)*. In populations where many adolescents are not in school, reaching them is a challenge, but school outreach programmes have been found effective *(109)*. Vocational schools, and other community-based institutions such as youth groups can also be involved, in addition to using the medias. Adolescents may also be reached through work-site programmes in certain cases.

The health promotion approach, which integrates the determinants of health and aims at empowering people, is particularly appropriate for addressing nutrition in adolescents. However, the same caveat applies to nutrition as to health promotion in general: empowering young people should not convey the message that adolescents themselves are to solve health, nutrition and social problems *(110)*. Furthermore, overemphasis on health and health risk should be avoided: health is a resource, not a religion or a tyrant *(111-112)*. Improving access to food and enhancing control of adolescents over their food resources should get appropriate emphasis as a major component of the supportive environment, and as a prerequisite for nutrition security *(113)*. Improving access to appropriate nutrition services for adolescents is also required (and is part of the second component of the overall strategy), in addition to strengthening their skills for adopting healthy eating and lifestyle. It is evident from this that adolescent nutrition promotion is overarching and should connect with health services on one side, and food security programmes on the other. Nonetheless, schools provide a wealth of opportunities to improve nutrition: formal learning, and in particular, gardening, cooking and feeding *(114)*. According to operations research, school-based health and nutrition

programmes have practical benefits and can be implemented at low cost, teachers may be trained to provide some health care to children, and schools are a good channel for activities such as micronutrient supplementation, and deworming as an entry point *(115)*.

Understanding how young people themselves view health-related issues such as nutrition is central to effective strategies. The various levels of influence, including culture, peers, family, have to be considered *(116)*. Several psycho-social and environmental models have been used for health and nutrition promotion with adolescents, and a mix of models and approaches appears promising. An example of a multiple approach is the school health clubs project in Cameroon *(109)*. The 'Social cognitive theory' *(117)*, the 'Health belief model' *(118)*, and the 'Life skills intervention model' *(119)* have been applied with adolescents. The 'Life events' approach as used to explain adolescents' perception of health may also provide insights for nutrition promotion strategies *(5)*. Future health risks are beyond adolescents' time perspective *(120)*. While linking behavioural change with reduced long term health risks is likely doomed to failure, there is more scope for emphasis on overall well-being resulting from healthful behaviours now, and on their empowering effect. Social marketing may also be particularly effective with adolescents, considering their liking (and being a preferred target) for commercial marketing, and its good track record as a strategy of behavioural change, in nutrition and other health-related matters *(121-123)*.

For nutrition promotion and education, what schools need to do specifically, or emphasise more, with adolescents for nutrition promotion and education is: to encourage healthy eating and physical activity; to strengthen self-esteem as a means of resisting adverse environmental influences on eating and dieting practices; to contribute to preventing obesity and disordered eating through these attitudes and behaviours; and to screen and refer adolescents with suspected obesity and eating problems to appropriate health services, as well as malnourished adolescents. Developing positive attitudes towards breastfeeding should also be part of nutrition promotion in schools, particularly among adolescents. It was found to have positive impact in Korea, for instance *(124)*. Selected focus and activities have to be adapted to location-specific issues and resources, but generic nutrition messages are applicable anywhere for promoting health as well as preventing various chronic diseases: emphasis on food variety, fruits and vegetables, and other sources of fibre; and moderation in saturated fat (where appropriate). Insistence on food sources of iron (and perhaps also calcium) is indicated for adolescents. Food-based dietary guidelines are recognised as a unique tool for nutrition

education *(125-127)*, and where country specific sets are available, they will assist teachers and health workers in their nutrition promoting activities with adolescents.

Schools may also be a focal point for micronutrient programmes and particularly food approaches, as will be discussed below.

3.2. Prevention and management of nutritional problems and risks

This second component of the strategy involves health care providers more directly, and primarily deals with micronutrient deficiencies, malnutrition, and obesity. The prevention and management mix has to be locally defined. A crucial component anywhere is nutritional monitoring and management of adolescent pregnancy; it may even be the most important activity in certain settings.

Prevention is particularly relevant in adolescents, and it is in line with nutrition promotion; the only difference is that it focuses on a specific condition, be it malnutrition, specific micronutrient deficiencies, or overweight. Prevention is less costly than treatment. It is challenging, however: there is no quick fix. Effective prevention in nutrition lies in large part in behaviour reinforcement or change. A commonly held belief is that such programmes are ineffective. Yet, the corpus of knowledge on effective means of inducing behavioural change through nutritional communication is growing *(128)*, as well as documented evidence of impact, particularly in young people . A major impediment, however, is the paucity of data on location and culture-specific determinants of behaviour and barriers to change. Research has an important role in this regard, as well as for evaluation of interventions. In addition to the behavioural approach, preventing nutrition-related chronic diseases involves prevention of foetal malnutrition (and adolescent girls are a key target group), as evidence is increasing in support of foetal programming as one risk factor for chronic diseases in later life *(43, 99, 101)*.

3.2.1. Nutritional assessment

Nutritional assessment should be an inherent part of preventive health care services to adolescents. This includes anthropometry, and weights and heights could even be regularly measured in schools. There is a need for improved tools to assess both undernutrition and obesity in adolescents, as underlined above, but meanwhile, existing height and BMI reference data *(48)* are useful, provided adjustments are made for maturity. At the individual

level, obesity needs to be confirmed with skinfold thickness or waist circumference measurements, as high BMI may not correspond to obesity. Adolescent-specific reference data for international use will need to be developed and validated against other measures of obesity, and also, against co-morbidity risk factors. Two years after puberty, adult BMI cut-offs may be used for overweight, and it has been suggested that equivalent cut-offs be defined for BMI-for-age at adolescence *(129)*. Overweight grade I, or BMI above 25 in adults, corresponds roughly to the 80th percentile, and grade II (BMI >30), to the 95th. Nutritional assessment also involves dietary assessment (and looking for clinical signs of specific nutritional deficiencies as appropriate). Dietary assessment is all too often by-passed as unnecessary or too complex in health and nutrition work, at population or individual level. Yet, it is essential, and simple dietary quality scores may be developed, or else, adapted from existing tools *(130-131)*. There should be a systematic dietary enquiry in adolescents, at least in cases of too low or too high BMI, during pregnancy, and when specific micronutrient deficiencies are suspected.

3.2.2. Control of micronutrient deficiencies

Iron deficiency and anaemia need to be controlled and prevented, particularly in girls, and ahead of pregnancy as much as possible. Iron deficiency is the predominant cause of anaemia *(132)*, and correcting it is an investment in adult productive and reproductive lives. Successful anaemia control programmes are indeed recognised as highly cost-effective, as underlined by the World Bank *(108)*. Adolescents are to us a key target group for inclusive approaches combining sanitation, parasite control, and dietary intake. Iron from animal sources is more highly bioavailable, but consumption is constrained by income. However, there are accessible means of improving bioavailability of inorganic iron, notably consumption of vitamin C-rich foods, and avoidance of iron absorption inhibitors, such as tea, with meals. Fermentation and germination of cereals and legumes are also beneficial, although often overlooked. Iron deficiency is often accompanied with other micronutrient deficiencies such as folate, and particularly in developing countries, vitamin A and possibly also zinc. Macronutrient intake may even be inadequate in certain cases. It is therefore wise to focus on food-based approaches to improve the quality of diets of adolescents. Schools are the primary entry point, through education, school-feeding programmes, and gardening; other community-based approaches also have to be considered. Micronutrient supplementation may be indicated based on prevalence data of anaemia and vitamin A deficiency. However, for one, data on adolescents is seldom collected. Furthermore, adolescents (and even school children) are

usually not a priority target group for iron and vitamin A supplementation. Improving diets may be more realistic, and schools are an excellent setting to pilot-test location-specific measures to improve the nutritional quality of diets. In the case of vitamin A at least, there is now enough examples of successful dietary-based programmes *(123, 133-134)* to argue for such approaches. In the long-run, it is more cost-effective to stimulate local production, processing, and trade of micronutrient-dense foods, rather than to increase micronutrient supplement imports. Additionally, foods are not only nutrient mixtures; heretofore unknown protective factors are increasingly identified in various foods. Youth groups may also be resourceful for programmes designed to increase production and intake of provitamin A providing foods.

In addition to education and dietary diversification, schools may be an effective vehicle for micronutrient-fortified foods. In Turkey, zinc-fortified bread was pilot-tested in school-age children, with positive preliminary results *(135)*. There is scope for the concept of multi-nutrient fortified snacks or drinks for school children, as successfully tested in South Africa *(136)*. Nonetheless, food-based approaches may not suffice, and adolescent girls should be a priority target group for iron-folate supplements to be distributed through schools, community workers, and youth groups. Weekly dosage may be appropriate outside of pregnancy, as some findings suggest *(137-138)*.

3.2.3. Nutritional management of adolescent pregnancy

Early pregnancy is also a nutritional issue, and preventing it should be the objective. Nutrition has to be an important dimension of antenatal (and postnatal) care particularly in adolescents. There have been reports of low effectiveness of antenatal care in general and for adolescents in developing countries, even among those attending care *(139-140)*. Pregnant adolescents are usually at high obstetric risk by definition, and particularly so if they are immature, short and underweight (<25th percentile of BMI) at the onset of pregnancy. Adequate weight gain may even be more critical than in adult women *(141)*, which implies close monitoring. Benchmarks for weight gain have been suggested (*142)*. A frequent weakness of weight monitoring however, whether in pregnancy or childhood, is that inadequate weight does not seem to trigger adequate nutrition responses. Health care providers may not have a clear idea of relevant and context-specific dietary advice that can be given to pregnant women, adolescent or not, or of the counselling approach, even if by chance they do a careful dietary enquiry. It is suggested that location-specific guidelines (adapted from generic ones) be

developed or made available for appropriate integration of nutrition counselling in antenatal health care.

Regarding food supplementation during pregnancy in order to improve foetal growth, there may be high benefit in malnourished women *(143-144)*. There is unfortunately no specific data on adolescents, and the possibility of an adverse effect on foetal growth is a concern, as already discussed. Micronutrient supplements do not seem to pose this problem, and based on available evidence, pregnant adolescents with marginal micronutrient status may derive particular benefit from supplements of vitamin A, zinc, and calcium, in addition to iron-folate, as they are more liable to be deficient that adult women. A controlled zinc supplementation trial in African-American pregnant women with low plasma zinc resulted in a significant and substantial increase in birth weight, particularly in low BMI women, without unduly increasing the risk of cephalopelvic disproportion *(145)*. Vitamin A supplementation during pregnancy resulted in a spectacular reduction of maternal mortality in Nepal *(18)*. Calcium supplements may reduce the risk of premature delivery (but not intra-uterine growth retardation), pre-eclampsia and pregnancy-induced hypertension, according to systematic reviews and meta-analyses of nutrition interventions in pregnancy *(146)*. As pregnant adolescents are at higher risk of pregnancy-induced hypertension and pre-eclampsia, calcium supplements may be of benefit *(147)*. Furthermore, calcium supplements during pregnancy were associated with significantly lower blood pressure in the offspring, according to a controlled trial *(148)*. In the Gambia, Prentice et al *(149)* observed no benefit of calcium supplements for one year after delivery on breastmilk calcium or on maternal bone mineral content, although dietary calcium intakes were low. Pregnant adolescents should be a priority subgroup for observational and intervention studies on calcium nutriture in different populations.

Before pregnancy, or as early as possible, it is important to supply iodine in endemic areas without a salt iodization programme, in order to improve survival and prevent mental abnormalities in the new-born *(150)*.

Nutritional care in the postpartum may be particularly important in teenage mothers, *(151)*. In addition to micronutrient supplementation as appropriate and diet counselling, support for breastfeeding is likely even more critical than in adult mothers, in view of reports of poorer

lactation performance and practices in adolescents, and of higher nutritional risk in the offspring, particularly among low-income mothers (*97)*.

3.2.4. Management of severe malnutrition in adolescents

Prevention of malnutrition in adolescents is done primarily through promotion of healthy eating, and food security measures for adequate access to food. The school has a key role in the former, while agriculture and community-based approaches are the main vehicle for the latter. In adolescents, malnutrition may be more common than normally assumed in emergency situations, and as part of emergency health care, the health sector should address this issue.

Once detected, severe malnutrition is reportedly to be treated much the same as in younger children *(152)*, although refeeding may be more difficult because of anorexia and resistance to tube feeding, and because protein content of the diet is more critical because of more common oedema. The problem is that owing to inadequate scientific basis for screening, management, and discharge criteria, severe malnourished adolescents are seldom included in therapeutic or supplementary feeding programmes offered younger children in emergency settings, other than on an *ad hoc* basis. Furthermore, unless the nutritional status of adolescents is appraised, it is uneasy to draw attention on high malnutrition rates, and on the need to provide nutritional support. This raises again the issue of inadequate anthropometric indicators for assessing nutritional status of adolescents. Not only height and BMI, but also the mid-arm circumference should be validated in adolescents.

3.2.5. Prevention (management) of obesity

Prevention of obesity among adolescents is highly relevant wherever it is widespread in certain population segments, or else where it may soon become so. It would likely be irrelevant only in poorer groups of low income countries, particularly in rural areas. Except perhaps in poorest countries, clustering of obesity and other chronic diseases is observed in the lower income population groups. The risk behaviours are first established in society sectors with time and money to access processed foods, motorised transportation, tobacco and alcohol; as such items become accessible, the risks spread to other groups, while the more privileged are switching to healthier foods and lifestyles *(50)*. Primary prevention of obesity is predominantly done through promoting healthy eating and physical activity, and schools are consequently the main entry point. It is not much different among adolescents and younger

school-age children, except that obesity prevention should be given more emphasis in adolescents. Essentially the same messages on eating hold, whether for general health, and for the prevention of obesity and other chronic diseases (see above). Where obesity is increasing and leanness is becoming a social norm, prevention of eating disturbances through strengthening self-esteem and a positive body image is more pertinent at adolescence, and particularly in girls. Schools appear as an ideal setting, as it can be assumed that in developing countries, the related problems of obesity and eating disturbances are more likely to be encountered in better-off adolescents, whose majority would still be in school, and who are under a marked influence of western youth lifestyles and values. Based on suggestions of Rosen and Neumark-Sztainer *(76)*, school-based prevention programmes should target the following: 1) Reducing body dissatisfaction; 2) Critical thinking about socio-cultural and peer norms; 3) Understanding physical development; 4) improved knowledge about nutrition and weight control; and 5) Skill development for healthy eating and weight management. Ideally, this should be combined with opportunities for healthy eating right at school.

As suggested above, BMI monitoring could be done in schools through systematic, perhaps yearly, measuring of weights and heights. Those above the cut-off for overweight (as well as the underweight school-children and adolescents) could be referred to health services for further assessment and counselling. Confirmation of obesity can be based upon skinfold thickness (or waist circumference: see *57*). Children or adolescents who are referred for obesity, and whose birth record indicates that they were born at term but were of small size, as well as those who have a family history of diabetes or cardiovascular disease, are at particularly high risk. They should get relevant advice and support, and benefit from closer monitoring for body weight reduction/maintenance. Sensible snacking, staying away from dieting, avoidance of meal skipping, breakfast in particular, are additional dietary advice for weight control. While breakfast may be useful in the framework of weight control *(153)*, it is observed that adolescents have a tendency to skip it, and obese people as well *(154)*. Physical activity requires particular emphasis. As recommended by the American Medical Association *(155)*, early signs of eating disorders are a low BMI ($<5^{th}$ percentile), or loss of 2 BMI units or loss of 10% of previous weight, combined with inappropriate feelings of being overweight, or extreme measures reported to lose weight. In addition to individual counselling, obesity/eating disorder prevention could involve small group work with those at particular risk.

3.3. Clinical nutrition case management

This may not receive as much attention as the other two components of the global strategy for adolescent nutrition, but it is nonetheless indispensable for health care services to deal with nutritional aspects of diseases in adolescents in an appropriate manner. Although conditions requiring special diets would normally be handled by specialised health personnel, health service providers have to be aware of basic principles of nutritional management of common diseases. Among adolescents, diabetes and HIV are relevant and particularly challenging nutrition-wise.

Type 1 diabetes is in industrialised countries the third most common disease in young people after asthma and cerebral palsy *(156)*. With increasing obesity, there is evidence of growing incidence of type-2 diabetes among adolescents of developed countries. It is likely that among the diseases that call for modified diets in adolescence, diabetes is close to the top of the list. There are quite a few reports of declining metabolic control of type-1 diabetes in adolescents, owing in part to reduced self-management *(157-158)*. A consistent observation is that family support is associated with better control of diabetes in adolescence *(159-160)*. Group approaches to self-care may be even more effective than in adults. In contrast with type-1, those with type-2 diabetes are generally obese, and the primary aim of treatment should be gradual and sustained weight loss for glucose control and reduction of blood lipids. However, treatment of adolescents with type-2 diabetes is reportedly very difficult. Specific education, a strong interaction with the health care team, and direct involvement of the family, have been advocated *(161)*.

Regarding HIV/AIDS, adequate nutrition can improve the status and course of the disease, in adolescents and other affected age groups. However, in developing countries where malnutrition is widespread owing to poverty, and where adolescents are not a priority group for nutrition, improving the quality of diet may be quite a challenge. Multiple micronutrient supplements may have benefits *(162)*. These supplements, and basic hygiene with food and water, may be the only feasible and the most cost-effective measures in many developing countries where HIV-infected people cannot afford the costly medication. A practical guide for nutrition in HIV has been recently developed in Zimbabwe *(163)*. There is a risk of vertical transmission of HIV by breastmilk, but it has to be measured against the advantages of breastfeeding. It has been suggested, based on current research data, that women with HIV could breastfeed for 4 months without increasing the transmission risk *(164)*. However, the

final decision is in the hands of mothers, who need to be adequately informed by health care providers, particularly adolescents. Multivitamin supplementation of infected women during pregnancy was shown to reduce low birth weights in Tanzania, while improving the immunity *(165)*. Pregnant adolescents should be the first to receive these supplements wherever available.

4. Conclusions and recommendations

Nutritional vulnerability may in certain respects be lower in adolescence than early childhood, although adolescent pregnancy is a high risk condition. It is mostly because adolescence provides a window of opportunity for long term positive impact that nutrition should be a programmatic priority in adolescents. It is a challenge, however, considering that while health is not a major concern at that age, promotion of healthy nutrition behaviours is the core element. Furthermore, there is very little data on adolescent nutrition to back up programmes and their funding. Adolescents who are not attending school may also be quite difficult to reach in certain settings.

Nutrition promotion is to be the pillar of the global strategy to address nutrition issues in adolescence. Schools, more than health care centres, appear as the main entry point: adolescents are generally healthy, nutrition can be integrated in health promoting school programmes, and nutrition activities may be school-led to also reach those adolescents that are no longer in school. Schools ought to develop close links with health services for prevention and management of specific nutrition disorders, and with community development programmes to address food security problems.

To us, a global strategy of this nature can be implemented without necessarily requiring a specific programme for adolescent nutrition. It is felt that explicit policies are needed at country level, however, to identify local priority issues, and to address these in a cohesive manner. WHO could provide guidance to nation states for developing their policy on adolescent nutrition.

A high priority in nearly all contexts is to improve nutritional status of girls, with emphasis on micronutrients, preferably before, and at least early in their first pregnancy. This could go a long way towards curbing maternal and infant mortality, and contribute to breaking the vicious cycle of intergenerational malnutrition, poverty, and even chronic disease. School-

based, health facility-based, and community-based activities carried out in a coordinated fashion should be considered to improve nutrition of adolescent girls. Another relevant priority world-wide is the prevention of obesity (and disordered eating), with a particular emphasis, again on adolescent girls because they are more susceptible. Urban schools are preferred settings, as it is assumed that those adolescents at higher risk of obesity are thereby targeted.

There is at present so little data on adolescents' nutritional status and micronutrient nutrition, eating patterns and underlying influences, and on impact of nutrition intervention in adolescence, that research needs are immense. In order to develop appropriate anthropometric reference data, a multi-country study, with longitudinal and cross-sectional components, on adolescents' somatic growth and maturation should be considered high priority. Such data are needed to define not only cut-off points, but also rates of too low or too high values that should trigger action at programme or individual level. Meanwhile, the feasibility of routine weight and height measurements in schools, including adolescents and younger children, deserves to be examined. BMI nomograms and tables with percentile cut-offs for under-, as well as over-weight, as well as appropriate guidelines for their use with adolescents (and younger school-age children), could be useful for schools and health services, while efforts are pursued to develop specific reference data.

Another priority research need is for well-controlled studies on the effects of micronutrient status/supplements on bone mineralisation, the timing and magnitude of the growth spurt, and maturation in adolescent boys and girls, in particular vitamin A, calcium, zinc, and iron.

It was suggested earlier that adolescents (and schools) were ideal targets for food-based approaches to improving micronutrient status, in particular vitamin A and iron. The effectiveness of pilot interventions focusing on achievable improvements of micronutrient status through food would urgently need to be evaluated, with considerations of process, cost and sustainability in addition to micronutrient status impact.

Much research is still needed to provide a stronger base for effective nutrition monitoring and management in pregnancy in general, and adolescent pregnancy in particular. In this regard, studies on the effect of multiple micronutrient (or food supplementation) on maternal and

foetal outcomes in adolescent pregnancy are warranted, because it is as yet unclear how the adolescent mother and the foetus partition the extra nutrients.

A better understanding of adolescents' diets and eating behaviours is essential for relevant education programmes. Additionally, dietary enquiry tools specifically designed for adolescents are direly needed. The enquiry should encompass household food security, food diversity (as indicator of nutritional quality), eating practices and underlying influences, and physical activity. These tools need to be developed and validated in different settings, in connection with school-based or health centre-based intervention programmes rather than as free-standing research, for higher relevance. Participatory approaches are particularly well suited for research work with adolescents.

Research on two contrasting themes – severe malnutrition and obesity in adolescents - is also recommended as a means of strengthening programmes. Studies on nutritional assessment, rehabilitation, and discharge criteria in severely malnourished adolescents are called for, as well as evaluation research on the impact of school-based pilot projects for nutrition promotion and prevention of obesity.

FIG.1. CONCEPTUAL FRAMEWORK OF NUTRITIONAL PROBLEMS AND CAUSAL FACTORS IN ADOLESCENCE

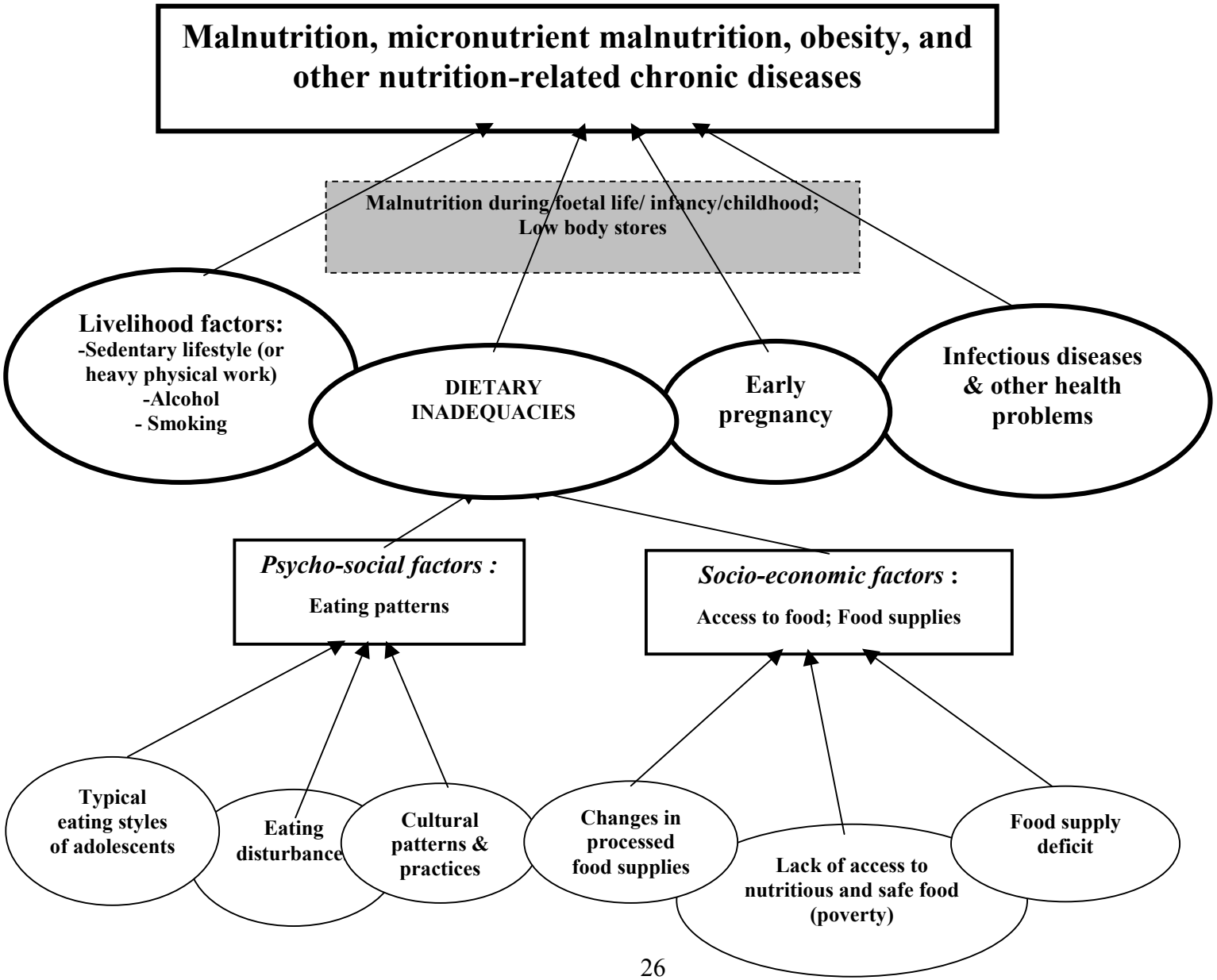

FIG 2. STRATEGY FOR NUTRITION INTERVENTION IN ADOLESCENCE

REFERENCES

15. Ahmed F, Khan MR, Karim R, et al. Serum retinol and biochemical measures of iron status in adolescent schoolgirls in urban Bangladesh. Eur J Clin Nutr 1996; 50:346-51

160. Anderson JA, Brackett J, Ho J, Laffel LMB. An office-based intervention to maintain parent-adolescent teamwork in diabetes management. Diabetes Care 1999; 22:713-21

137. Angeles-Agdeppa I, Schultink W, Sastroamidjojo S, et al. Weekly nutrient supplementation to build iron stores in female Indonesian adolescents. Am J Clin Nut 1997; 66:177-83

32. Aspray TJ, Prentice A, Cole TJ, et al. Low bone mineral content is common but osteoporotic fractures are rare in elderly rural Gambian women. J Bone Miner Res 1996; 11: 1019-25

147. Atallah AN, Hofmeyr GJ, Duley L. Calcium supplementation during pregnancy to prevent hypertensive disorders and related adverse outcomes (Cochrane Review). In: The Cochrane Library Issue 3, 1998. Oxford: Update Software

117. Bandura A. Social foundations of thought and action: A social cognitive theory. Englewood Cliffs, NJ: Prentice-Hall, 1986

99. Barker DJP. Mothers, babies, and disease in later life. London: BMJ Publ Group, 1994

16. Barker DJP, Bull AR, Osmond C, Simmonds SJ. Fetal and placental size and risk of hypertension in adult life. Brit Med J 1990; 301:259-62

14. Barr F, Brabin L, Agbaje S, et al. Reducing iron deficiency anaemia due to heavy menstrual blood loss in Nigerian rural adolescents. Public Health Nut 1998; 1:249-57

9. Behrman JR. The economic rationale for investing in nutrition in developing countries. Washington: USAID, Office of Nutrition, 1992

148. Belizan JM, Villar J, Bergel E, et al. Long-term effect of calcium supplementation during pregnancy on the blood pressure of offspring: follow-up of randomised controlled trial. Brit Med J 1997; 315:281-5

156. Betts P, Buckley M, Davis R, et al. The care of young people with diabetes. Diab Med 1996; 13 (Suppl 4):S54-9

162. Bijlsma M. Living positively. Nutrition Guide for People with HIV/AIDS (2nd ed). Zimbabwe: Mutare City Health Department 1997

2. Blum RW. Global trends in adolescent health. J Am Med Assoc 1991; 265:2711-9

88. Blum RW. Improving the health of youth. A community perspective. J Adolesc Health 1998; 23:254-8

87. Bongaarts J, Cohen B. Introduction and overview. Studies in Family Planning 1998; 29:99-105

140 Brabin L, Verhoeff FH, Kazembe P, et al. Improving antenatal care for pregnant adolescents in southern Malawi. Acta Obstet Gynecol Scand 1998; 77:402-9

157. Brink SJ, Moltz K. The message of the DCCT for children and adolescents. Diabetes Spectrum 1997; 10:259-67

159. Burrough TE, Harris MA, Pontious SL, Santiago JV. Research on social support in adolescents with IDDM: a critical review. Diab Educ 1997; 23:438-48

97. Buvinic M. The costs of adolescence childbearing: evidence from Chile, Barbados, Guatemala, and Mexico. Studies in Family Planning 1998; 29:201-9

45. Castillo-Duran C, Garcia H, Venegas P, et al. Zinc supplementation increases growth velocity of male children and adolescents with short stature. Acta Paediatr 1994; 83:833-7

69. Cavadini C, Decarli B, Dirren H, et al. Assessment of adolescent food habits in Switzerland. Appetite 1999; 32:97-106

143. Ceesay SM, Prentice AM, Cole TJ, et al. Effects on birth weight and perinatal mortality of maternal dietary supplements in rural Gambia : 5-year randomized controlled trial. Brit Med J 1997; 315 :786-90

25. Chan GM, McMurray M, Westover K, et al. Effects of increased dietary calcium intake upon calcium and bone mineral status of lactating adolescent and adult women. Am J Clin Nutr 1987; 46:319-23

27. Chan GM, Hoffman K, McMurray M. Effects of dairy products on bone and body composition in pubertal girls J. Paediatr 1995; 126:551-6

65. Chauliac M, deBeco J. Nutritional habits of adolescents in the Paris suburbs. Arch Pediatr 1996; 3:227-34

114. Chauliac M, Barros T, Masse-Raimbault AM, Yepez R. Jardins scolaires et éducation alimentaire en milieu andin. Food Nutr Agric [FAO] 1996; 16:14-22

109. Chendi H. Adolescent sexuality and reproductive health: does education matter? In: Kuate-Defo B (ed): Sexuality and reproductive health during adolescence in Africa with special reference to Cameroon. Ottawa, Canada: University of Ottawa Press, 1998, pp.351-63

118. Contento IR, Manning AD, Shannon B. Research perspective on school-based nutrition education. J Nutr Educ 1992; 24:247-60

138. Cook JD, Reddy MB. Efficacy of weekly compared with daily iron supplementation. Am J Clin Nutr 1995; 62:117-20

5. Cordonnier D. Événements quotidiens et bien-être à l'adolescence. Vers de nouvelles stratégies d'éducation pour la santé. Genève: Éd Méd Hyg, 1995

154. Cornelius LJ. Health habits of school-age children. J Health Care Underserv 1991; 2:374-95

113. Delisle H. La sécurité alimentaire, ses liens avec la nutrition et la santé. In: Delisle H, Shaw DJ (Eds). The Quest for Food Security in the Twenty First Century. Can J Development Studies 1998a; 19 (Special Issue): 307-21

150. De Long GR, Leslie PW, Wang SH et al. Effect on infant nortality of iodination of irrigation water in a severely iodine-deficient area of China. Lancet 1997; 350 :771-3

7. DeMaeyer E, Adiels-Tegman M. The prevalence of anaemia in the world World Health Stats Q 1985; 38:302-16

62. Dennison CM, Shepherd R. Adolescent food choice: an application of the theory of planned behaviour. J Human Nutr Dietet 1995; 8:9-23

123. De Pee S, Bloem MW, Satoto, et al. Impact of a social marketing campaign promoting dark-green leafy vegetables and eggs in Central Java, Indonesia. Int J Vitam Nutr Res 1998a; 68:389-98

129. Dietz WH, Robinson TN. Use of the body mass index (BMI) as a measure of overweight in children and adolescents (editorial). J Pediatr 1998; 132:191-3

82. Dinger MK, Waigandt A. Dietary intake and physical activity behaviors of male and female college students. Am J Health Prom 1997; 11:360-2

64. Douch JG, Story M, Dresser C, et al. Correlates of high-fat/low nutrient-dense snack consumption among adolescents: results from two national health surveys. Am J Health Prom 1995; 10:85-8

58. Douketis JD, Feightner JW, Attia J, et al. Examen médical périodique, mise à jour de 1999: 1. Détection, prévention et traitement de l'obésité. Can Med Assoc J 1999; 160 (10 Suppl):S1-12

155. Elster AB, Kuznets NJ. AMA guidelines for adolescent preventive services (GAPS). Recommendations and rationale. Chicago: AMA, 1995

91. Eveleth PB, Tanner JM. Worldwide variation in human growth, 2nd ed. Cambridge: Cambridge University Press, 1990

128. FAO. Social communication in nutrition: a methodology for intervention. Rome: FAO, 1994

127. FAO. Preparation and use of food based dietary guidelines. Rome: FAO, 1997.

164. Fawzi WM, Msaamanga GI, Spiegelman D, et al. Randomised trial of effects of vitamin supplements on pregnancy outcomes and T cell counts in HIV-1 infected women in Tanzania. Lancet 1998; 351:1477-82

19. Fazio-Tirrozzo G, Brabin L, Brabin B, et al. A community based study of vitamin A and vitamin E status of adolescent girls living in Shire Valley, Malawi. Eur J Clin Nutr 1998; 52:637-42

72. Fisher M, Golden NH, Katzman DK, et al. Eating disorders in adolescents. A background paper. J Adolesc Health 1995; 16:420-37

112. Fitzgerald FT. The tyranny of health. N Engl J Med 1994; 331:196-8

111. Førde OH. Is imposing risk awareness cultural imperialism? Soc Sci Med 1998; 47:1155-9

101. Forrester TE, Wilks RJ, Bennett FI, et al. Fetal growth and cardiovascular risk factors in Jamaican school children Brit Med J 1996; 312:156-60

57. Freedman DS, Serdula MK, Srinavasan R, Berenson GS. Relation of circumferences and skinfold thicknesses to lipid and insulin concentrations in children and adolescents: the Bogalusa Heart Study. Am J Clin Nutr 1999; 69:308-17

162. Friis H, Michaelsen KF. Micronutrients and HIV infection: a review. Eur J Clin Nutr 1998; 52:157-63

74. Gard MCE, Freeman CP. Dismantling a myth: Review of eating disorders and socioeconomic status. Int J Eat Disord 1996; 20:1-12

151. Gillespie S. Improving adolescent and maternal nutrition: an overview of benefits and options. UNICEF Staff Working Papers, Nutrition Series, 1997

132. Gillespie SR, Johnston J. Expert consultation on anemia determinants and interventions. Ottawa: Micronutrient Initiative, 1998

100. Godfrey K, Forrester T, Barker DJP, et al. Maternal nutritional status in pregnancy and blood pressure in childhood. Br J Obstet Gynaecol 1994; 101:398-403

35. Golden MHN. Is complete catch-up possible for stunted malnourished children? Eur J Clin Nutr 1994; 48 (Suppl 1): S58-71

59. Gortmaker SL, Must A, Perrin JM, et al. Social and economic consequences of overweight in adolescence and young adulthood. N Engl J Med 1993; 329:1008-12

120. Greene AL. Future time perspective in adolescence: the present of things future revisited. J Youth Adolesc 1986; 15:99-113

146. Gülmezoglu M, de Onis M, Villar J. Effectiveness of interventions to prevent or treat impaired fetal growth. Obstet Gynecol Survey 1997; 52:139-49

92. Gutierrez Y, King JC. Nutrition during teenage pregnancy. Pediatr Ann 1993; 22:99-108

38. Haas JD, Murdoch S, Rivera J, Martorell R. Early nutrition and later physical work capacity. Nut Rev 1996; 54 (Suppl II): S41-48

115. Hall A, Bundy D. The partnership for child development: promoting the health, nutrition and education of school-age children. SCN News 1998; 16:4-7

37. Harrison K, Fleming A, Briggs N, Rossiter C. Growth during pregnancy in Nigerian teenage primigravidae. Brit J Obstet Gynecol 1985; 92(Suppl 5):32-9

24. Heany RP. Nutrition and catch-up bone augmentation in young women (Editorial). Am J Clin Nutr 1998; 68:523-4

78. Heinberg LJ, Wood KC, Thompson JK. Body image. In: Rickert VI (Ed). Adolescent Nutrition – Assessment and management. New York: Chapman & Hall Inc., 1996:136-56

86. Inoussa S, Alihonou E, Vissoh S, et al. Influence of women's social status on the nutritional status of adolescent girls in Bénin. Washington, D.C: ICRW Nutrition of Adolescent Girls Research Program, No.8, 1994

131. International Vitamin A Consultative Group (IVACG). Guidelines for the development of a simplified dietary assessment to identify groups at risk for inadequate intake of vitamin A. Washington, D.C.: International Life Science Institute, 1989

106. Jacoby ER, Cueto S, Pollitt E. When science and politics listen to each other: good prospects from a new school breakfast program in Peru. Am J Clin Nutr 1998; 67 (Suppl):S795-7

104. James P. The global nutrition challenge in the Millenium: Presentation of the draft Commission Report. *In:* ACC/SCN Symposium Report Nutrition Policy Paper #17, Challenges for the 21st Century: A gender perspective on nutrition through the life cycle, pp.25-55, 1998

66. Johnston PK, Haddad EH. Vegetarian and other dietary practices. In: Rickert VI (Ed). Adolescent Nutrition – Assessment and management. New York: Chapman & Hall Inc, 1996:57-88

22. Key JD, Key LL Jr. Calcium needs of adolescents. Curr Opin Pediatr 1994; 6:379-82

135. Kilic I, Ozalp I, Coskun T, et al. The effect of zinc-supplemented bread consumption on school children with asymptomatic zinc deficiency. J Pediatr Gastroenterol Nutr 1998; 26:167-71

124. Kim Y. The effects of a breastfeeding campaign on adolescent Korean women. Pediat Nurs 1998; 24:235-40

44. King JC. Does poor zinc nutriture retard skeletal growth and mineralisation in adolescents? Am J Clin Nutr 1996; 64:375-6

121. Kotler P, Roberto E. Social marketing: strategies for changing public behavior. New York: The Free Press, 1989

90. Kramer MS. Determinants of low birth weight: methodological assessment and meta-analysis. Bull WHO 1987; 65:663-737

145. Krebs NF. Zinc supplementation during lactation. Am J Clin Nutr 1998; 68 (Suppl):509S-12

34. Kurz KM. Adolescent nutritional status in developing countries. Proc Nutr Soc 1996; 55:321-31

89. Kurz KM. Health consequences of adolescent childbearing in developing countries. Washington, D.C., ICRW Working Paper No. 4, 1997

6. Kurz KM, Johnson-Welch C. The nutrition and lives of adolescents in developing countries: Findings from the nutrition of adolescent girls research program. ICRW, 1994

54. Lauer R, Clarke W. Use of cholesterol measurements in childhood for the prediction of adult hypercholesterolemia. J Am Med Assoc 1990; 264:3034-8

17. Law CM, Shiell AW, Is blood pressure inversely related to birthweight? The strength of evidence from a systematic review of the literature. J Hypertension 1996; 14:935-41

43. Léger J, Czernichow P. Croissance et taille finale des sujets nés avec un retard de croissance: facteurs prédictifs. In: Journées Parisiennes de Pédiatrie 1999. Paris: Médecine-Sciences Flammarion 1999:61-7

52. Leon DA, Koupilova I, Lithell HO, et al. Failure to realise growth potential in utero and adult obesity in relation to blood pressure in 50 year-old Swedish men. BMJ 1996; 312:401-6

164. Leroy V, Newell ML, Dabis F et al. International multicentre pooled analysis of late postnatal mother-to-child transmission of HIV-1 infection. Lancet 1998; 352:597-600

85. Leslie J. Improving the nutrition of women in the Third World. In: Pinstrup-Andersen P et al (eds). Child Growth and nutrition in developing countries: Priorities for Action. New York: Cornell University Press, 1995

10. Li R, Chen X, Yan H, et al. Functional consequences of iron supplementation in iron-deficient female cotton mill workers inn Beijing, China. Am J Clin Nutr 1994; 59:908-13

26. Lloyd T, Andon MB, Rollings N, et al. Calcium supplementation and bone mineral density in adolescent girls. J Am Med Assoc 1993; 270:841-4

139. McDonagh M. Is antenatal care effective in reducing maternal morbidity and mortality? Health Policy Plann 1996; 11:1-15

3. Maddaleno M, Silber TJ. An epidemiological view of adolescent health in Latin America. J Adolesc Health 1993; 14:595-604

36. Martorell R, Kettel Khan L, Schroeder DG. Reversibility of stunting: Epidemiological findings in children from developing countries. Eur J Clin Nutr 1994; 48 (Suppl 1):S45-57

81. Milligan RAK, Burke V, Dunbar D, et al. Associations between lifestyle and cardiovascular risk factors in 18-year-old Australians. J Adolesc Health 1997; 21:186-95

158. Morris AD, Boyle DIR, McMahon AD, et al. Adherence to insulin treatment, glycaemic control and ketoacidosis in insulin dependent diabetes mellitus. Lancet 1997; 350:1505-10

96. Motil KJ, Kertz B, Montandon CM, Ellis KJ. Dietary nutrients are diverted from milk production to body stores in lactating adolescents. Fed Proc 1996; 10:A190

47. Must A, Jacques PF, Dallal GE, Dietz WH. Reference data for obesity: 85th and 95th percentiles of body mass index (wt/ht^2) and triceps skinfold thickness. Am J Clin Nutr 1991; 53:839-46, 1991 (Correction: Am J Clin Nutr 1991; 54:773)

56. Must A, Jacques PF, Dallal GE, et al. Long-term morbidity and mortality of overweight adolescents: a follow-up of the Harvard Growth Study of 1922 to 1935. N Engl J Med 1992; 327:1350-5

11. Nelson M. Anaemia in adolescent girls: effects on cognitive function and activity. Proc Nutr Soc 1996; 55:359-67

80. Neumark-Sztainer D, Story M, Toporov E, et al. Covariations of eating behaviors with other health-related behaviors among adolescents. J Adolesc Health 1997; 20:450-8

68. Neumark-Sztainer D, Story M, Resnick MD, Blum RW. Lessons learned about adolescent nutrition from the Minnesota Adolescent Health Survey. J Am Diet Assoc 1998; 98:1449-56

77. Neumark-Sztainer D, Story M, Falkner NH, et al. Sociodemographic and personal characteristics of adolescents engaged in weight loss and weight/muscle gain behaviors: Who is doing what? Prev Med 1999; 28:40-50

67. Nowak M, Speare R. Gender differences in food-related concerns, beliefs and behaviours of north Queensland adolescents. J. Paediatr Child Health 1996; 32:424-7

110. Nutbeam D. Promoting health and preventing disease: An international perspective on youth health promotion. J Adolesc Health 1997; 20:39-402

134. Pant CR, Pokharel GP, Curtale F, et al. Impact of nutrition education and mega-dose vitamin A supplementation on the health of children in Nepal. Bull WHO 1996; 74:533-45

29. Parra-Cabrera S, Hernandez-Avila M, Tamayo-y-Orozco J, et al. Exercise and reproductive factors as predictors of bone density among osteoporotic women in Mexico City. Calcif Tissue Int 1996;59: 89-94

49. Pietrobelli A, Faith MS, Allison DB, et al. Body mass index as a measure of adiposity among children and adolescents: A validation study. J Pediatr 1998; 132:204-10

161. Pinhas-Hamiel O, Zeitler P. A weighty problem – Diagnosis and treatment of Type 2 diabetes in adolescents. Diabetes Spectrum 1997; 10:292-8

41. Popkin BM, Richards MK, Montiero CA. Stunting is associated with overweight in children of four nations that are undergoing the nutrition transition. J Nutr 1996; 126:3009-16

39. Post GB, Kemper HC. Nutrient intake and biological maturation during adolescence. The Amsterdam growth and health longitudinal study. Eur J Clin Nutr 1993; 47:400-8

149. Prentice A, Jarjou LM, Stirling DM, et al. Biochemical markers of calcium and bone metabolism during 18 months of lactation in Gambian women accustomed to a low calcium

intake and in those consuming a calcium supplement. J Clin Endocrinol Metab 1998; 83:1059-66

8. Raunklar RA, Sabio H. Anemia in the adolescent athlete. Am J Dis Child 1992; 146:1201-5

23. Recker RR, Davies KM, Hinders SM, et al. Bone gain in young adult women. J Am Med Assoc 1992; 268: 2403-8

21. Rees JM, Christine MT. Nutritional influences on physical growth and behavior in adolescence. In: Adams G (ed). Biology of adolescent behaviour and development. California: Sage Publications, 1989

141. Rees JM, Englebert-Fenton K, Gong E, Bach C. Weight gain in adolescents during pregnancy: rate related to birthweight outcome. Am J Clin Nutr 1992; 56:868-73

83. Robinson TN, Killen JD. Ethnic and gender differences in the relationship between television viewing and obesity, physical activity, and dietary fat intake. J Health Educ 1995; 26 (Suppl.2):91-7

130. Rockett HR, Colditz GA. Assessing diets of children and adolescents. Am J Clin Nutr 1997; 65 (Suppl): S1116-22

76. Rosen DS, Neumark-Sztainer D. Review of options for primary prevention of eating disturbances among adolescents. J Adolesc Health 1998; 23:354-63

94. Rush D. Effects of changes in maternal energy and protein intake during pregnancy, with special reference to fetal growth. In: Sharp F, Fraser RB, Milner RDG (Eds). Fetal growth. London: Royal Coll Obstetr and Gynecol 1989:203-29

122. Samuels SE. Project LEAN – Lessons learned from a national social marketing campaign. Pub Health Rep 1993; 108:45-53

28. Sandstead HH. Zinc deficiency. A public health problem? Am J Dis Child 1991; 145:853-9

42. Sawaya Al, Dallal G, Solymos G, et al. Obesity and malnutrition in a shantytown population in the city of Sao Paolo, Brazil. Obes Res 1995; 3 (Suppl 2): S107-15

153. Schlundt DG, Hill JO, Sbrocco T, et al. The role of breakfast in the treatment of obesity: a randomized clinical trial. Am J Clin Nutr 1992; 55:645-51

95. Scholl TO, Hediger ML, Ances IG. Maternal growth during pregnancy and decreased infant birth weight. Am J Clin Nutr 1990; 51:790-3

116. Schucksmith J, Hendry LB. Health issues and adolescents: growing up, speaking out. England: Routledge, 1998

30. Scrimgeour EM. Prevention of fracture of the neck of the femur: evidence from developing countries of the relative unimportance of osteoporosis. Aust N Z J Med 1992; 22:85-6

4. Senderowitz J. Adolescent health: reassessing the passage to adulthood. World Bank Discussion Paper No. 272, Washington, D.C: World Bank, 1995

55. Serdula MK, Ivery D, Coates RJ, et al. Do obese children become obese adults? A review of the literature. Prev Med 1993; 22:167-77

70. Sharma I. Trends in the intake of ready-to-eat food among urban school children in Nepal. SCN News 1998; 16:21-2

31. Shatrugna V. Osteoporosis in the Asian region: newer questions. In: Shetty P, Gopalan G (ed). Diet, nutrition and chronic disease. An Asian perspective. UK: Smith & Gordon, 1998:81-3

60. Sheperd R and Dennison CM. Influences on adolescent food choices. Proc Nutr Soc 1996; 55:345-57

107. Simeon DT. School feeding in Jamaica: a review of its evaluation. Am J Clin Nutr 1998; 67 (Suppl):S790-4

133. Smitasiri S, Attig GA, Valyasevi A, et al. Social marketing vitamin A-rich foods in Thailand: a model nutrition communication behavior change process. New York: UNICEF, and Thailand: Institute of Nutrition of Mahidol University, 1993

61. Spear B. Adolescent growth and development. In: Rickert VI (Ed). Adolescent nutrition. Assessment and management. New York: Chapman & Hall, 1996:1-24

53. Stark D, Atkins E, Wolff DH et al. Longitudinal study of obesity in the National Survey of Health and Development. Brit Med J 1981; 283:12-7

73. Story M, French SA, Resnick MD, et al. Ethnic/racial and socioeconomic differences in dieting behaviors and body image perceptions in adolescents. Int J Eat Disord 1995; 18:173-9

71. Strasburger VC, Donnerstein E. Children, adolescents, and the media: issues and solutions. Pediatrics 1999; 103:129-39

33. Strause L, Saltman P, Smith KT, et al. Spinal bone loss in postmenopausal women supplemented with calcium and trace minerals. J Nutr 1994; 124:1060-4

20. Tiwari BD, Godbole MM, Chattopadhyay N, et al. Learning disabilities and poor motivation to achieve due to prolonged iodine deficiency. Am J Clin Nutr 1996; 63:782-6

103. Tullock J. Integrated approach to child health in developing countries. Lancet 1999; 354 (Suppl II):16-20

1. United Nations. The sex and age distribution of the world populations: The 1996 revision. New York: United Nations, 1997

63. U.S. Dept Health and Human Services, Am Sch Health Assoc, Assoc Adv Health Educ, Soc Public Health Educ, Inc. The National Adolescent Student Health Survey: A Report of the Health of America's Youth. Oakland, CA: Third Party, 1989

84. U.S. Dept Health and Human Services. Physical activity and health: A report of the Surgeon General. Atlanta, Ga: Centers for disease control and prevention, 1996

13. Van den Broek NR, Letsky EA, White SA, Shenkin A. Iron status in pregnant women: which measurements are valid? Br J Haematol 1998; 103:817-24

40. Van Lenthe FJ, Kemper CG, van Michelen W. Rapid maturation in adolescence results in greater obesity in adulthood: the Amsterdam Growth and Health Study. Am J Clin Nutr 1996; 64:18-24

136. Van Stuijvenberg ME, Kvalsvig JD, Faber M, et al. Effect of iron-, iodine-, and β-carotene-fortified biscuits on the micronutrient status of primary school children: a randomized controlled trial. Am J Clin Nutr 1999; 69:497-503

98. Vieira Bruno Z, Bailey P. Brazil: Adolescent longitudinal study. Summary of final report prepared for the Women's Study Project, Family Health International, 1998

12. Walker SP, Grantham-McGregor S, Himes JH, Williams S. Adolescent Kingston girls' school achievement: nutrition, health and social factors. Proc Nutr Soc 1996; 55:333-43

93. Wallace JM, Aitken RP, Cheyne MA. Nutrient partitioning and fetal growth in rapidly growing adolescent ewes. J Reprod Fertil 1996; 10:183-90

51. Wang Y, Popkin B, Zhai F. The nutritional status and dietary pattern of Chinese adolescents, 1991 and 1993. Eur J Clin Nutr 1998; 52: 908-16

18. West K, Katz J, Khatry SK, et al. Double blind, cluster randomised trial of low dose supplementation with vitamin A or β-carotene on mortality related to pregnancy in Nepal. Brit Med J 1999; 318:570-5

48. WHO. Physical status: The use and interpretation of anthropometry. Report of a WHO Expert Committee. Technical Report, Geneva, 1995a

142. WHO Maternal anthropometry and pregnancy outcomes. A WHO collaborative study. Geneva: WHO, 1995b

105. WHO. Promoting health through schools: The World Health Organization's Global School Health Initiative. Geneva: WHO, 1996a

125. WHO. Preparation and use of food-based dietary guidelines. Report of a joint FAO/WHO Expert Consultation, Nicosie, Cyprus, 1995. Geneva: WHO, 1996b

50. WHO. Obesity - Preventing and managing the global epidemic. Report of a WHO consultation on obesity, 3-5 June 1997. Geneva: WHO, 1998a

126. WHO. Preparation and use of food-based dietary guidelines. Report of a joint FAO/WHO consultation. Geneva, WHO Tech Rep Series No 880, 1999b

152. WHO. Management of severe malnutrition: a manual for physicians and other senior health workers. Geneva: WHO, 1999c

102. WHO/UNFPA/UNICEF Study Group on Programming for Adolescent Health. Programming for Adolescent Health: Discussion Paper, WHO, 1995

75. Wilfley DE, Schreiber GB, Pike KM, et al. Eating disturbance and body image: comparison of a community sample of adult black and white women. Int J Eat Disord 1996; 20:377-87

144. Winkvist A, Habicht JP, Rasmussen KM. Linking maternal and infant benefits of a nutritional supplement during pregnancy and lactation. Am J Clin Nutr 1998; 68:656-61

119. Wodarski JS, Smokowski PR, Feit MD. Adolescent preventive health: a cost-beneficial social and life group paradigm. J Prevent Interv Community 1996; 14:1-40

46. Woodruff BA, Duffield A, Blanck H, et al. Prevalence of low body mass index and specific micronutrient deficiencies in adolescents 10-19 years of age in Bhutanese refugee camps, Nepal. UNHCR, 1999-11-25

99. Woodward M, Bolton-Smith C, Tunstall-Pedoe H. Deficient health knowledge, diet and other lifestyles in smokers: is a multifactorial approach required? Prev Med 1994; 23:354-61

108. World Bank. World Development Report 1993: Investing in Health. Washington, World Bank, 1993