United Nations System

Standing Committee on Nutrition

6th report on the world nutrition situation

PROGRESS IN NUTRITION

- Regional trends
- Maternal nutrition
- Nutrition security

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Foreword

The nutrition community is witnessing, living through and helping to build very exciting and important times to Nutrition globally. The food and nutrition scene is definitely changing. New actors are joining forces, more effective connections are being made and stronger leadership is emerging. A nutrition movement to support countries to bring their efforts to scale is born. It is our collective responsibility to nourish and nurture this movement, setting aside individual stakeholder's interests and agendas, acting as one team, and engaging in a truly collaborative joint work to improving nutrition. There simply is no time to waste.

The Sixth report on the world nutrition situation focuses on "Progress in Nutrition" and confirms that there has been notable progress in the reduction of undernutrition in some countries. Control of iodine deficiency, for example, is a success story in progress. Vitamin A deficiency is gradually being controlled either when measured by serum retinol levels or clinical signs of the deficiency. The reader will also find out what the trends are for stunting and underweight and how these trends differ geographically. However, this report clearly delivers the message that despite progress, quick acceleration of efforts is needed for bringing actions to scale.

With 5 years to come to achieve the Millennium Development Goals (MDGs) set in 2000, it is important to evaluate whether the nutrition target is on track and where additional efforts and support are needed.

This report also critically looks at the intergenerational cycle of growth failure, which continues to claim and compromise lives. It makes a strong call for a renewed effort to invest in maternal nutrition in a sustainable and holistic manner.

Finally, this report shows the need for making stronger connections between food security and nutrition for sustainable solutions and a lasting change. One chapter is dedicated to the challenges for achieving this and identifies a number of emerging themes, including climate change.

There is an urgent need for strengthening nutrition governance in countries, but also in regions and globally, to create an enabling policy and institutional environment for accelerated progress. Appropriate nutrition governance mechanisms should take the form of broad-based partnerships gathered in multi-stakeholder platforms that convene and provide the political space for all key nutrition stakeholders to be able to speak and be heard, to take joint decisions and reach agreements on concrete ways to develop capacities for country-led responses to malnutrition in a sustainable way. Special attention should be given to four elements that good governance mechanisms should address: 1) leadership and stewardship, 2) development of existing in country capacities, 3) strengthening service delivery systems, and 4) sufficient, adequate and appropriate financing.

From a global perspective the landscape is complex and initiatives are increasingly taking place, mobilizing the health, food security and social protection constituencies. Within this intricate architecture of initiatives, constituencies, stakeholders and mechanisms, providing leadership and steering efforts towards convergence, bridging them and creating synergies are paramount to maximize impact and further contribute to achieving nutrition security. For the progressive strengthening of nutrition systems at all levels, stakeholders and initiatives must act synergistically, and not be competitive.

The UNSCN was mandated by the United Nations General Assembly intergovernmental Economic and Social Council (ECOSOC) in 1977 to be a global point of convergence in harmonizing nutrition policies and activities and providing initiative in the development and harmonization of concepts, policies, strategies and programmes in response to the nutritional needs of countries. Along its 30 years of existence, the UNSCN has been playing a relevant role in global nutrition. The time has come to reconstruct its working processes including all key nutrition stakeholders in the dialogue – country

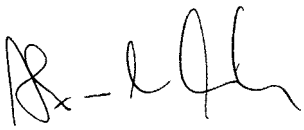
governments, bilateral cooperation partners, nongovernmental organizations, civil society organizations, private philanthropic foundations and the business sector, research and academic institutions, Bretton Woods institutions and the UN entities. The time is now to advance in re-organizing and modernizing its ways of operating. Through its reform, the UNSCN will better deliver global support functions that meet current needs.

The reform is progressing fast and institutional arrangements relating to nutrition are being looked at directly by senior executives of the UN as recognition that an effective mechanism for better collaboration, harmonization and accountability in nutrition is critically important.

Meanwhile, the work continues in full speed. Some highlights:

1) During the summer of 2010, the UNSCN has provided decisive support to developing the Scaling Up Nutrition (SUN) Road Map which proposes what needs to be done, what investments are required and highlights the key working principles. The next step is to implement the Road map and I am working with the UN Secretary-General Special Representative on Food Security and Nutrition on effective arrangements for creating a special and unified team to take the work forwards;
2) More recently, the UNSCN has been called to become a member of the Advisory Group of the Committee on World Food Security (CFS) to ensure that nutrition is considered in all deliberations of that committee. The UNSCN is expected to act as a "connector" to ensure food security and nutrition constituencies collaborate and move forward jointly; and
3) New electronic discussion fora were set up and are actively working in producing harmonized position papers on a variety of emerging issues such as climate change.

I trust this report will help making the case that we must collectively place people, especially the most vulnerable women and children, at the centre of all our actions. I am confident it will bring light on what needs to happen in countries. I hope it will trigger genuine efforts to focus on what needs to be quickly done now. Enjoy the reading.



Alexander Müller
Chair

United Nations System
Standing Committee on Nutrition

Chapter 1 Introduction

Hunger and inadequate food supply are still affecting large parts of the world's population with serious consequences for health and well-being, especially in children. Undernutrition and malnutrition in childhood interfere with physical and mental development, thus compromising whole lives. Assuring adequate nutrition from an early age on is therefore a prerequisite for a society's prosperity. Diet plays a special role because of the importance of specific micronutrients for growth and development.

So far, efforts to combat undernutrition and malnutrition, and make progress towards the first Millennium Development Goal (MDG), which aims to "eradicate extreme poverty and hunger", by reaching the target of halving (by 2015, as compared with 1990) the proportion of people who suffer from hunger, have achieved some success. Thus, the proportion of undernourished children less than 5 years of age has been lowered from 33% in 1990 to 26% in 2006. Worldwide, however, the number of undernourished people is continuing to rise, and recent economic hardship threatens to postpone further achievements.

The aim of the UNSCN's periodically published reports on the world nutrition situation is to highlight the impact nutrition problems have, particularly on developing nations, by describing and analyzing the global food and nutrition situation. After its predecessor's excursion into the role of nutrition in strategies for health improvement, this Sixth report on the world nutrition situation brings regional trend analyses to the fore, while at the same time pursuing the subject of nutrition throughout the life-cycle (discussed in the Second and Fourth reports) with a chapter dedicated to maternal nutrition and its effects on child health.

Chapter 2 of this report compares regional trends in undernutrition and malnutrition. As in previous reports, the three major nutrition-related health issues, vitamin A and iodine deficiency as well as anaemia, are considered in more detail. While anaemia can have a number of causes not necessarily related to nutrition, a high proportion results from iron deficiency, especially in women of childbearing age. Accordingly, measures to counteract anaemia are strongly focused on iron supply. Data on underweight and stunting are given as indicators of undernutrition, and are analysed using the new WHO growth standards. Trends in the prevalence of underweight, stunting and low energy intake provide a means to monitor progress towards MDG 1.

Chapters 3 and 4 of this report are more analytical, the first one focussing on progress towards the MDG 3 (gender equality) and MDG 5 (maternal health), the second one on MDG 7 (environmental sustainability). MDG 5 and 7 have been seriously affected by the food price crisis.

Chapter 3 looks at the importance of maternal nutrition in the intergenerational transmission of growth failure. Recent events associated with the food price crisis have shown how the intergenerational transmission of growth failure first manifests in a worsening of the nutritional status of the mother (Shrimpton et al., 2009). Because of gender inequality, the mother is often the last to benefit in a household when things are going well and the first to be sacrificed when things are going poorly. As shown in Figure 1, if the first impact of the food price crisis is on the mother, then MDG 5 is obviously affected. This then also influences the survival, growth and development of her offspring, so that progress towards the achievement of MDG 1 and MDG 4 (child health) is also affected. Chapter 3 revisits the discussions of the importance of maternal nutrition, which were first raised in the Second Report on the world nutrition situation, and looks at the importance of maternal nutrition across the life-course, and especially during adolescence, in the intergenerational cycle of growth failure.

Chapter 4 introduces a new subject to the series of reports on the world nutrition situation. It looks at the sustainability of food security, especially focusing on ways to assure the right to food that is adequate in quantity, quality, and is culturally acceptable. In the light of recent environmental, climatic and economic developments, sustainability is getting increasing attention. The food price crisis has revealed how fragile global food security is. In many countries, food security has been put in peril because of the uncertainties caused by the malfunction of global market mechanisms. Financial constraints bring about a decline of diet quality and diversity when more expensive nutrient-dense foods are replaced by cheaper staple foods. As already mentioned, pregnant women and children are the hardest hit by such attempts to cope.

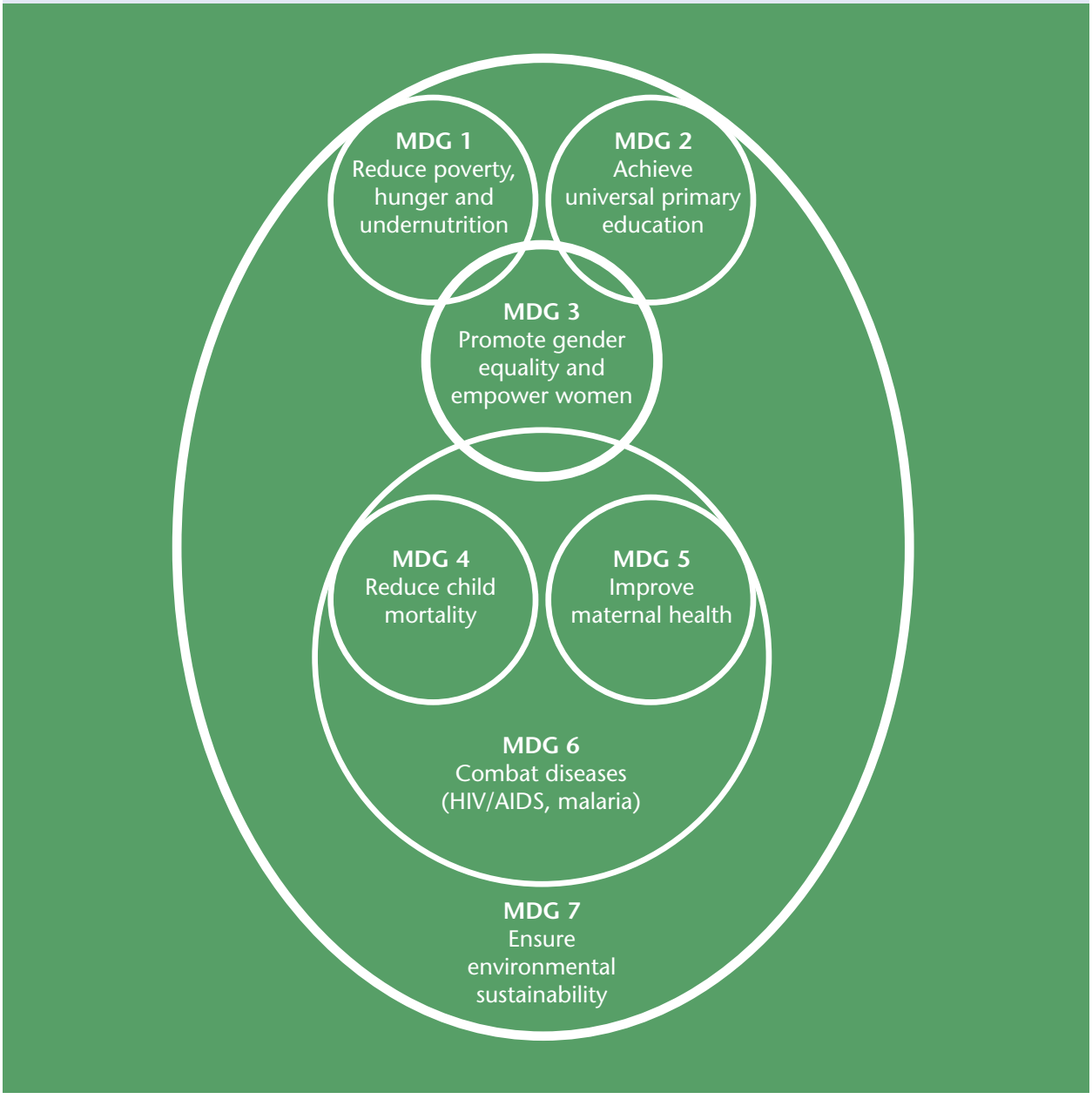
Bearing in mind recent difficulties, the perspectives for feeding the projected global population of nine billion in 2050 seem daunting. In such a scenario, how can the human right to adequate food be realized? Some approaches to improving access to food are presented, with the focus being particularly on local food production. Special atten-

tion is given to the need to provide assistance to smallholders in order to maintain agricultural diversity, and thus both improve the nutritional situation and minimize the ecological consequences of agriculture. However, reconciling environmental interests with the needs of low-income communities is crucial for the success of any strategy.

Furthermore, the impact of nutritional transition in many developing countries has to be considered.

Facing the current economic crisis, assuring the human right to adequate food and nutrition and freedom from hunger is more important than ever for future achievements.

Figure 1. The Millennium Development Goals (MDGs): the critical importance of MDG 3 and MDG 7 for achieving all other MDGs



Summary chapter 2
Regional trends

Chapter 2 updates the trend estimates for undernutrition – child underweight and micronutrient deficiencies – going back to 1990.

VITAMIN A DEFICIENCY

In all developing countries, an estimated 163 million children are vitamin A deficient (by low serum retinol), with a prevalence of about 30%. South central Asia (which includes India) has the highest prevalence, and along with central and west Africa has a prevalence of more than 40%. South and central America and the Caribbean have the lowest prevalences, near 10%. South central Asia has two thirds of the affected children.

Is progress in eliminating vitamin A deficiency adequate to meet the MDG targets for malnutrition – of halving the prevalences between 1990 and 2015? In east Asia (China and Mongolia), and much of south and central America and the Caribbean, the rates of reduction of vitamin A deficiency (low serum retinol) are not far off those needed to halve the prevalence from 1990 to 2015. But in most of Africa (except north Africa) and south central Asia progress is lagging far behind that needed.

More effective interventions, including expanded fortification with vitamin A, will be needed to reduce vitamin A deficiency at an accelerated rate.

IODINE DEFICIENCY DISORDERS

The main driving force for change in the prevalence of iodine deficiency disorders is coverage of iodized salt, unlike for the other nutritional deficiencies where socioeconomic, health and dietary change may establish an underlying secular trend.

Looking at the period <1990, we can see that increased coverage of iodized salt was associated with lower total goitre rate. This pattern is repeated for 1990–1994.

As salt iodization expanded to more countries through time, surveys tended to come from countries with higher coverage. By 1995–2000, the surveys from countries with iodization >75% had a mean total goitre rate of 12.0% (n=17). In the period >2000, the mean rate was 10.5%. The gradient with endemic groups and low (<25%) iodization persisted – as would be expected – in the first three time bands, although numbers of surveys in this group become progressively less, as iodization has continued to expand.

These associations can be examined by plotting total goitre rate against iodized salt coverage. The slope overall is significant, confirming that the associations discussed above are meaningful. The significant interaction term indicates that countries with higher endemic prevalence respond more strongly to salt iodization – as expected.

Similar results were found using low urinary iodine as the outcome. Low urinary iodine prevalences are notably high – more than 60% – with low salt iodization coverage. Low urinary iodine does not appear to vary systematically with endemic total goitre rate; it varies only with iodized salt coverage. This might be in line with low urinary iodine being a shorter term measure, reflecting current iodized salt coverage, but the spread of data is inadequate to examine this further.

ANAEMIA

Repeated national surveys of anaemia in non-pregnant women provide a first insight into current levels and recent trends. About half the countries (16/33) suggest deterioration. Although this provides only a rough indication of possible directions of change – compared with vitamin A deficiency or child underweight, for which most countries were improving – it is one sign that anaemia is different, and not showing the long-term slowly improving trend of the other malnutrition problems assessed here.

For non-pregnant women, no trend really appears; rather, the levels seem fairly static at around 45% in Africa and Asia, and somewhat lower in the Americas/Caribbean. For pregnant women the results are similar to those for non-pregnant women, with prevalences somewhat higher (although cut-off points defining anaemia are lower). For children, the data availability itself is interesting because it shows how few surveys were done before 1995. Since then, high prevalence in children has been established, reaching over 60% in Africa.

Anaemia in women is a particularly persistent problem, and it is not going away, not even at a slow rate like the other nutritional problems. Some 40% of women are affected, especially in Asia and Africa, but even in south America and the Caribbean one quarter of women are anaemic. An estimated 500 million or more women are anaemic, most of them in Asia.

Given the implications of anaemia for iron deficiency in children, and its relation to constraining cognitive development, the very high prevalences – up to two thirds in east Africa, for example – should be of broad concern in terms of education and fostering human capital.

What do these estimates suggest about country priorities and programmes? In most regions progress is slow, especially for women as the most numerous affected group. Anaemia among non-pregnant women in south central Asia (mainly India) is nearly 60% and improving little. In African countries the prevalence is around 45% and is not improving or even worsening. The Caribbean situation also gives grounds for concern. The causes of this extensive anaemia are diverse and no doubt vary between countries. Malaria has a substantial effect where endemic, and anaemia is one of many reasons for malaria control. Animal products in the diet are highly correlated with lowering anaemia levels.

In general, dietary improvement with enhanced bioavailability of iron and better public health can be expected to gradually decrease anaemia. But we are not seeing this, at least not in women. This contrasts with the slow but fairly steady improvement seen in other nutritional problems in children (as we do as well for anaemia). It is essential to reduce anaemia in adolescence; and supplementation in schools may have a role. But there is no escaping the urgent need to widely increase the intakes of bioavailable iron, and widespread fortification is likely to be part of the solution.

UNDERWEIGHT AND STUNTING

Although underweight and stunting results are similar in Africa and Asia, in south and central America & Caribbean child malnutrition is represented more by stunting. Stunting prevalence in some countries in this region is in the 30-50% range (e.g. Bolivia, Guatemala, Haiti, Honduras, Peru). Overall, stunting prevalences in the region are falling at a rate similar to (or faster than) underweight. However, for the high stunting prevalence countries listed above there is little recent change.

For Africa, the rates of improvement are low, with prevalences declining by 0.1 percentage points per year over the region as a whole, and by less than 0.2 percentage points per year in all subregions. This represents slow improvement, except in the southern Africa subregion which exhibits no change. In north Africa, the prevalence is relatively low and the improvement rate is enough to meet MDG1. In eastern, central and west Africa the trend needs to be accelerated to parallel that envisaged by MDG 1. HIV/AIDS no doubt contributes to this situation, particularly in southern Africa and elsewhere where HIV prevalences are high. Drought and economic stress, in places interacting with HIV/AIDS, are major constraints.

In east, south central and south east Asia steady gains are generally in line with the rates required to meet MDG1. Trends in China and India substantially drive those in Asia and indeed in the developing world. In China, the underweight prevalence in children aged 0–5 years was reported as 6.8% in 2002, compared with 18.7% in 1987 and 17.4% in 1992. Halving the 1990 prevalence of 17% means reaching 8.5%; evidently, the MDG1 for China was achieved some years ago. In India, the underweight prevalence in children aged 0–3 years decreased from 44.4% in 1998-1999 to 41.6% in 2005. This represents a decrease of 0.4-0.5 percentage points per year. The rate required to achieve MDG1 in India is a decrease of approximately 1 percentage point per year, so acceleration is required.

South and central America and the Caribbean have low prevalences of underweight, and generally these are moving downwards, in line with or better than MDG1.

Child stunting trends are, in general, similar to those for underweight. Except for south and central America and the Caribbean, and west Asia, underweight and stunting prevalences are highly correlated, moving together through time and telling a similar story. However, for south and central America, stunting prevalences remain substantial, and suggest a continuing problem to be addressed. For example, in Africa the prevalence of underweight is 20% and the prevalence of stunting is 39%. In Asia, the prevalence of underweight is 22% and the prevalence of stunting is 31%. But in south and central America & Caribbean, the prevalence of underweight is only 4%, whereas the prevalence of stunting is 15% – there is proportionately more stunting.

Countries often do not improve slowly and steadily; rather, they go through transitions, from persistent high prevalences to low which tend to be resilient. When these trends are averaged by region they appear to be steadier than when teased apart. Most countries thus start off with high prevalences of underweight (and stunting) of around 30-60%, which may continue decreasing at up to 0.5 percentage points per year. Then, at a certain point, a transition may begin, and over two or more decades prevalences may reach single figures.

A key question is: what triggers (and sustains) periods of rapid improvement in child nutrition? And can such transitions be initiated and supported by deliberate policy decisions and intervention programmes?

Most long-term health and nutrition changes are part of broader trends, probably both contributing to and depending on them. In general, both the improved socio-economic environment and the wide coverage of health and nutrition programmes play a role. In most cases, community-based programmes have expanded so that mothers and children have contact with trained and supported community health and nutrition workers.

Community-based programmes and extended primary health care need to be implemented successfully and need to provide near-universal coverage. That is where much of the challenge now lies.

LOW BIRTH WEIGHT

The incidence in south and south east Asia has fallen by approximately 0.3 percentage points per year over the past two decades: in south Asia from 34% to 27%, and in south east Asia from 18% to 12%. East Asia (mainly China) already had low incidence of low birth weight in the 1980s, and the rate has now fallen to about 6%. In this region, only west Asia shows a deteriorating trend in the past two decades. The incidence of low birth weight in Asia has fallen, from 22% in the 1980s to 18% in the 2000s. Despite these improvements, Asia still has the highest percentage of low-birth-weight babies.

Overall, low birth weight in Latin America and the Caribbean was already relatively low in the 1980s and has remained fairly static. The region reached 10% in the 2000s from 13% in the 1980s. Nearly half of the countries in this region show improvement, but the overall rate of change for the region is slow (0.1 percentage points per year over 20 years). Central America had the highest incidence of low birth weight in the region in 1980 (15%) and has shown the most change (0.25 percentage points per year). In line with trends in underweight and stunting, sub-Saharan Africa has essentially remained static over the past twenty years, perhaps with east Africa showing some improvement.

Low maternal pre-pregnancy body mass index is a known determinant of low birth weight, and persistence of low body mass index from a mother's own low birth weight is likely to contribute to the intergenerational nature of growth failure. Regional trends in maternal underweight and low birth weight from the 1980s to the 2000s show that low birth weight tends to move with the prevalence of low body mass index in women.

This has several implications. First, in Asia particularly, these suggest a virtuous cycle of improved birth size leading to better grown children, thence to better grown mothers, and hence further lowered low-birth-weight rates. Second, improvements in women's nutrition and health, growing up and in adulthood, benefits the next generation. Third, other factors that support intrauterine growth have a beneficial effect on this process – of which one of the most important may be preventing teenage pregnancies discussed in the maternal nutrition chapter.

Adolescent and child marriage continues to be a strong social norm in the developing world, particularly in central and west Africa, and south and south east Asia.

Age at marriage is highly correlated with age at first birth. Increased median age at marriage is associated with lower incidence of low birth weight overall, and in Africa and Asia.

The implications are that policies and programmes – such as helping to keep girls in school and implementing laws to prevent under-age marriage – that postpone first pregnancies until the mother is fully grown will have important benefits for the health of both mother and child. Indeed, this could be a crucial factor in sustainably cutting the intergenerational transmission of malnutrition, and hastening transitions from high levels of low birth weight and malnutrition to those seen in more developed countries, accelerating the progress towards the normal growth and development.

Chapter 2
Regional trends

This chapter updates the trend estimates for undernutrition – child underweight and micronutrient deficiencies – going back to 1990. The exercise draws on results from early reports on the world nutrition situation for comparative purposes, particularly the first two reports (ACC/SCN, 1987, 1992), for example to assess the joint evolution of low birth weight, child underweight, and maternal body mass index. The data and analyses build on those published in 2005, including the work on micronutrient deficiencies by Tulane University (Mason, Rivers & Helwig, 2005).

VITAMIN A DEFICIENCY[1]

Vitamin A deficiency has well-recognized clinical signs, including night blindness and corneal damage (eye signs are known as xerophthalmia), having low prevalences typically of 2% or less, which are difficult to assess accurately by surveys. Increasingly, the extent and trends in vitamin A deficiency have come to be assessed using other methods, of which "the only biochemical parameter validated and found practical for routine survey use is serum retinol concentration" (Sommer & Davidson, 2002). One agreed cut-off point is 20 µg/dl, and the criterion for establishing a public health problem is >15% prevalence. The term "sub-clinical" has been generally dropped, and low serum retinol can be referred to as vitamin A deficiency, meaning the state of inadequate vitamin A nutrition. For clarity, the term used here is low serum retinol (< 20 µg/dl, which is the same as < 0.7 µmol/l).

Serum retinol has been estimated on the basis of national surveys in about 100 developing countries, with 80 of these surveys being carried out after 1990.[2] As described in more detail in the Annex to this report, trends can be assessed in three main ways: by comparing national surveys in the same countries at different times; by averaging survey results within time bands and regions (which has the drawback of not usually having the same countries in each time band); and by estimating prevalence of low serum retinol from models for each country and for selected years, and comparing weighted averages by region. Similar estimates can be made for xerophthalmia – although with fewer results and low prevalences – and these are given below using the first two methods. The main focus here is, however, on low serum retinol.

Repeated national survey estimates of xerophthalmia are available from 12 countries, as shown in Table 1, more being available in earlier years. These results suggest that xerophthalmia prevalences improved in the 1980s and 1990s in most of the countries with comparable data. Averaging all available national results (not just those with repeated estimates) indicates a prevalence of about 1-2%, and likely improvement (Table 2). Clinical signs mean severe deficiency. When vitamin A deficiency causes blindness (a small but relevant proportion of overall xerophthalmia), the case-fatality rate may be as high as 50%. Thus any significant prevalence indicates a continuing problem. Sommer & Davidson (2002) define significant prevalence as night blindness > 1%, or Bitot spots > 0.5%.

Trends indicated by repeated comparable national surveys of prevalence of low serum retinol (see Table 3) suggest that there has been a general improvement, roughly of 1 percentage point per year, in countries where the starting prevalence is substantial (e.g. Ethiopia and Guatemala). The crude average prevalences are around 30-40% in Africa and Asia, and 10-20% in Latin America and the Caribbean (Table 4), but no real trend is apparent from these averages (which, as noted in the Annex, do not usually contain the same countries in each time band, and thus are not really comparable by region).

The main method for assessing trends is to compute values for the prevalence of low serum retinol for each country for selected years (2000, 2005 and 2007), and then to combine these values with estimates for 1990, 1995 and 2000 (Mason, Rivers & Helwig, 2005) to establish a trend. The trend can then be compared with progress towards targets such as those associated with Millennium Development Goal 1 (MDG).[3] This method for assessing trends is described in the Annex. It involves using predictor variables, available for each country and year, in a multivariable regression model (number of cases =109). The model

1 Based on the work of Bibi Al-Ebrahim, MPH.

2 A recently developed field method using retinol-binding protein immunoassay is becoming available but has not been widely enough applied for the results to be incorporated here (see http://www.path.org/files/TS_update_rbp-eia.pdf).

3 The World Summit for Children (1990) set the goal of the "virtual elimination of vitamin A deficiency and its consequences, including blindness, by the year 2000" (UN, 1990).

values are estimated using available data, and are applied to each country for the base years. Population-weighted means are then calculated for groups of countries.

The method is based on models used to provide earlier anthropometric estimates (ACC/SCN, 1988, 1993) as well as estimates of micronutrient deficiencies (Mason et al., 2001; Mason, Rivers & Helwig, 2005). It is similar to models used by WHO (2009), except here the focus is on trends so that estimates are made for single specified years, compared to WHO's estimates for the time band 1995-2005. The levels estimated here for the middle of the period are almost identical to those estimated by WHO (2009) for the ten-year period, if the different regional definitions are taken into account.

In all developing countries, an estimated 163 million children are vitamin A deficient (by low serum retinol), with a prevalence of about 30%. Regional estimates are given in Table 5 and Figures 2-4. South central Asia (which includes India) has the highest prevalence, and along with central and west Africa has a prevalence of more than 40%. South and central America and the Caribbean have the lowest prevalences, near 10%. South central Asia has two thirds of the affected children. These prevalences and numbers affected are very similar to those estimated by WHO (2009, Tables 11 and 14), for 1995-2005.

The trends, especially compared to MDG goals, are of particular operational interest. Is progress in eliminating vitamin A deficiency adequate to meet the MDG targets for malnutrition – of halving the prevalences between 1990 and 2015? In Figures 2-4 the data are plotted along with the rates implied by the MDGs. Similar comparisons are made in Table 5, columns G-J. In east Asia (China and Mongolia), and much of south and central America and the Caribbean, the rates of reduction of vitamin A deficiency (low serum retinol) are not far off those needed to halve the prevalence from 1990 to 2015. But in most of Africa (except north Africa) and south central Asia progress is lagging far behind that needed. The rates in southern Africa and south central Asia should probably be calculated from 1995. Estimates for southern Africa are largely determined by data from South Africa, and the 1990 estimate is affected by the changes which took place at that time in South Africa. In south central Asia, although India is dominant, the 1990 estimate is not really comparable with later estimates as the central Asian countries (the "Stans") were coming into existence. Calculated from 1995, both southern Africa and south central Asia are thus probably lagging, so an overall picture of about half the reduction rate needed to halve the prevalence is seen in most country groups.

It should be noted that the widespread use of vitamin A supplements (UNICEF, 2007), reaching more than half the developing countries' children, does not appear to be affecting the prevalence of low serum retinol very much. Studies show that vitamin A supplementation every six months has little effect on serum retinol, and the purpose is usually seen as aiming to reduce child mortality rather than affecting serum retinol itself. This can be seen, for example, in the continued apparent increase (or at least no reduction) in low serum retinol in the Philippines (Table 3) during a period in which 6-monthly supplementation coverage has been at least 80%; analyses have shown that any increase here in serum retinol only lasts 2 months or so (Pedro et al., 2004). In contrast, central American countries (e.g. Nicaragua, see Table 3) where sugar and wheat have been fortified with vitamin A have reached and maintained low prevalences of low serum retinol.

Subregional trends can be estimated, as shown in Table 5, and individual countries can be classified in terms of bands of prevalences reflecting the extent of the problem of vitamin A deficiency. Countries can be described as having a "severe problem but improving" through to "minor problem but worsening", with several categories in between. The classification given by the International Vitamin A Consultative Group/Micronutrient Forum, known as the Annecy Accords (Sommer & Davidson, 2002), suggests that a 15% prevalence of < 20 µg/dl serum retinol should define a problem requiring attention. We can then use 15%, 15-30% and > 30% to categorize the severity of the public nutrition problem. This reflects more diversity than the 10% and 20% cut-off points previously used by WHO, where most (58%, 60/104) developing countries fall into the worst (> 20%) category. Using the 15%, 15-30% and > 30% categories: 47% of developing countries have >30% prevalence; 24% have 15-30% prevalence; and 29% have <15% prevalence. The results are shown in Table 6.

The 15%, 15-30% and > 30% classification makes it possible to identify countries of particular concern – in eastern, central and west Africa, and in south central Asia – where the improvement rate is low and prevalences are high

Table 1. Prevalence of xerophthalmia (night blindness XN + Bitot spots X1B) in preschool children: results from repeated national surveys

Country	Survey year (a)	Prevalence (%)	Age group surveyed (months)	Trend
Bangladesh	1983 1996 1997 1999	4.5 1.2 0.9 0.5	0-59 0-59 0-59 6-59 (b)	Improvement
Cambodia	1993 2000	6.2 1.05	12-72 18-72	Improvement
Ethiopia	1980 1996	2.0 1.5	6-83 6-60	Improvement
India	1988 2000 2001	1.4 1.2 1.7	0-59 0-59 24-72(b)	No change
Indonesia	1978 1995	2.0 0.3	0-59/0-71 0-59	Improvement
Lao People's Democratic Republic	1995 2000 2000	1.1 4.7 0.1	24-71 6-59 0-59 (by examination) (c)	Improvement
Mongolia	1998 1999 2001	0.2 0.8 1.65	6-72 6-72 6-72	Deterioration
Myanmar	1991 1994	1.2 0.8	0-59 0-59	Possible improvement
Nepal	1981 1993 1996 1998	1.0 3.0 1.5 0.6	0-71(b) 0-59 6-35(b) 0-59	Improvement
Niger	1988 1992 2000	3.0 3.7 3.15	0-71 24-59 24-72	Deterioration
Philippines	1982 1987 1993	3.2 0.9 0.4	0-59 0-59 0-72	Improvement
Viet Nam	1994 1998 2000	0.1 0.3 0.0	0-59 0-59 0-72	Improvement

a No data found after 2001 could be compared with earlier data, because no relevant country data were available for comparison purposes.
b Age groups surveyed are as shown, but prevalences have been adjusted to be equivalent to 0-59 months.
c Trend is unclear because of the different ways in which clinical signs were reported: prevalence based on individuals reporting night blindness was much higher than that obtained from eye examinations.

Table 2. Mean prevalence (%) of clinical vitamin A deficiency (night blindness XN + Bitot spots X1B) calculated by averaging survey[a] results, by date of survey and region

Region / Date of survey	Before 1990	1990-1994	1995-1999	2000-2004	After 2005
Africa	2.52 (4)	2.43 (2)	.85 (2)	2.52 (3)	1.95 (1)
Asia	2.02 (6)	.97 (5)	.70 (11)	1.13 (7)	NS
Latin America and Caribbean	1.67 (1)	NS	NS	NS	NS
Total	2.17 (11)	1.39 (7)	.73 (13)	1.55 (10)	1.95 (1)

NS. No survey available.
a Number of surveys is given in parentheses. Data include national survey results for children up to 72 months of age.

Table 3. National prevalence of moderate vitamin A deficiency (serum retinol < 20 µg/dl or < 0.7 µmol/l) in preschool children: results from repeated national surveys

Country	Survey year	Prevalence (%)	Age group surveyed (months)	Trend
Costa Rica	1979 1981 1996	2.3 1.8 8.7	0-59 0-59 12-72	Possible deterioration
Ethiopia	1980 1996	59.6 38.9	6-59 6-59	Improvement
Guatemala	1970 1995	26.2 15.8	0-59 12-59	Improvement
Honduras	1987 1996	20.0 13.0	0-59 12-71	Improvement
Mongolia	1998 2001	19.8 4.0	6-72 6-60	Improvement
Nicaragua	2000 2003 2004	8.8 0.2 3.1	12-59 6-60 6-60	Improvement (fortified sugar from 2000 on)
Nigeria	1993 2001	28.1 29.5	6-60 6-60	No change or deteriorating
Oman	1995 2004	20.8 5.5	6-60 6-60	Improving
Panama	1992 1999	6.0 9.4	0-72 12-59	Unclear
Peru	1999 2000 2001	10.9 13.1 14.9	<60 NS-5 NS-5	Possible deterioration
Philippines	1993 1998 2003	35.5 38.0 40.1	6-60 6-59 6-60	Deterioration
Sri Lanka	1995 1996	33.0 28.0	6-60 6-60	Too short a period to assess trend
Zambia	1999 2003	65.7 54.1	<60 6-60	Improvement

Table 4. Mean prevalence (%) of moderate vitamin A deficiency (serum retinol < 20 µg/dl or < 0.7 µmol/l) calculated by averaging survey results, according to date of survey[a] and region

Date of survey	Before 1990	1990-1994	1995-1999	2000-2004	After 2005
Region					
Africa	35.1 (5)	33.7 (7)	39.9 (13)	45.8 (7)	27.9 (1)
Asia	35.4 (5)	36.4 (4)	29.8 (7)	31.4 (8)	NS
Latin America and Caribbean	20.5 (10)	19.3 (8)	12.4 (15)	11.6 (7)	5.9 (1)
Total	27.9 (20)	28.2 (19)	26.1 (35)	29.7 (22)	16.9 (2)

NS. No survey available.
a Number of surveys is given in parentheses. Data include national survey results for children up to 72 months of age.

Table 5. Estimated prevalence of serum retinol < 20 µg/dl, children 6-60 months, 1990-2007 (columns A-E); numbers affected in 2007 (column F); rate of prevalence change in percentage points per year (column G); rate and change required to reach the Millennium Development Goal (columns H-J)

Sub-region			Preva-lence			Number (million)	Rate 1990-2007	Rate required to reach MDG	Change required to reach MDG	Comment on effort needed to reach MDG
	1990	1995	2000	2005	2007	2007	ppts/yr			
	A	B	C	D	E	F	G	H	I	J
Africa										
East Africa	43.7	43.2	41.5	39.5	37.5	17,825	-0.36	-0.87	-0.51	Much increase in rate needed
Central Africa	40.8	42.8	45.8	45.8	42.5	9,259	0.10	-0.82	-0.92	Much increase in rate needed
North Africa	32.6	29.4	24.9	21.9	22.4	4,942	-0.60	-0.65	-0.05	On track
Southern Africa	37.2	27.4	27.7	27.3	25.0	1,530	-0.20(a)	-0.74	-0.03	Much increase in rate needed (a)
West Africa	45.0	45.5	44.4	42.4	40.4	19,163	-0.27	-0.90	-0.63	Much increase in rate needed
Total for the region	41.4	40.6	39.5	38	36.4	52,718	-0.29	-0.83	-0.53	
Asia										
East Asia	17.1	17.2	15.3	11.4	10.6	8,892	-0.38	-0.34	0.04	On track
South central Asia	55.2	49.7	47.9	44.7	44.4	82,147	-0.64/- 0.29(b)	-1.10	-0.47	Much increase in rate needed (b)
South east Asia	29.3	26.4	23.5	22.2	21.2	10,038	-0.48	-0.59	-0.11	Some increase in rate needed
West Asia	27.8	21.3	24.5	21.7	20.9	3,236	-0.41	-0.56	-0.15	Some increase in rate needed
Total for the region	37.3	35.2	33.8	31.8	31.4	104,312	-0.35	-0.75	-0.40	
South and central America & Caribbean										
Caribbean	19.1	16.7	18.3	16.2	15.0	506	-0.24	-0.38	-0.14	Some increase in rate needed
Central America	17.2	14.3	13.3	12.2	12.9	2,005	-0.25	-0.34	-0.09	Some increase in rate needed
South America	19.6	16	13.1	11.7	10.6	3,859	-0.53	-0.39	0.14	On track
Total for the region	19.1	15.6	13.5	12.1	11.5	6,369	-0.45	-0.38	0.07	On track
Overall for the above regions	**36.4**	**34.6**	**33.2**	**31.3**	**30.7**	**163,400**	**-0.34**	**-0.73**	**-0.39**	

a Rate calculated from 1995 (rate from 1990 anomalous because of South Africa).
b Rate better when calculated from 1995 (-0.29) because countries of the former Soviet Union are not included in 1990 figure.

Figure 2.
Vitamin A deficiency in children in Africa, trends 1990-2010

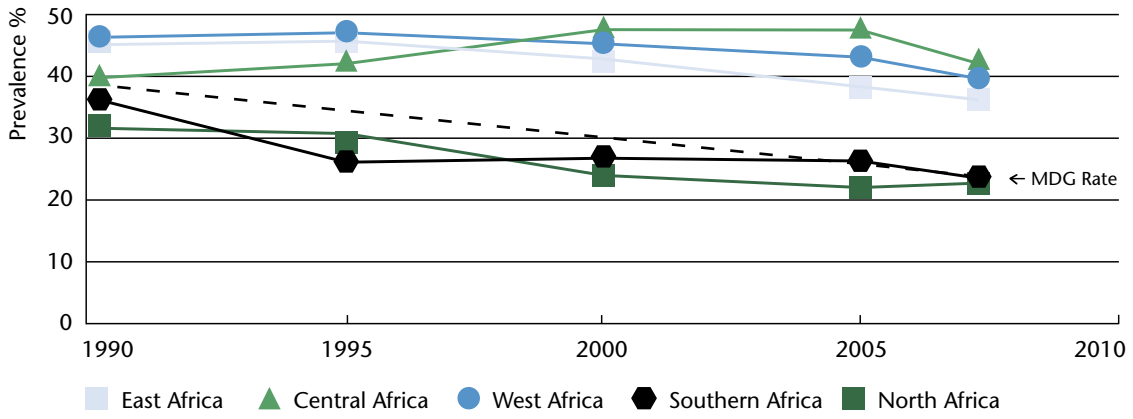


Figure 3.
Vitamin A deficiency in children in Asia, trends 1990-2010

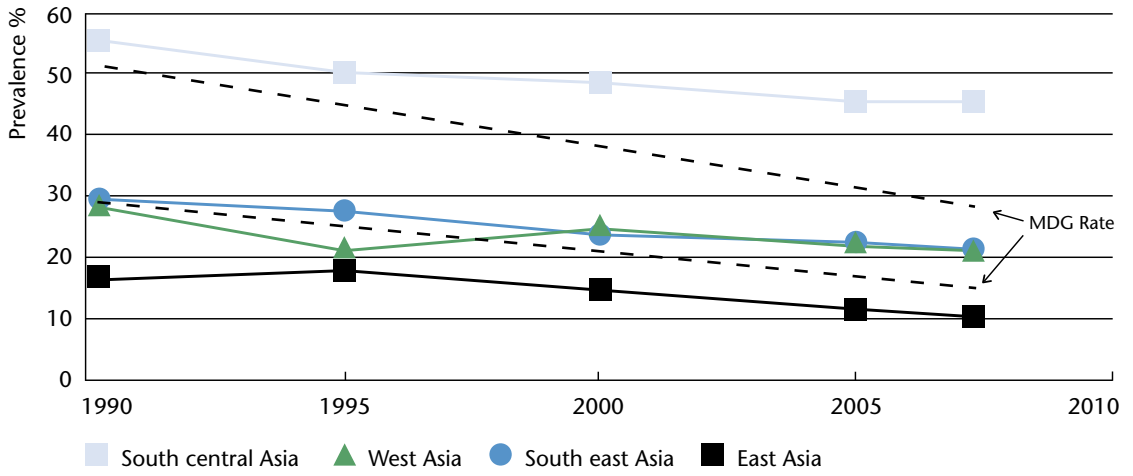


Figure 4.
Vitamin A deficiency in children in South and Central America, trends 1990-2010

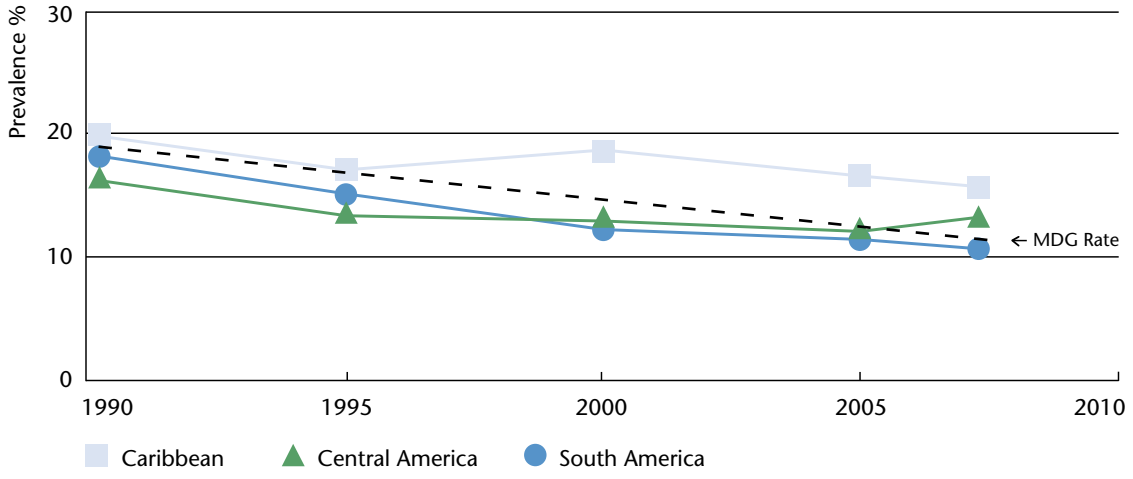


Table 6. Vitamin A deficiency (low serum retinol) prevalence and severity as a public nutrition problem, by WHO and UNSCN estimates and classification

Country	Prevalence WHO estimate (1995-2005)	WHO source: Survey (a)	WHO classification (b)	UNSCN classification (c)	Prevalence UNSCN estimate (2007)
Burundi	27.9	N	4	2	42.6
Eritrea	21.4		4	1	28.2
Ethiopia	46.1		4	2	41.2
Kenya	84.4	N	4	2	34.1
Madagascar	42.1	N	4	2	33.1
Malawi	59.2	N	4	2	47.1
Mauritius	9.2	N	2	1	18.8
Mozambique	68.8	N	4	2	33.4
Rwanda	6.4	N	2	2	41.5
Somalia	61.7		4	2	47.7
Uganda	27.9	N	4	2	35.8
United Rep. of Tanzania	24.2	N	4	2	33.8
Zambia	54.1	N	4	2	40.2
Zimbabwe	35.8		4	1	27.3
Angola	64.3	N	4	2	43.8
Cameroon	38.8	N	4	2	37.2
Central African Rep.	68.3	N	4	2	46.7
Chad	50.1		4	2	52.3
Congo	24.6		4	2	32.3
Congo, DR	61.1	N	4	2	42.2
Gabon	16.9		3	1	28.5
Algeria	15.7		3	1	18.3
Egypt	11.9	N	3	1	17.8
Libya	8.0		2	0	12.5
Morocco	40.4	N	4	2	35.1
Sudan	27.8		4	1	21.3
Tunisia	14.6		3	0	14.3
Botswana	26.1		4	1	23.1
Lesotho	32.7		4	1	28.5
Namibia	17.5		3	1	25.1
South Africa	16.9		3	1	24.8
Swaziland	44.6		4	2	30.1

Table continued on next page.

(table 6 continued from previous page). Vitamin A deficiency (low serum retinol) prevalence and severity as a public nutrition problem, by WHO and UNSCN estimates and classification

Country	Prevalence WHO estimate (1995-2005)	WHO source: Survey (a)	WHO classification (b)	UNSCN classification (c)	Prevalence UNSCN estimate (2007)
Benin	70.7	S	4	2	41.2
Burkina Faso	54.3			2	47.8
Cote d'Ivoire	57.3		4	2	37.4
Gambia (the)	64.0	N	4	1	22.4
Ghana	75.8	S	4	2	34.8
Guinea	45.8		4	2	45.4
Guinea-Bissau	54.7		4	2	44.1
Liberia	52.9	N	4	2	40.5
Mali	58.6		4	2	50.4
Mauritania	47.7		4	2	36.9
Niger	67.0		4	2	44.0
Nigeria	29.5	N	4	2	38.9
Senegal	37.0		4	2	36.7
Sierra Leone	74.8		4	2	56.2
Togo	35.0		4	2	36.6
China	9.3	N	2	0	10.6
Mongolia	19.8	N	3	1	21.4
Afghanistan	64.5		4	2	51.7
Bangladesh	21.7	N	4	1	23.4
Bhutan	22.0		4	1	25.7
India	62.0	S	4	2	52.1
Iran	0.5	N	1	0	14.7
Kazakhstan	27.1	S	4	2	40.8
Kyrgyzstan	26.3		4	2	39.9
Nepal	32.3	N	4	1	24.5
Pakistan	12.5	N	3	2	30.1
Sri Lanka	35.3	S	4	0	10.2
Tajikstan	26.8	S	4	2	40.0
Turkmenistan	28.0		4	2	37.4
Uzbekistan	53.1		4	2	36.2

Table continued on next page.

(table 6 continued from previous page). Vitamin A deficiency (low serum retinol) prevalence and severity as a public nutrition problem, by WHO and UNSCN estimates and classification

Country	Prevalence WHO estimate (1995-2005)	WHO source: Survey (a)	WHO classification (b)	UNSCN classification (c)	Prevalence UNSCN estimate (2007)
Cambodia	22.3	N	4	2	32.8
Indonesia	19.6		3	1	20.5
Lao PDR	44.7	N	4	2	30.2
Malaysia	3.5	N	2	1	17.2
Myanmar	36.7		4	2	30.1
Papua New Guinea	11.1	S	3	2	31.0
Philippines	40.1	N	4	1	19.0
Thailand	15.7		3	1	15.9
Viet Nam	12.0	S	3	1	20.8
Armenia	0.6	N	1	2	33.0
Azerbaijan	32.1		4	2	35.3
Georgia	30.9		4	0	10.0
Iraq	29.8		4	2	26.9
Jordan	15.1	N	3	2	11.5
Kuwait				0	8.5
Lebanon	11.0		3	0	14.0
Saudi Arabia	3.6		2	0	13.0
Syrian Arab Republic	12.1		3	0	12.5
Turkey	12.4		3	0	
United Arab Emirates					8.6
Yemen	27.0		4	2	27.2
Cuba	3.6	N	2	0	6.2
Dominican Republic	13.7		3	0	13.1
Haiti	32.0	N	4	1	22.3
Jamaica	29.4	N	4	0	11.7
Trinidad and Tobago	7.2		2	0	11.6

Table continued on next page.

(table 6 continued from previous page). Vitamin A deficiency (low serum retinol) prevalence and severity as a public nutrition problem, by WHO and UNSCN estimates and classification

Country	Prevalence WHO estimate (1995-2005)	WHO source: Survey (a)	WHO classification (b)	UNSCN classification (c)	Prevalence UNSCN estimate (2007)
Belize	11.7		3	1	15.1
Costa Rica	8.8	N	2	0	7.8
El Salvador	14.6		3	0	12.5
Guatemala	15.8	N	3	1	16.5
Honduras	13.8	N	3	0	12.0
Mexico	26.8	N	4	0	12.5
Nicaragua	3.1	N	2	0	14.0
Panama	9.4	N	2	0	9.9
Bolivia	21.8		4	1	17.2
Brazil	13.3		3	0	10.9
Chile	7.9		2	0	7.5
Colombia	5.9	N	2	0	9.7
Ecuador	14.7		3	0	10.6
Guyana	4.1	N	2	0	11.5
Paraguay	14.1		3	0	11.0
Peru	14.9	N	3	0	12.6
Uruguay	11.9		3	0	7.8
Venezuela (Bol. Rep. of)	9.4		2	0	9.7

a WHO source: N indicates national survey, S indicates subnational survey (first administrative level), blank indicates regression result (WHO, 2009).
b WHO classification as a public nutrition problem (based on WHO estimates for 1995-2005): 1=0-2%, 2=2-10%, 3=10-20%, 4>=20%.
c UNSCN classification (based on UNSCN estimates for 2007): 0=0-14.9%, 1=15-29.9%, 2= ≥30%.

(> 30%). This directs attention to most of the eastern, central and west African countries, as well as to Afghanistan, India and Pakistan, and several of the central Asian countries.

IODINE DEFICIENCY DISORDERS[4]

Goitre from iodine deficiency has been recognized for centuries, and until recently provided the primary means of assessing the extent of iodine deficiency disorders. Iodine deficiency in pregnancy and early life causes mental retardation, stunted growth, and other developmental abnormalities, which are largely irreversible. In later life it reduces intellectual vigour, educational achievement and productivity, which can be improved with increased iodine intakes.

The global campaign to iodize the salt supply in almost all countries has now led to an estimated 68% of households using iodized salt, in both developing and industrialized countries (UNICEF, 2009). Assessment of progress in controlling iodine deficiency is shifting from reliance on assessment of goitre to biochemistry, using urinary iodine concentrations. While the latter is less subjective, it measures current iodine status (over the last few days before sampling), whereas goitre reflects a considerably longer history. Nonetheless, goitre prevalences do respond usefully, and reductions can be observed at least from year to year with increased iodine intakes.[5] More surveys of goitre are available for earlier years, and more for urinary iodine for the later period.

Interpreting changes in goitre prevalences needs to take account of the endemic (pre-iodized-salt) rate, which varies widely by country, and the coverage and length of time of exposure to iodized salt. A key variable needed therefore is an estimate of the prevalence of goitre in the absence of salt iodization – known here as the endemic goitre rate – from which likely prevalences by country can be predicted from the known iodized salt coverage. This method, including the derivation of the pre-iodization or endemic goitre rate, is described by Mason, Rivers & Helwig (2005, pp. 69-73), and is applied to updated data here. Calculated endemic goitre rates are included in the Annex.

Estimates of the prevalence of low urinary iodine are also available, usually as reported by national surveys. In some cases, estimates are derived from the median urinary iodine, when only this is reported, using a method similar to that given by WHO (2004, p. 7), recalculating the model to include newer data. For iodine deficience disorders indicated by either goitre prevalence or low urinary iodine (<100 µg/l), the estimates for each country (and hence for subregions) by time depend on data on iodized salt coverage, which was only itself available by time bands (1995-2000, 2001-2007). Thus the prevalence estimates derived from modelled interpolations are also presented for these time periods.[6]

Trends in goitre prevalences from available repeated national surveys (with the most recent survey in 1995 or later) from 31 countries show a consistent picture of almost universal improvement – of the 31 countries only 5 were not improving (see Table 7). Moreover, the extent of the improvement is substantial, often from 30% or 40% prevalence down to single digit percentages, over the 10-20 years for which data are available. Indeed, there is not much suggestion of a slowing down of the improvement rate in goitre prevalences. It should be noted that few surveys are post-2003, and it is necessary also to look at urinary iodine to get an idea of trends in the past 5 years or so.

Far fewer repeated surveys of low urinary iodine are available (see Table 8), but again a picture of improvement is seen. However, prevalences remain in double digits, for the limited number of estimates shown here. It is useful to look at these data in other ways to broaden the conclusions.

One approximate method is simply to average survey results within time bands – although the countries are not the same in each time band – and this provides some initial guidance. Results are given in Tables 9 and 10 (note that Tables 9 and 10 include all surveys, whereas Tables 7 and 8 include only repeated surveys). For total goitre rate, even in this rough average the trend is in line with that seen from repeated surveys, and recent regional averages are in the low teens. For urinary iodine, the trend is perhaps less marked, but still likely to be improving for Asia and Africa. Prevalences measured in this way are at least double those for goitre, and over 30% for Asia and Africa.

The main driving force for change in the prevalence of iodine deficiency disorders is coverage of iodized salt, unlike for the other nutritional deficiencies where socioeconomic, health and dietary change may establish an underlying

4 This section is based on the work of Katie Robinette, MPH.

5 Some striking national examples of the prevalence of goiter falling while the use of iodized salt increases are from Bolivia, Cameroon, Nicaragua, Peru, Thailand, United Republic of Tanzania, and Viet Nam (see Mason et al., 2001, Figure 5, p. 24; Mason, Rivers & Helwig, 2005, Figure 8, p. 91).

6 In deriving the models, interpolations for iodized salt coverage were done to match survey years for total goitre rate or urinary iodine.

secular trend. Together with the endemic (pre-iodization) prevalence of iodine deficiency disorders (see Annex Table A5), time of exposure to iodized salt and coverage with iodized salt could be expected to explain observed prevalences – goitre is used here as having a longer time series and more data, as well as presumably being more stable to short-term effects (urinary iodine probably reflects iodine intake in the past few days). Analysing by these three factors (plus outcome, total goitre rate) does give a consistent picture, although the multi-variable nature plus limited amount of data complicates the presentation of the results.

Results for total goitre prevalence are shown in Table 11, which should be read as follows. Countries are categorized by the estimated band of endemic (pre-iodization) goitre rate as <20%, 20-40% and >40%, which defines the rows in Table 11. Four periods are then distinguished, as the broad columns: before 1990; 1990-1994; 1995-2000; and 2000 onwards. Within these broad periods, survey results are presented by current (or at-that-time) iodized salt coverage: <25%, 25-49.9%, 50-74.9 and ≥75%. Table 11 gives information reading both across and down. Looking at the period <1990, in the column referring to coverage before iodization or <25%, the sequence 15.8%, 27.5% and 46.2% reflects the sorting into low, medium and high categories for endemic total goitre rate. The majority of surveys (n=52) come from this category, with a mean total goitre rate of 29.6%. Reading across the row showing 20-40% endemic total goitre rate for <1990 (where most cases fall), we can see that even at that time increased coverage of iodized salt was associated with lower total goitre rate, from 27.5% to 15.6% and on down (but with few cases at higher levels of iodization). This pattern is repeated for 1990-1994: for example the mean of 31.7% (n=14) for coverage before iodization or <25% falls to 15.5%, 18.6% and 12.5% with increased salt coverage. (The significance of these trends is tested using continuous variables, as discussed below in relation to Figure 5.)

As salt iodization expanded to more countries through time, the surveys tended to come from countries with higher coverage, as can be seen in Table 11 by the shift in numbers of surveys by coverage group – the larger numbers of surveys by time band are shaded in the "Total" row – 52/66 in <1990 from <25% iodized salt through 28/57 in this group in 1990-94, but the higher coverage (>75%) increasing to 15/57; then to 17/37 in the high iodization category in 1995-2000, and 14/20 in >2000.

By 1995-2000, the surveys from countries with iodization >75% had a mean total goitre rate of 12.0% (n=17). In the period >2000, the mean rate was 10.5%. The gradient with endemic total goitre rate groups and low (<25%) iodization persisted – as would be expected – in the first three time bands, although numbers of surveys in this group become progressively less, as iodization has continued to expand.

These associations can be examined by plotting total goitre rate against iodized salt coverage, as shown in Figure 5. The slope overall is significant, confirming that the associations discussed above are meaningful. The significant interaction term indicates that countries with higher endemic prevalence respond more strongly to salt iodization – as expected. This is reflected in the steeper gradient for endemic total goitre rate >40%, as compared with the slopes for the lower endemic total goitre rates. A variable measuring time since iodization started (mean = 7.1 years, median = 5.0 years, n=98) was not or only marginally significant (see notes to Figure 5), in line with most of the explanation being associated with the endemic total goitre rate and salt coverage variables tested.

Similar results were found using low urinary iodine as the outcome, albeit with fewer survey data points (see Table 10). Low urinary iodine prevalences are notably high – more than 60% – with low salt iodization coverage. Low urinary iodine does not appear to vary systematically with endemic total goitre rate; it varies only with iodized salt coverage (see Figure 6 and the note on regression results). This might be in line with low urinary iodine being a shorter term measure, reflecting current iodized salt coverage, but the spread of data is inadequate to examine this further. However, looking at the right hand side of Table 12, for the period >2000, the overall decrease in low urinary iodine prevalence with increased iodized salt coverage ("Total" row) – and possibly within endemic (pre-iodization) total goitre rate categories – can be seen. The size of the effect is important here. Where endemic (pre-iodization) total goitre rate is 20% or more, even with >75% iodized salt coverage, a prevalence of around 20% of low urinary iodine is seen, and the prevalence is over 30% with 50-75% coverage. In general, the prevalence is higher in the countries with more endemic iodine deficiency disorders (as endemic goitre).

Prevalences of goitre by region and subregion were estimated for 1995-2000 and 2001-2007 (see Table 13) by applying the results of the multi-variable models to all countries for these two time periods (see Annex). The results are not far different from those obtained by simply averaging surveys (Tables 9 and 10) or by observing repeated surveys (Table 7), which is reassuring. Improvements are seen across the board, in line with the gradual expansion of iodized salt coverage (also shown in Tables 9 and 10), of about 0.5 percentage points per year. Nonetheless, goitre prevalences are estimated to remain substantial, between 10% and 20%, fairly evenly distributed between regions.

The numbers affected are estimated at almost 700 million people.

Equivalent estimates for low urinary iodine are given in Table 14, showing prevalences generally in the 30-40% range, and about 1.7 billion people affected, of whom 1.3 billion are in Asia.

Applying the pre-iodization (endemic) goitre rate to the 2005 population, and comparing this with the estimated current prevalence, indicates the change achieved by salt iodization. This is shown in Figure 7. If iodized salt had not been available in developing countries, some 2 billion people would be affected by iodine deficiency disorders as determined by goitre; as it is, the number is estimated

Table 7.
Total goitre prevalence: results from repeated national surveys (with latest result in 1995 or later)

Subregion	Country	Year survey conducted	Total goitre prevalence (%)	Recent trend
East Africa	Kenya	1984	20.0	
		1994	16.3	
		2004	6.2	Improvement
	Rwanda	1990	49.6	
		1996	17.8	
		1997	25.9	Improvement
	United Republic of Tanzania	1983	42.5	
		1985	37.0	
		1999	23.0	
		2001	17.0	
		2004	6.9	Improvement
	Zimbabwe	1989	42.3	
		1999	14.8	Improvement
Central Africa	Cameroon	1984	70.0	
		1991	26.3	
		1995	10.3	Improvement
	Chad	1993	63.0	
		2003	5.5	Improvement
North Africa	Egypt	1991	5.2	
		1995	6.5	No change
Southern Africa	Lesotho	1988	16.2	
		1999	4.9	Improvement
West Africa	Benin	1983	23.7	
		1994	19.1	
		2000	1.1	Improvement
	Togo	1986	22.1	
		2001	7.2	Improvement

Table continued on next page.

(table 7 continued from previous page).
Total goitre prevalence: results from repeated national surveys (with latest result in 1995 or later)

Subregion	Country	Year survey conducted	Total goitre prevalence (%)	Recent trend
East Asia	China	1986	9.2	
		1995	20.4	
		1997	10.8	
		1999	8.0	
		2002	6.5	Improvement
	Mongolia	1993	28	
		1999	21.4	
		2001	23.0	Same
South central Asia	Bhutan	1982	65.4	
		1992	25.0	
		1996	14.0	Improvement
	Maldives	1995	23.6	
		2002	25.7	Deterioration
	Nepal	1960	55	
		1982	57.6	
		1986	44.2	
		1998	40.0	Improvement
	Sri Lanka	1986	14.4	
		1988	16.6	
		2000	21.0	
		2003	3.0	Improvement
South east Asia	Cambodia	1994	62.0	
		1997	17.0	Improvement
	Indonesia	1981	32.0	
		1982	37.0	
		1988	27.7	
		1996	9.8	
		2003	11.0	Improvement (long-term)
	Lao People's Democratic Republic	1988	25.0	
		1990	20.5	
		2000	9.0	Improvement

Table continued on next page.

(table 7 continued from previous page).
Total goitre prevalence: results from repeated national surveys (with latest result in 1995 or later)

Subregion	Country	Year survey conducted	Total goitre prevalence (%)	Recent trend
South east Asia	Myanmar	1990	18.01	
		1992	25.5	
		1994	33.1	
		1997	25.1	
		1999	12.2	Improvement
	Thailand	1982	14.7	
		1986	17.0	
		1989	19.3	
		1990	17.2	
		1991	16.3	
		1992	12.2	
		1993	11.0	
		1994	7.9	
		1995	5.4	
		1996	5.9	
		2000	2.2	Improvement
	Viet Nam	1993	34.9	
		1994	31.0	
		1995	27.1	
		1998	14.9	
		2000	10.1	Improvement
West Asia	Jordan	1993	37.7	
		2000	32.1	Improvement
	Yemen	1991	40.0	
		1998	16.8	Improvement
Central America	Honduras	1969	17.0	
		1987	8.8	
		1996	4.9	Improvement
	Mexico	1945	28.8	
		1996	3.0	Improvement
	Nicaragua	1971	32.0	
		1981	20.0	
		1990	4.3	
		2000	2.5	Improvement

Table continued on next page.

(table 7 continued from previous page).
Total goitre prevalence: results from repeated national surveys (with latest result in 1995 or later)

Subregion	Country	Year survey conducted	Total goitre prevalence (%)	Recent trend
Central America	Panama	1967	16.5	
		1975	6.0	
		1991	13.2	
		1999	10.2	Improvement
South America	Colombia	1945	52.6	
		1950	33.9	
		1994	6.5	
		1998	6.5	Improvement
	Peru	1977	28.9	
		1987	35.8	
		1999	1.0	Improvement
	Venezuela (Bolivarian Republic of)	1981	17.2	
		1990	10.7	
		1996	14.0	
		2000	2.5	Improvement

Table 8.
Low urinary iodine (< 100 µg/dl): results from repeated national surveys (with latest result in 1995 or later)

Subregion	Country	Year of survey	Urinary iodine <100 µg/l (%)	Recent trend
East Africa	Rwanda	1990	94.2	
		1996	0	Improvement
Southern Africa	Lesotho	1999	100.0	
		2002	21.5	Improvement
West Africa	Côte d'Ivoire	1996	64.8	
		2004	27.6	Improvement
	Nigeria	1998	39.8	
		2001	27.5	Improvement
East Asia	China	2002	16.2	
		2005	15.7	No change
	Mongolia	1999	54.0	
		2001	48.9	
		2006	52.8	Deterioration
South central Asia	Iran (Islamic Republic of)	1996	14.9	
		2001	19.7	Deterioration
	Maldives	1995	65.5	
		2002	43.1	Improvement
	Nepal	1998	35.1	
		2005	27.4	Improvement
	Uzbekistan	1998	97.4	
		2005	39.8	Improvement
South east Asia	Lao People's Democratic Republic	1993	94.8	
		2000	26.9	Improvement
	Myanmar	1999	55.5	
		2001	38.2	
		2004	22.3	Improvement
	Philippines	1998	65.3	
		2003	23.8	Improvement
West Asia	Lebanon	1993	62.5	
		1997	55.2	Improvement
Central America	Nicaragua	2000	13.4	
		2003	8.9	
		2004	11.9	Improvement (long-term)

Table 9. Prevalence of goitre calculated by averaging survey results (unweighted, N= number of surveys) according to time of survey and region

	1995-2000		2001-2007		Estimated endemic total goitre rate
Region	Prevalence (%)	N	Prevalence (%)	N	
Africa	25.6	18	14.5	7	35.1
Asia	17.9	25	12.7	6	36.0
Americas/Caribbean	7.2	9	–	–	34.8
Total	18.7	52	13.6	13	35.2

Table 10. Prevalence of low urinary iodine calculated by averaging survey results (unweighted, N= number of surveys) according to time of survey and region

	1995-2000		2001-2007	
Region	Prevalence (%)	N	Prevalence (%)	N
Africa	35.6	15	32.5	13
Asia	43.8	16	35.4	21
Americas/Caribbean	16.5	10	22.5	4
Total	34.1	41	33.0	38

Table 11. Total goitre prevalence, by country category of endemic (before iodization) goitre prevalence (rows) and iodized salt coverage (columns), within time periods: estimates from available national surveys (number of surveys in brackets) within the corresponding time periods

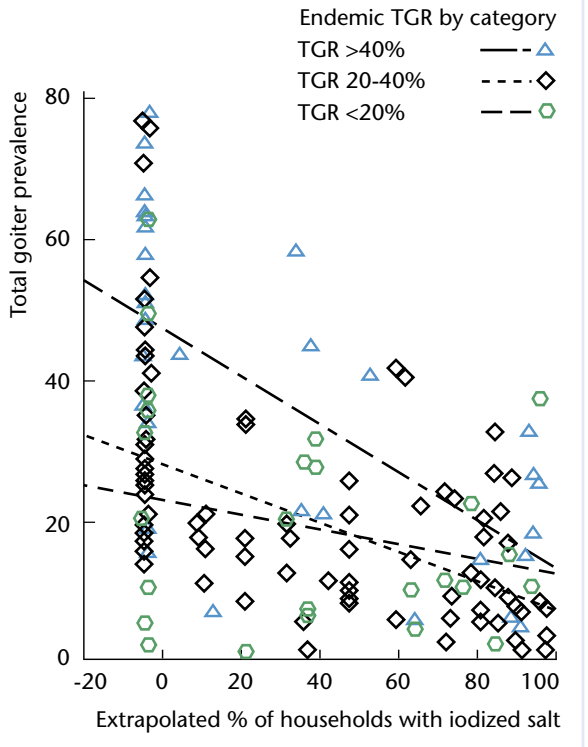
Endemic (pre-iodization) total goitre rate	Coverage of iodized salt (% of households)															
	<1990				1990-1994				1995-2000				>2000			
	Before iodization or <25%	25-50%	50-75%	>75%	Before iodization or <25%	25-50%	50-75%	>75%	Before iodization or <25%	25-50%	50-75%	>75%	Before iodization or <25%	25-50%	50-75%	>75%
<20%	15.8 (5)	17.9 (3)	–	–	25.7 (7)	12.9 (3)	4.3 (1)	17.6 (2)	16.3 (2)	27.1 (1)	9.8 (1)	20.6 (3)	–	–	11.0 (1)	6.3 (2)
20-40%	27.5 (38)	15.6 (4)	12.9 (3)	8.0 (1)	31.7 (14)	15.5 (6)	18.6 (4)	12.5 (10)	36.5 (4)	18.6 (2)	21.5 (7)	6.9 (10)	–	17.1 (1)	2.2 (1)	11.7 (11)
>40%	46.2 (9)	40.9 (3)	–	–	53.3 (7)	–	–	20.5 (3)	63.0 (1)	20.4 (1)	40.0 (1)	18.1 (4)	24.8 (2)	–	5.5 (1)	5.7 (1)
Total	29.6 (52)	23.9 (10)	12.9 (3)	8.0 (1)	35.6 (28)	14.6 (9)	15.2 (5)	14.8 (15)	34.5 (7)	21.2 (4)	22.2 (9)	12.0 (17)	24.8 (2)	17.1 (1)	6.2 (3)	10.5 (14)

Note: as salt iodization coverage expanded, surveys were increasingly in countries with more iodized salt. The prevalences based on the majority of surveys by time period are shaded in the "Total" row.

Table 12. Prevalence of urinary iodine < 100 µg/dl, by country category of endemic (before iodization) goitre prevalence (rows) and iodized salt coverage (columns), within time periods: estimates from available national surveys (number of surveys in brackets) within the corresponding time periods

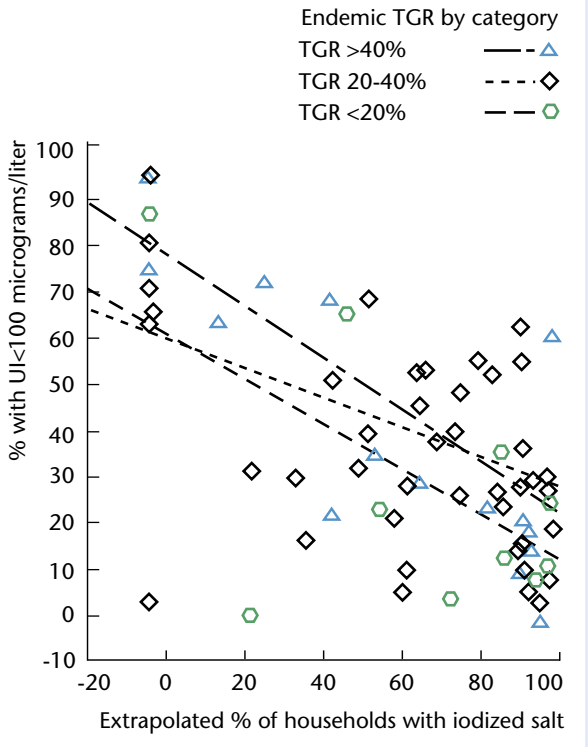
Endemic (pre-iodization) total goitre rate	Coverage of iodized salt (% of households)							
	<2000				>2000			
	Before iodization or <25%	25-50%	50-75%	>75%	Before iodization or <25%	25-50%	50-75%	>75%
<20%	86.0 (1)	33.1 (2)	–	17.0 (2)	–	–	14.5 (2)	17.6 (4)
20-40%	63.4 (7)	33.5 (3)	33.4 (4)	42.5 (8)	–	30.5 (1)	38.3 (8)	26.2 (13)
>40%	84.3 (2)	22.7 (1)	35.1 (1)	26.0 (5)	63.6 (1)	70.1 (2)	29.4 (1)	30.7 (3)
Total	69.8 (10)	31.6 (6)	33.7 (5)	33.6 (15)	63.6 (1)	56.9 (3)	33.1 (11)	25.2 (20)

Figure 5. Association between goitre prevalence and use of iodized salt



Regressions: (a) TGR = 6.810 – 0.02414 (HHIOD) + O.826 (ENDTGR) – 0.006992 (HHIOD*ENDTGR). N= 174, Adj R squ = 0.441. Coefficients: HHIOD NS, ENDTGR p = 0.000, interaction p = 0.004. (Without interaction, HHIOD = -0.244, p = 0.000. (b) Removing HHIOD values of < 5%, HHIOD = -0.139, p = 0.000, n = 95, without interaction term; when included, interaction coefficient NS, p = 0.15. Years since iodized salt started was NS in (a), p=0.10 in (b) (with interaction included).

Figure 6. Association between low urinary iodine and use of iodized salt



Regresssion: UI low = 58.9 – 0.436 (HHIOD) + 0.221 (ENDTGR). N= 69, Adj R squ = 0.302. Coefficients: HHIOD p = 0.000, ENDTGR NS (p = 0.33). Interaction (HHIOD*ENDTGR) NS. Removing HHIOD < 5, HHIOD = -0.324, p = 0.010, n = 59.

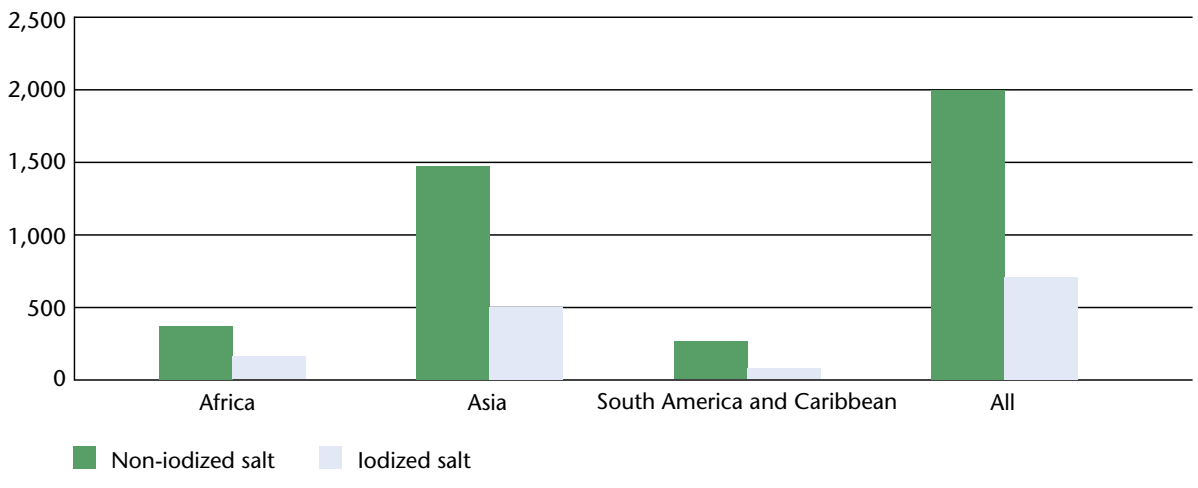
Table 13.
Estimated prevalence of goitre (total goitre rate), numbers affected, and iodized salt coverage

Subregion	Prevalence %		Number (thousand)		% households with iodized salt		
	1995-2000	2000-2007	1995-2000	2000-2007	1995-2000	2001-2007	Estimated endemic total goitre rate
Africa							
East Africa	19.6	15.8	49 945	44 936	62	61	33.2
Central Africa	25.0	17.6	23 902	19 255	49	53	42.8
North Africa	16.4	15.3	28 684	29 161	64	58	36.1
Southern Africa	11.1	10.0	5 638	5 395	49	72	30.6
West Africa	15.7	12.9	37 271	33 852	42	40	34.0
Region	17.9	14.7	145 441	132 599	64	64	35.1
Asia							
East Asia	13.3	10.1	169 578	138 038	80	89	32.3
South central Asia	19.2	18.1	286 540	292 019	42	68	45.5
South east Asia	10.9	7.9	56 676	44 163	54	63	18.7
West Asia	20.2	15.1	22 421	18 937	58	64	30.9
Region	15.8	13.5	535 216	493 157	52	67	36.0
South and central America & Caribbean							
Caribbean	18.9	9.4	5 879	3 057	30	48	10.1
Central America	10.6	8.8	14 462	12 875	86	81	26.2
South America	12.2	11.1	42 248	41 458	92	92	40.4
Region	12.2	10.4	62 589	57 389	77	79	34.8
Overall	15.8	13.3	758 755	692 262	63	71	35.2

Table 14.
Estimated prevalence of low urinary iodine (< 100 µg/dl), numbers affected, and iodized salt coverage

Subregion	Prevalence %		Number (thousand)		% households with iodized salt	
	1995-2000	2000-2007	1995-2000	2000-2007	1995-2000	2001-2007
Africa						
East Africa	50.3	43.2	128 525	123 300	62	61
Central Africa	59.7	40.1	57 111	43 953	49	53
North Africa	41.9	41.5	73 472	79 065	64	58
Southern Africa	35.5	33.1	18 021	17 911	49	72
West Africa	40.2	34.8	95 082	91 521	42	40
Region	45.7	39.4	372 211	355 752	64	64
Asia						
East Asia	32.6	26.0	414 018	355 075	80	89
South central Asia	41.4	40.9	618 526	658 947	42	68
South east Asia	42.6	35.8	221 681	199 054	54	63
West Asia	54.8	44.2	60 789	55 525	58	64
Region	38.7	34.7	1 315 013	1 268 601	52	67
South and central America & Caribbean						
Caribbean	58.2	35.8	18 156	11 686	30	48
Central America	20.5	18.4	27 978	27 042	86	81
South America	14.7	13.5	51 100	50 534	92	92
Region	18.9	16.1	97 234	89 263	77	79
Overall	37.2	33.0	1 784 458	1 713 615	63	71

Figure 7. Predicted 2005 population (million) in developing countries with goitre if there were no iodized salt, compared with current estimate (with 68% iodized salt coverage)



as 0.7 billion. Thus 1.3 billion people have been spared this debilitating deficiency, including children protected from developmental abnormalities.

There are some differences between these results for iodine deficiency disorders and those published by WHO (2004), see Annex Table A5. The regions used are not the same, but some comparisons can be made. The major differences are in estimated trends; the levels are similar between the two estimates for the 1990s, but diverge because WHO (2004) shows a major deterioration between the 1990s and 2000s – almost a doubling of goitre prevalence for Africa and the Eastern Mediterranean (which here is classified as partly north Africa and partly west Asia). The results given here – not only those from models – show consistent improvement into the 2000s in all regions (Tables 7-11). WHO's current exercise to update the estimates for iodine deficiency disorders may shed further light on this discrepancy.

ANAEMIA[7]

Anaemia is assessed by measuring haemoglobin levels, rather than by clinical signs, which are less obvious than for vitamin A deficiency and iodine deficiency disorders. The less obvious nature of anaemia may have contributed to insufficient awareness of the problem – for example, there is no MDG for anaemia. Because assessment requires drawing blood, the extent of representative survey data has tended to be limited and the results are often very variable. In particular, anaemia in children was only recently widely assessed and recognized as extensive. The recent inclusion of haemoglobin estimation in the Demographic and Health Surveys has contributed most usefully to extending our understanding of the anaemia problem.

Anaemia (see Viteri, 1998, for an authoritative overview) is known to be very extensive, affecting nearly half the women in the developing world. This contributes to increased maternal mortality risks, ill-health and debilitation. Anaemia in the general (non-pregnant) female population is assessed as haemoglobin less than 12g/dl, and this leads to anaemia in pregnancy, estimated as < 11 g/dl (in part to take account of increased blood volume in pregnancy and consequent haemodilution). Entering pregnancy anaemic is very difficult to reverse by intervention during pregnancy, although supplementation is important in preventing further falls in haemoglobin levels. In turn, low maternal iron availability leads to reduced iron stores in the newborn infant, a risk factor for childhood anaemia.

Iron deficiency and anaemia are related, but they are not the same problem. Iron deficiency has consequences beyond anaemia, notably for cognitive development. Anaemia is often taken as an indicator of iron deficiency, although the correlation may be poor. Many factors other than iron deficiency may cause anaemia. These may be nutritional, such as folic acid or vitamin A deficiencies; or they may result from disease, through malabsorption and iron loss from intestinal parasites, or malaria causing destruction of red blood cells. Blood losses in reproductive age women, including from pregnancy and childbirth, are a major contributor. The results discussed here refer to anaemia, and the implications for intervention (ACC/SCN, 1991; Caulfield et al., 2006) include increasing iron intake and bioavailability, as well as public health measures to prevent iron loss and control malaria.

Repeated national surveys of anaemia in non-pregnant women provide a first insight into current levels and recent trends. Results from 33 countries with a latest survey after 1999 are shown in Table 15; estimated change with a difference of at least 2 percentage points is considered likely to be significant.[8] About half the cases (16/33) suggest deterioration. Although this provides only a rough indication of possible directions of change – compare with vitamin A deficiency or child underweight, for which most countries were improving – it is one sign that anaemia is different, and not showing the long-term slowly improving trend of the other malnutrition problems assessed here. The results draw particular attention to Africa's potentially worsening problem but suggest that central America may have been improving.

Another approximate look at levels and trends by region can be had from averaging survey results, without taking account of different countries in different groups, as shown in Table 16. For non-pregnant women (Table 16), no trend really appears; rather, the levels seem fairly static at around 40% in Africa and Asia, and somewhat lower in the Americas/Caribbean. Averaged survey results are shown for pregnant women (< 11 g/dl), and for children (< 11g/dl) in Table 16. For pregnant women the results are similar to those for non-pregnant women, with higher prevalences (although cut-off points defining anaemia are lower). For children, the data availability itself is interesting because it shows how few surveys were done before 1995. Since then, high prevalence in children has been established, reaching over 60% in Africa.

7 Based on the work of Amit Wadhwa, MPH.

8 Based on likely sample sizes, see methods.

To fill in the gaps and estimate prevalences for each country for 2000, 2005 and 2007, and hence to derive regional and subregional estimates, multi-variable models were developed. The results are given in Tables 17-19 for non-pregnant women, pregnant women and children, respectively. In addition, for non-pregnant women, previous estimates for 1990, 1995 and 2000 (Mason, Rivers & Helwig, 2005) were linked to allow estimation of the longer-term trend and comparison with potential goals (such as the MDGs). These results are given graphically in Figure 8.

The lack of any improvement in Africa is apparent from these results. Indeed, over all developing regions the rate is not far from zero (Table 17, column G). Anaemia in women is a particularly persistent problem, and it is not going away, not even at a slow rate like the other nutritional problems. Some 40% of women are affected, especially in Asia and Africa, but even in south America and the Caribbean one quarter of women are anaemic. An estimated 500 million or more (Table 17, column F) women are anaemic, most of them in Asia. The long-term (1990-2007) estimated prevalence trend overall of one-tenth of a percentage point per year – only one percent decrease in prevalence per decade – is essentially static, so that the number of non-pregnant women with anaemia will increase with population growth.

A slightly improving trend for anaemia in pregnancy may be occurring (Table 18). This may be in line with improving birth weight trends (see below) and possibly for similar reasons. A similar trend appears to be happening for children (Table 19), again in line with estimated changes in child underweight and stunting. It is difficult to suggest why trends for non-pregnant women and others should be different, and the matter certainly would need further research. Nonetheless, the rates of change for pregnant women and children are still slow. The rates for pregnant women would be about 60% of that required to halve the prevalence over the period 1990-2015 (for instance), and a bit better for children, but starting from a very high level especially in Africa.

Given the implications of anaemia for iron deficiency in children, and its relation to constraining cognitive development, these very high prevalences – up to two thirds in east Africa, for example – should be of broad concern in terms of education and fostering human capital.

The estimates given here are generally in line with those averaged over the period 1993-2005, by UN developing region, given by WHO (2008), as shown in Annex Table A4. The main difference is for non-pregnant women in Asia, which is likely to result from differences in the estimates for China and India. Representative surveys are problematic over such large populations.

The results given here are model-based. If recent results of surveys are substituted the prevalence estimates are closer, as shown in the Annex. These level differences do not affect the trend estimates. Otherwise the estimates are similar, particularly taking account of the differences in location in time.

What do these estimates suggest about country priorities and programmes? In most regions progress is slow, especially for women as the most numerous affected group. Anaemia among non-pregnant women (Figure 8) in south central Asia (mainly India) is nearly 60% and improving little, probably in part because of vegetarian diets. In African countries the prevalence is around 50% and is not improving or even worsening. The Caribbean situation also gives grounds for concern. The causes of this extensive anaemia are diverse and no doubt vary between countries. Malaria has a substantial effect where endemic, and anaemia is one of many reasons for malaria control. Animal products in the diet are highly correlated with lowering anaemia levels (including in the models used here).

In general, dietary improvement with enhanced bioavailability of iron and better public health can be expected to gradually decrease anaemia. But we are not seeing this, at least in women. This contrasts with the slow but fairly steady improvement seen in other nutritional problems in children (as we do as well for anaemia). While iron supplementation in pregnancy is of high priority, this will not affect the broader problem of anaemia in women. Here it is essential to reduce anaemia in adolescence; and supplementation in schools may have a role. But there is no escaping the urgent need to widely increase the intakes of bioavailable iron, and widespread fortification is likely to be part of the solution.

Table 15. Anaemia in non-pregnant women: results from repeated national surveys (with latest result in 2000 or later)

Subregion	Country	Survey year	Prevalence	Recent trend (a)
East Africa	Burundi	1983	64.4	
		2003	28.0	Improvement
	Madagascar	1996	42.4	
		2004	44.9	Deterioration
	Uganda	2000	30.3	
		2001	26.3	
		2007	43.1	Deterioration
	United Republic of Tanzania	1993	55.0	
		2004	46.9	Improvement
	Zambia	1998	41.0	
		2003	29.1	Improvement
	Zimbabwe	1999	34.3	
		2006	37.3	Deterioration
Central Africa	Cameroon	2000	23.7	
		2004	44.5	Deterioration
North Africa	Egypt	1983	25.9	
		2000	26.7	
		2005	38.8	Deterioration
	Morocco	1995	30.8	
		2000	32.6	No change
Southern Africa	Lesotho	1994	15.1	
		2004	33.1	Deterioration
West Africa	Gambia	1987	41.0	
		2001	56.0	Deterioration
	Guinea	2000	50.4	
		2001	59.7	
		2005	49.6	
		2006	66.5	Deterioration
East Asia	China	1981	50.0	
		1988	34.0	
		1992	21.5	
		2002	19.9	Improvement

Table continued on next page.

(table 15 continued from previous page). Anaemia in non-pregnant women: results from repeated national surveys (with latest result in 2000 or later)

Subregion	Country	Survey year	Prevalence	Recent trend (a)
South central Asia	Bangladesh	2001	29.0	
		2004	46.0	Deterioration
	India	1998	51.9	
		2006	53.2	No change
	Nepal	1998	65.0	
		2006	34.0	Improvement
	Sri Lanka	1988	59.8	
		1994	45.1	
		2001	31.9	Improvement
	Pakistan	1987	18.0	
		2001	27.9	Deterioration
South east Asia	Cambodia	2000	56.2	
		2006	44.4	Improvement
	Myanmar	1995	42.0	
		2001	44.9	Deterioration
	Philippines	1978	50.5	
		1982	27.3	
		1993	43.6	
		1998	32.5	
		2003	42.1	Deterioration
	Viet Nam	1987	40.0	
		1995	41.2	
		2001	24.3	Improvement
West Asia	Jordan	1996	28.0	
		2002	28.2	No change
	Armenia	2000	12.4	
		2005	24.2	Deterioration
	Azerbaijan	2001	40.2	
		2006	35.7	Improvement
	Kazakhstan	1995	48.5	
		1999	35.6	Improvement
Caribbean	Haiti	2000	54.4	
		2006	45.1	Improvement

Table continued on next page.

(table 15 continued from previous page). Anaemia in non-pregnant women: results from repeated national surveys (with latest result in 2000 or later)

Subregion	Country	Survey year	Prevalence	Recent trend (a)
Central America	Guatemala	1995	35.0	
		2002	20.2	Improvement
	Honduras	1994	26.0	
		1995	25.8	
		2001	14.7	
		2005	18.1	Deterioration
	Mexico	1977	14.0	
		1988	15.4	
		1990	14.0	
		2006	15.5	No change
	Nicaragua	1993	36.3	
		2000	24.0	
		2000	22.3	
		2003	16.0	Improvement
South America	Bolivia	1998	27.1	
		2004	30.6	Deterioration
	Peru	1996	35.7	
		2000	31.6	
		2004	38.2	Deterioration

a Trend estimated as changing with 2 percentage points or more difference between surveys.

Table 16. Mean prevalence (unweighted) of anaemia calculated by averaging survey results (N=number of surveys), according to time of survey and region

	Before 1990		1990-1994		1995-1999		2000-2004		2005 or later	
Region	Prevalence (%)	N	Prevalence (%)	N	Prevalence (%)	N	Prevalence (%)	N	Prevalence (%)	N
Non-pregnant women 15-49 years old										
Africa	38.7	17	33.5	4	43.4	5	41.0	23	44.1	12
Asia	50.6	29	31.2	4	39.8	14	35.4	19	38.3	5
Americas & Caribbean	26.6	22	26.6	5	31.1	6	28.0	14	24.2	4
Total	39.8	68	30.1	13	38.4	25	35.8	56	38.9	21
Pregnant women										
Africa	44.8	28	31.2	6	46.6	5	53.9	21	55.9	13
Asia	50.4	40	36.7	10	45.3	14	39.4	18	48.3	5
Americas & Caribbean	36.0	23	34.9	8	38.1	9	41.9	10	28.5	4
Total	45.0	91	34.7	24	43.2	28	46.1	49	49.2	22
Children 0-5 years old										
Africa	40.0	2	31.6	3	64.3	5	65.4	23	68.0	14
Asia	54.5	3	22.2	3	48.2	14	41.0	23	51.2	5
Americas & Caribbean	50.5	2	18.0	1	43.3	10	42.0	15	41.4	3
Total	49.2	7	25.6	7	49.3	29	50.5	61	60.6	22

Table 17. Estimated prevalence of anaemia in non-pregnant women, 1990-2007

Region	Prevalence (%)					Number (thousand)	Rate (percentage points per year)
	1990	1995	2000	2005	2007	2007	1990-2007
	A	B	C	D	E	F	G
Africa							
East Africa	42.5	46.7	46.8	46.7	46.6	32 561	0.24
Central Africa	37.4	40.1	43.5	43.2	43.0	11 319	0.33
North Africa	36.9	37.8	38.1	37.4	37.1	18 496	0.01
Southern Africa	34.3	34.4	36.6	35.5	35.4	5 108	0.06
West Africa	46.5	46.1	46.3	46.0	45.7	29 644	-0.05
Region	41.1	42.9	43.6	43.2	43.1	97 128	0.12
Asia							
East Asia	35.6	32.0	28.5	26.0	26.2	94 089	-0.55
South central Asia	59.9	59.5	57.1	56.7	56.8	241 184	-0.18
South east Asia	37.9	35.9	38.0	37.1	36.8	57 017	-0.07
West Asia	30.5	32.7	36.3	35.4	35.1	18 281	0.27
Region	44.6	43.4	42.1	41.2	41.4	410 571	-0.19
South and central America & Caribbean							
Caribbean	30.8	31.5	34.4	33.4	33.3	2 024	0.15
Central America	28.2	24.7	23.8	20.3	20.3	8 997	-0.46
South America	26.8	24.2	25.3	25.1	26.1	23 903	-0.04
Region	27.6	24.7	25.5	24.3	24.9	34 923	-0.16
Overall	42.1	41.3	40.6	39.8	40.0	542 623	-0.12

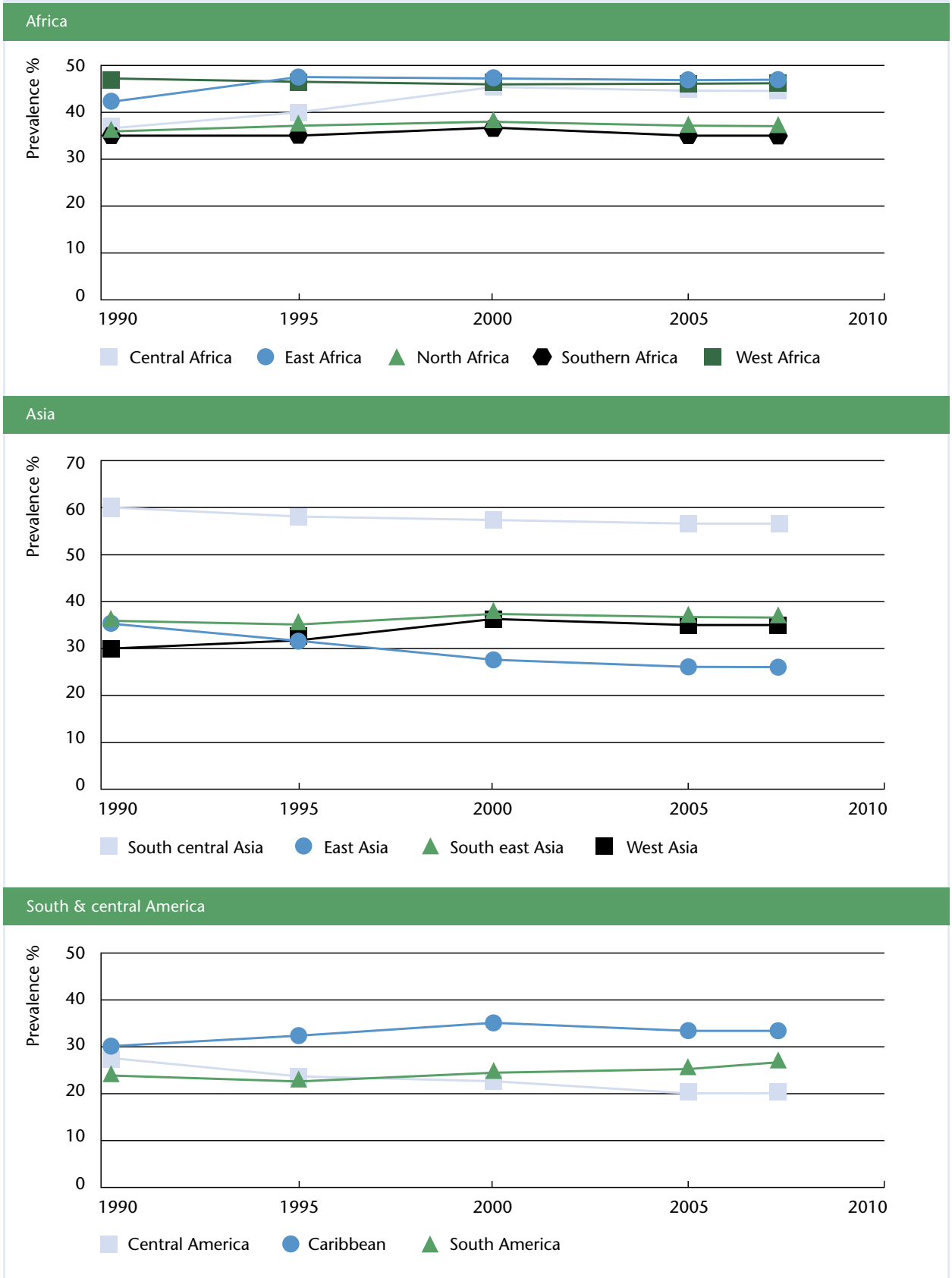
Table 18. Estimated prevalence of anaemia in pregnant women, 2000-2007

Region	Prevalence (%)			Number (thousand)	Rate (percentage points per year)
	2000	2005	2007	2007	2000-2007
Africa					
East Africa	53.6	52.3	52.6	6 156	-0.14
Central Africa	54.1	52.0	53.2	2 723	-0.12
North Africa	41.4	38.8	37.6	1 751	-0.53
Southern Africa	32.4	28.4	27.1	354	-0.76
West Africa	51.4	47.4	46.7	5 195	-0.66
Region	50.3	47.9	47.7	16 179	-0.36
Asia					
East Asia	19.1	13.6	11.2	1 961	-1.13
South central Asia	59.0	56.0	54.6	22 209	-0.62
South east Asia	44.3	41.2	38.7	4 461	-0.79
West Asia	33.9	31.6	31.0	1 496	-0.41
Region	45.6	42.2	40.4	30 127	-0.74
South and central America & Caribbean					
Caribbean	39.5	38.0	36.8	211	-0.38
Central America	29.4	26.9	23.8	796	-0.80
South America	26.9	24.8	22.4	1 529	-0.64
Region	28.4	26.1	23.6	2 537	-0.67
Overall	45.2	42.3	41.0	48 842	-0.61

Table 19.
Estimated prevalence of anaemia in children 0-5 years old, 2000-2007

Region	Prevalence (%)			Number (thousand)	Rate (percentage points per year)
	2000	2005	2007	2007	2000-2007
Africa					
East Africa	70.7	68.8	66.7	34 524	-0.6
Central Africa	70.3	64.9	62.7	13 604	-1.1
North Africa	42.2	36.3	33.9	7 467	-1.2
Southern Africa	47.5	42.3	40.7	2 485	-1.0
West Africa	69.3	64.2	61.9	29 387	-1.1
Region	64.6	60.8	58.7	87 467	-0.8
Asia					
East Asia	14.1	7.5	4.2	3 626	-1.4
South central Asia	66.8	61.8	59.5	111 857	-1.0
South east Asia	38.0	33.9	30.8	17 068	-1.0
West Asia	35.9	31.2	28.6	6 441	-1.0
Region	46.4	42.2	39.6	138 991	-1.0
South and central America & Caribbean					
Caribbean	37.6	35.4	33.5	915	-0.6
Central America	26.6	25.2	23.7	3 842	-0.4
South America	46.6	44.7	41.7	13 780	-0.7
Region	39.7	38.1	35.6	18 538	-0.6
Overall	50.1	46.7	44.3	244 996	-0.8

Figure 8. Trends in anaemia in non-pregnant women, by region



UNDERWEIGHT AND STUNTING[9]

The Millennium Development Goals, and earlier the World Summit for Children (UN, 1990), set a 50% reduction in child underweight as the main indicator related to hunger and malnutrition. Specifically, MDG1[10] is to "eradicate extreme poverty and hunger", and within this the third target (1c) is to "reduce by half the proportion of people who suffer from hunger" (by 2015 compared with 1990). Two indicators are stipulated to measure progress: prevalence of underweight among children aged 0-5 years; and proportion of the population below the minimum level of dietary energy consumption. Measuring inadequate dietary energy remains difficult, with methods (details were laid out in an FAO meeting in 2002) ranging from calculations based on national food balance sheets to periodic food consumption surveys (FAO, 2002). Anthropometric indicators, such as prevalence of underweight children, are more widely available and result from more direct measurements (i.e. children's weights and ages). The complementarity between these types of indicators was stressed in the 2002 FAO meeting.

The UNSCN's reports on the world nutrition situation have relied substantially on anthropometry, starting with the first report in 1987 (ACC/SCN, 1987). The present report provides an opportunity to include a 30-year-plus perspective – the first developing country estimate from 11 surveys was for 1975/1976 – as well as assessing more immediate trends. Data availability has expanded enormously: the first report was able to identify 43 surveys, rising to 118 by the time of the second report in 1993 (ACC/SCN, 1993). The WHO database used to calculate the underweight trend for this report has 608 estimates from national surveys. These survey results [11] are widely used, for example by UNICEF in the State of the World's Children reports (UNICEF, 2009) and online databases.[12] UNICEF has also reported in a recent publication on nutritional status in developing countries and highlighted the persistent challenge of stunting (UNICEF, 2009). Many national surveys are supported by partners, particularly the Demographic and Health Surveys (with USAID and other funding) and UNICEF's Multiple Indicator Cluster Surveys.

The aim here is to continue the UNSCN's reporting in the world nutrition series, focusing on trends in malnutrition. This has become progressively more feasible with the steady expansion of high quality data in the public domain. WHO's anthropometric standards (see Annex) have been used throughout the analyses reported here, where necessary using the WHO algorithm for conversion (Yang & de Onis, 2008, p. 6).

The first method of assessing trends in child malnutrition is to compare estimates from national surveys, repeated over time, by country. Data on child underweight prevalence from 86 countries (in Africa, Asia, and south central America & Caribbean), having a latest survey in the 2000s, were assessed. Trends were categorized as improving or deteriorating when there was a 2 percentage point or more difference between surveys, based on typical sample sizes and prevalences. Of the 86 countries, 38 (44%) were improving and 17 were deteriorating (21%) – thus the overall tendency has been for improvement (see the summary of results in Table 20). This tendency was more pronounced in Asia (14/25 cases improving; only 1/25 deteriorating), but in Africa also there was more improvement than deterioration (18 versus 14 cases). In south central America & Caribbean the prevalences are generally much lower, and therefore likely to change less and be less easy to determine – and this is seen in the results with 11/19 categorized as no change, with few cases (2/19) worsening.

For underweight the availability of data is now so extensive that in many countries national trends over the past 25 years or so can be directly observed from multiple surveys, as shown in Figure 9. The countries showing a typical S-shaped pattern, moving from high to low prevalences of underweight, are in Figure 9(a); these countries are mostly in the midst of this transition – reminiscent of demographic transitions – and tend to be reducing underweight at a rate of 0.7-1.0 percentage points per year. This rate is also seen for Asia in Table 21, discussed later. In contrast, African countries (Figure 9(b) and (c), while starting with lower underweight prevalences than Asia, show limited evidence of having begun this trend. It may be that the beginnings are being seen in some, for example in Ethiopia, Rwanda and the United Republic of Tanzania. Initiating and sustaining this pattern of change is now the challenge.

An analysis for stunting, like that for underweight based on repeated surveys, yields 63 comparisons with the latest survey in the 2000s, and is summarized in Table 22. The

9 Based in part on the work of Emily Cercone, MPH.
10 Available from UNDP at: http://www.undp.org/mdg/goal1.shtml (accessed 8 December 2009).
11 Available from WHO at: http://www.who.int/nutgrowthdb/database/en/ (accessed 22 March 2010).
12 Available from UNICEF at: http://www.childinfo.org/undernutrition.html (accessed 8 December 2009).

proportions of results that were improving, not changing, or deteriorating were similar to those for underweight; for stunting, half (49%) the results were improving. The distribution of stunting between regions was also similar to the distribution of underweight.

Although underweight and stunting results are similar in Africa and Asia, in south and central America & Caribbean child malnutrition is represented more by stunting. Stunting prevalence in some countries in this region is in the 30-50% range (e.g. Bolivia, Guatemala, Haiti, Honduras, Peru). Overall, stunting prevalences in the region are falling at a rate similar to (or faster than) underweight – as discussed later in the context of Table 23. However, for the high stunting prevalence countries listed above there is little recent change.[13] The results for the prevalence of stunting among children aged 0-5 years in Guatemala (1998, 53.1%; 2002, 54.3%), Haiti (2000, 28.3%; 2005-2006, 29.7%) and Peru (1996, 31.6%; 2000, 31.3%; 2005, 29.8%) show little change. There was, however, progress in Bolivia (1998, 33.1%; 2003, 32.5% for children aged 3 months to 5 years; 2008, 27.1%).

A somewhat different picture emerges in the association of underweight and stunting in these countries. The WHO Department of Nutrition for Health and Development has developed trend models to predict estimates of underweight and stunting prevalences by region and subregion, from 1990 to 2007 (see Tables 21 and 23). The underweight results (Table 21) allow rates of prevalence change to be calculated and compared with progress towards MDG 1, and these are shown in columns F-I of Table 21. The trends are also displayed graphically in Figure 9. These results give an overall improvement rate of 0.5 percentage points per year for 1990-2007, which is in fact almost the global rate required to meet MDG 1.

The current estimate is for an overall prevalence in developing regions of 19%[14] underweight in 2007. Trends within regions and subregions can be compared with those implied by MDG 1, as shown in columns G-I of Table 21.

For Africa, the rates of improvement are low, with prevalences declining by 0.1 percentage points per year over the region as a whole, and by less than 0.2 percentage points per year in all subregions. This represents slow improvement, except in the southern Africa subregion which exhibits no change. In north Africa, the prevalence is relatively low and the improvement rate is enough to meet MDG 1. In eastern, central and west Africa the trend needs be accelerated to parallel that envisaged by MDG 1. HIV/AIDS no doubt contributes to this situation, particularly in southern Africa and elsewhere where HIV prevalences are high. Drought and economic stress, in places interacting with HIV/AIDS, are major constraints.

In east, south central and south east Asia steady gains are generally in line with the rates required to meet MDG 1. Trends in China and India substantially drive those in Asia (indeed in the developing world). In China, the underweight prevalence in children aged 0-5 years was reported as 6.8% in 2002, compared with 18.7% in 1987 and 17.4% in 1992.[15] Halving the 1990 prevalence of 17% means reaching 8.5%; evidently, the MDG 1 for China was achieved some years ago. In India, the underweight prevalence in children aged 0-3 years decreased from 44.4% in 1998-1999 to 41.6% in 2005.[16] This represents a decrease of 0.4-0.5 percentage points per year. The rate required to achieve MDG 1 in India is a decrease of approximately 1 percentage point per year (halving the 1990 prevalence of about 50% by 2015 meant achieving a prevalence of 25% over 25 years, which required a decrease of about 1 percentage point per year), so some acceleration is required.

South and central America and the Caribbean have low prevalences of underweight, and generally these are moving downwards, in line with or better than MDG 1.

Child stunting trends are given in Table 23. In general these are similar to those for underweight. Except for south and central America & Caribbean, and west Asia, underweight and stunting prevalences are highly correlated, moving together through time and telling a similar story. However, for south and central America, stunting prevalences remain substantial, and suggest a continuing problem to be addressed. For example, Tables 21 and 23 show that in Africa the prevalence of underweight is 20% and the prevalence of stunting is 39%. In Asia, the prevalence of underweight is 22% and the prevalence of stunting is 31%. But in south and central America & Caribbean, the prevalence of underweight is only 4%, whereas the prevalence of stunting is 15% – there is proportionately more stunting. This diver-

13 Available from WHO at: http://www.who.int/nutgrowthdb/database/en/ (accessed 22 March 2010).

14 The prevalence rates of underweight and stunting in the UNICEF Tracking Progress on Child and Maternal Nutrition (2009) show differences with the rates being reported here, but they are close to the confidence intervals given. The differences in reported prevalence are due to differences in assessment methodology.

15 Available from WHO at: http://www.who.int/nutgrowthdb/database/en/ (accessed 22 March 2010).

16 The Indian prevalences by age band for 2005 are: 0-5 years, 43.5%; 0-0.5 years, 32.2%; 0.5-1 years, 36.8; 1-2 years, 44.6; 2-3 years, 46.1%. The average, weighted by sample distribution, is 41.7%. Data available from WHO at: http://www.who.int/nutgrowthdb/database/en/ (accessed 22 March 2010). Comparisons for children aged 0-5 years are not possible because the 1998-1999 survey results only children up to 3 years of age.

gence is smaller in the Caribbean, and strongest in Central America. There is proportionately more stunting and this difference is statistically significant.

The associations between stunting and underweight are further examined in Figure 10. These are similar in Africa and Asia – Asia has about 5 percentage points less stunting at a given level of underweight than Africa or about 7 percentage points more underweight at a given level of stunting: Asian children tend to be thinner than African children.

South and central America and the Caribbean are different: this can be seen in the slope of the relation between stunting and underweight in Figure 10(c) – this is highly significant (see footnote of Figure 10(d)). At a given level of stunting there is much less underweight in this region. The Caribbean countries have a significant lower level of stunting at a given level of underweight as compared to south and central American countries as shown in Figure 10(d). While the central American countries have, or have had, high stunting levels, these are falling on average (e.g. from 25.1% to 20.6% in 2000-2007, see Table 23). In south America stunting prevalences are also falling on average, although some are improving slowly or not at all (e.g. Peru). In contrast, Brazil has decreased stunting rapidly (from 20.4% in 1989 to 7.1% in 2006), as has Mexico (from 40.4% in 1989 to 21.7% in 1998-1999 and 15.5% in 2006).[17]

Countries often do not improve slowly and steadily; rather, they go through transitions, from persistent high prevalences to low (which tend to be resilient), as illustrated in Figure 9(a). When these trends are averaged by region they appear to be steadier than when teased apart. Most countries thus start off with high prevalences of underweight (and stunting) of around 30-60%, which may continue decreasing at up to 0.5 percentage points per year. Then, at a certain point, a transition may begin, and over two or more decades prevalences may reach single figures. This S-shaped curve has some similarities to the demographic transition – with which it is linked. The list of countries completing this transition in the past 30 years or so is limited – e.g. Brazil, China, Costa Rica, Jamaica, Malaysia, Mexico, Thailand – but supports the hypothesis. Several other countries may be in the process of transition, not yet completed – Indonesia, Philippines, Bolivarian Republic of Venezuela, and Viet Nam are examples. Such a transition may be under way in India (see Figure 9(a)), but recent declines in prevalence may be temporary, which merits further research.

At aggregate level, the long-term underweight trends for the three regions and overall are remarkably persistent. Going back to include the earliest estimates in the 1980s (ACC/SCN, 1992, Table 1.2), the trend for developing countries was a decline of 0.46 percentage points per year[18] for 1975-1990 and (see Table 21) a decline of 0.55 percentage points per year for 1990-2007.

This aggregate level masks important underlying differences, as displayed for example in Figure 9. First, the trends since 1975 in Africa show virtually no change. Recently, however, there seems to be some slight improvement. This is important, and if new stimulus is needed anywhere it must be here. Within Africa, recent data highlight significant diversity. Northern and southern Africa have low underweight prevalences, but significant stunting, and progress in reducing the prevalence of underweight is slow. Elsewhere in Africa, prevalence of underweight is worsening in recent years (see Figure 11), particularly in the countries of west Africa and the Sahel. Of the 17 countries where the underweight prevalence is estimated to be increasing, 14 are in Africa.

A key question is: what triggers (and sustains) periods of rapid improvement in child nutrition? And can such transitions be initiated and supported by deliberate policy decisions and intervention programmes?

Most long-term health and nutrition changes are part of broader trends, probably both contributing to and depending on them. For example, in Thailand, nutritional changes preceded economic expansion (ACC/SCN, 1993, p. 39). In Costa Rica, nutritional changes were part of sweeping improvements in health and nutrition programmes (Munoz & Scrimshaw, 1995). In China, comprehensive changes brought nutritional improvement with them (Wang, Monteiro & Popkin, 2002; Monteiro, Conde & Popkin, 2004). In most cases, both the improved socioeconomic environment and the wide coverage of health and nutrition programmes played a role.

In most cases, community-based programmes have expanded so that mothers and children have contact with trained and supported community health and nutrition

17 From WHO http://www.who.int/nutgrowthdb/database/en/ accessed 22 March 2010.

18 Converted to WHO standards.

workers. In Viet Nam, for example, the number of community nutrition workers increased from around 30,000 to 105,000 between 1996 and 2005.[19] Programmes involving community workers have played a key role in most of these countries; indeed, achieving a high ratio of community workers to families is a key measure of the potential for impact. Starting and continuing these actions probably requires government's decision to do so combined with communities and families beginning to take control of their own health, nutrition and well-being (Mason et al., 2006, pp. 1053-1074).

Community-based programmes and extended primary health care (WHO, 2008) need to be implemented successfully and to provide near-universal coverage. That is where much of the challenge now lies.

Table 20. Number of countries with change in child underweight prevalence (children aged 0-5 years), categorized as improving, no change or deteriorating, from repeated national surveys with latest result in 2000 or later, by region

Region		Total	Improving	No change	Deteriorating
Africa	Number	42	18	10	14
	%	100%	43%	24%	33%
Asia	Number	25	14	10	1
	%	100%	56%	40%	4%
South and central America & Caribbean	Number	19	6	11	2
	%	100%	32%	58%	11%
Total		86	38	31	17
		100%	44%	36%	20%

Note: a change of 2 percentage points or more was taken as improving or deteriorating.

Table 22. Numbers of countries with change in the prevalence of child stunting (children aged 0-5 years), categorized as improving, no change or deteriorating, from repeated national surveys with latest result in 2000 or later, by region

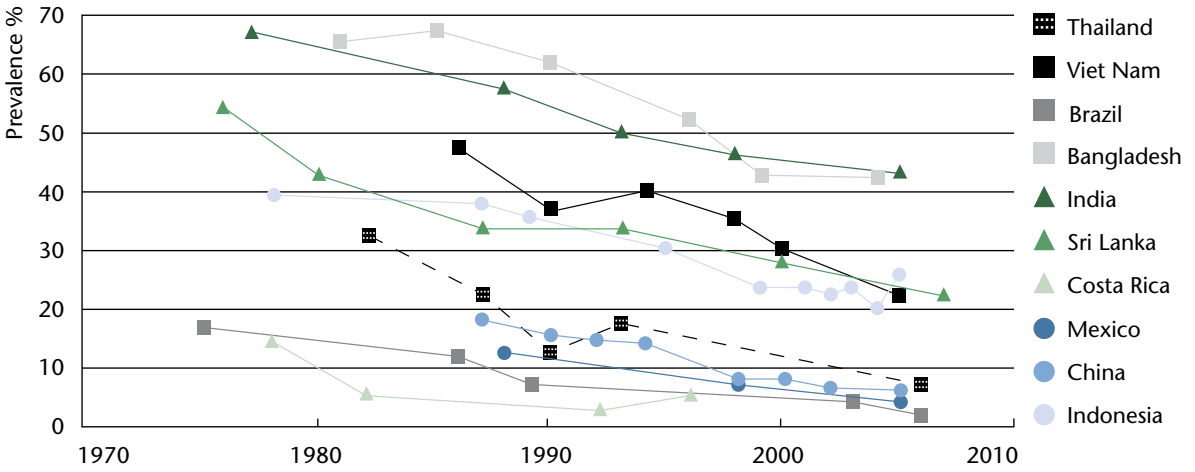
Region		Total	Improving	No change	Deteriorating
Africa	Number	29	12	6	11
	%	100%	41%	21%	38%
Asia	Number	20	13	6	1
	%	100%	65%	30%	5%
South and central America & Caribbean	Number	14	6	7	1
	%	100%	43%	50%	7%
Total		63	31	19	13
		100%	49%	30%	21%

Note: a change of 2 percentage points or more was taken as improving or deteriorating.

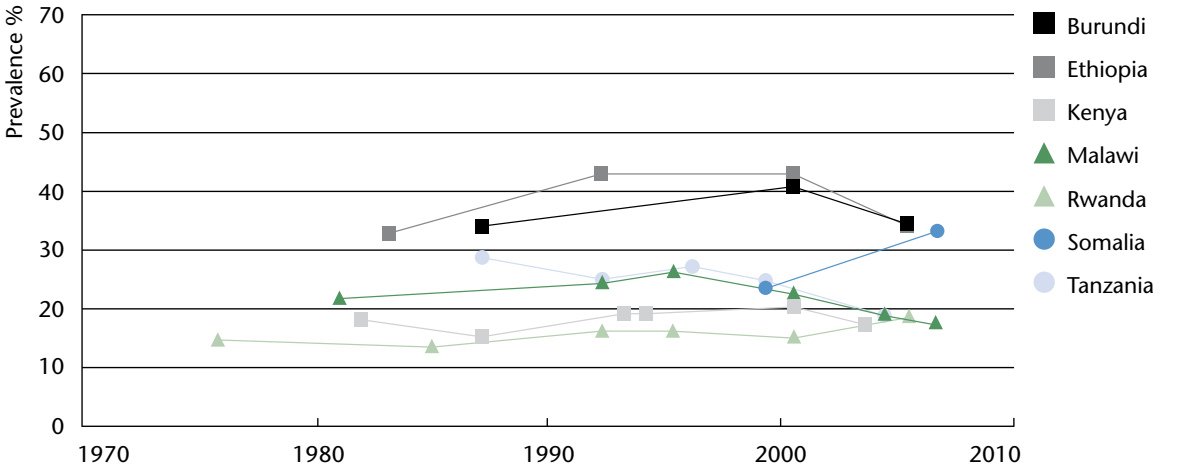
19 Data from the Government of Viet Nam for 1998, and from the Protein-Energy Malnutrition Control Program, National Institute of Nutrition, Viet Nam, for 2006.

Figure 9. National trends in prevalence of underweight children (0-5 years) in selected countries from repeated national surveys

(a) Countries showing transitions (in progress or completed) from higher to lower prevalence of underweight



(b) East African countries, some showing the possible start of a reduction in the prevalence of underweight



(c) Prevalence of underweight in west and southern African countries

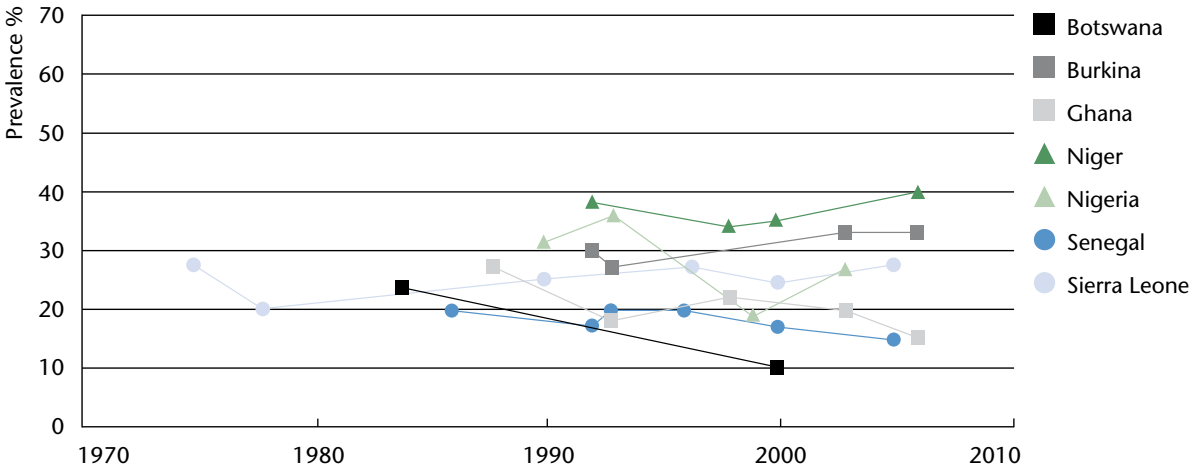


Table 21. Child underweight trends by UN region and subregion, and comparison with rates required to achieve the MDG 1 (prevalence, 95% confidence interval)

UN region or subregions	1990 A	1995 B	2000 C	2005 D	2007 E	2015 MDG target F	Present rate (percentage points/year) G	Required rate to achieve MDG 1 H	Comment (a) I
Africa	21.5	21.1	20.5	19.9	19.6	10.8	-0.11	-1.10	Insufficient progress
	19.0-24.0	18.8-23.3	18.4-22.6	17.8-22.0	17.5-21.8				
Eastern	25.6	24.6	23.6	22.7	22.3	12.8	-0.19	-1.20	Insufficient progress
	20.8-31.0	20.4-29.3	19.8-27.9	18.9-26.9	18.5-26.6				
Middle	24.3	23.3	22.3	21.4	21.0	12.2	-0.19	-1.10	Insufficient progress
	17.9-32.0	17.6-30.1	17.1-28.6	16.4-27.3	16.1-26.9				
Northern	10.8	10.0	9.2	8.5	8.2	5.4	-0.15	-0.35	Insufficient progress
	6.5-17.5	5.7-16.9	5.0-16.4	4.3-16.0	4.0-15.9				
Southern	11.7	12.1	12.5	13.0	13.2	5.9	+0.09	-0.91	No progress
	7.7-17.3	8.6-16.7	9.5-16.4	10.1-16.6	10.2-16.9				
Western	25.1	24.4	23.6	22.8	22.5	12.6	-0.15	-1.24	Insufficient progress
	21.1-29.7	21.0-28.1	20.4-27.1	19.5-26.5	19.0-26.5				
Asia	33.8	30.0	26.4	23	21.6	16.9	-0.72	-0.59	On track
	29.8-37.7	25.8-34.2	22.0-30.7	18.6-27.4	17.3-25.9				
Eastern	16.2	11.5	8.1	5.6	4.8	8.1	-0.67	n/a(b)	Met MDG goal
	15.5-17.0	11.0-12.1	7.6-8.5	5.3-5.9	4.5-5.1				
South-central	49.9	44.6	39.4	34.4	32.5	25.0	-1.02	-0.94	On track
	41.7-58.2	36.4-53.1	31.3-48.0	26.6-43.1	24.9-41.2				
South-eastern	30.6	26.6	22.9	19.6	18.3	15.3	-0.72	-0.38	On track
	26.1-35.5	22.7-30.8	19.5-26.6	16.5-23.0	15.4-21.7				
Western	12.8	10.7	9.0	7.5	7.0	6.4	-0.34	-0.08	On track
	9.6-16.8	7.2-15.7	5.1-15.3	3.6-15.1	3.1-15.1				
Latin America & Caribbean	7.5	6.2	5	4.1	3.8	3.8	-0.22	n/a(b)	Met MDG goal
	5.4-9.7	4.4-8.0	3.5-6.6	2.7-5.4	2.5-5.0				
Caribbean	8.4	6.8	5.5	4.5	4.1	4.2	-0.25	n/a(b)	Met MDG goal
	4.9-13.9	3.8-11.8	3.0-10.0	2.3-8.5	2.1-8.0				
Central America	10.6	8.5	6.8	5.4	4.9	5.3	-0.34	n/a(b)	Met MDG goal
	6.5-16.9	5.2-13.8	4.0-11.5	3.0-9.7	2.7-9.1				
South America	6.1	5.1	4.2	3.5	3.2	3.1	-0.17	n/a(b)	Met MDG goal
	4.0-9.3	3.3-7.7	2.7-6.4	2.2-5.3	2.0-5.0				
Oceania	n/a(b)	18.5	17.3	16.2	15.8	n/a(b)			
		13.1-25.4	11.6-25.1	9.7-25.9	8.9-26.3				
All developing countries	28.7	25.7	22.8	20.3	19.3	14.4	-0.55	-0.61	
	25.9-31.5	22.8-28.6	19.9-25.7	17.4-23.2	16.5-22.2				
Developed countries	1.9	1.8	1.7	1.6	1.5	1.0	-0.02	-0.06	
	1.4-2.6	1.3-2.4	1.2-2.3	1.1-2.2	1.0-2.1				
Global	25.4	23	20.5	18.3	17.4	12.7	-0.47	-0.59	
	23.0-27.9	20.4-25.6	17.9-23.1	15.8-20.9	14.9-20.0				

a "Met MDG goal" means that the 2007 estimate is same or lower than the MDG goal; "On track" means that present rate is equal to or greater than the rate required to achieve the MDG (and the MDG goal has not yet been met); "Insufficient progress" means that the present rate is less than the rate required to achieve the MDG; "No progress" means that the present rate is around zero.

b Has met the MDG goal hence there is no required rate to be derived.

Source: Growth Assessment and Surveillance Unit, Department of Nutrition for Health and Development, WHO.

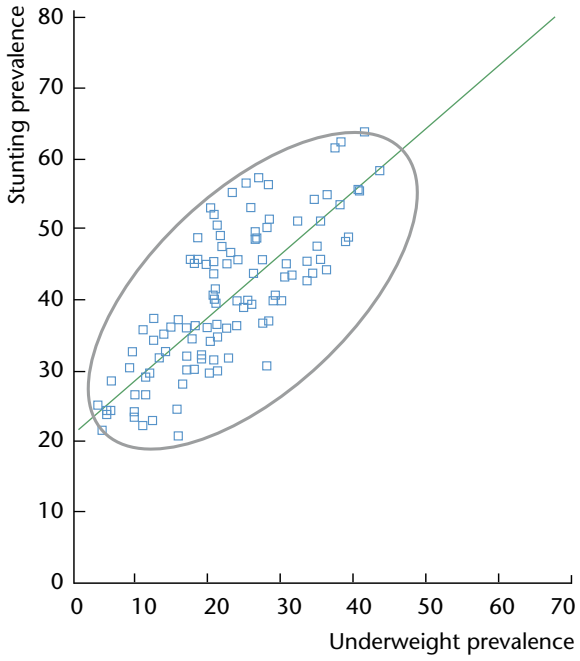
Table 23. Child stunting trends by UN region and subregion, and comparison with rates required to achieve MDG 1 (prevalence, 95% confidence interval)

UN region or subregions	1990	1995	2000	2005	2007
Africa	40.3	39.8	39.3	38.8	38.5
	37.7-42.8	37.5-42.1	37.1-41.6	36.4-41.1	36.1-41.0
Eastern	48.1	47.4	46.7	46.0	45.7
	43.0-53.1	42.9-51.9	42.5-50.9	41.7-50.3	41.4-50.1
Middle	45.3	43.8	42.3	40.8	40.3
	37.7-53.2	37.3-50.6	36.8-48.1	36.3-45.6	36.0-44.6
Northern	29.4	27.4	25.5	23.7	23.0
	23.2-36.5	21.5-34.2	19.4-32.7	17.2-31.7	16.2-31.4
Southern	35.4	34.7	34.1	33.5	33.3
	29.5-41.7	29.1-40.8	28.7-40.0	28.1-39.4	27.8-39.2
Western	38.1	38.1	38.1	38.1	38.1
	34.4-42.0	34.8-41.6	34.7-41.7	34.1-42.3	33.8-42.7
Asia	48.6	43.1	37.7	32.6	30.6
	46.1-51.0	40.4-45.8	34.8-40.5	29.5-35.7	27.5-33.7
Eastern	35.9	28.2	21.7	16.3	14.4
	34.7-37.1	27.1-29.4	20.6-22.8	15.4-17.2	13.6-15.3
South-central	60.7	54.6	48.4	42.3	39.9
	56.1-65.0	49.7-59.4	43.3-53.6	36.9-47.8	34.5-45.6
South-eastern	47.0	41.5	36.2	31.3	29.4
	38.4-55.7	34.3-49.1	30.1-42.9	25.8-37.4	24.0-35.5
Western	28.2	25.9	23.7	21.6	20.9
	22.5-34.6	19.4-33.7	16.2-33.2	13.4-33.0	12.4-33.0
Latin America & Caribbean	23.7	20.9	18.1	15.7	14.8
	18.6-28.9	15.9-25.9	13.1-23.1	10.7-20.7	9.8-19.8
Caribbean	15.0	12.0	9.6	7.5	6.9
	8.4-25.5	6.3-21.9	4.6-18.7	3.4-15.8	3.0-14.8
Central America	32.5	28.6	25.1	21.8	20.6
	22.1-45.0	19.1-40.6	16.2-36.6	13.7-32.9	12.7-31.5
South America	20.9	18.3	16.0	13.9	13.1
	15.3-27.9	12.9-25.3	10.6-23.3	8.5-21.8	7.7-21.3
Oceania	n/a	39.8	39.1	38.5	38.2
		25.2-56.4	22.7-58.5	19.0-62.5	17.5-64.4
All developing countries	44.4	40.1	36.1	32.5	31.2
	42.5-46.3	38.2-42.1	34.0-38.1	30.4-34.6	29.0-33.3
Developed countries	6.0	6.0	6.0	6.0	6.0
	4.2-8.4	4.2-8.5	4.1-8.6	4.1-8.7	4.1-8.7
Global	39.7	36.3	32.9	29.7	28.5
	38.1-41.4	34.5-38.0	31.0-34.7	27.8-31.6	26.5-30.4

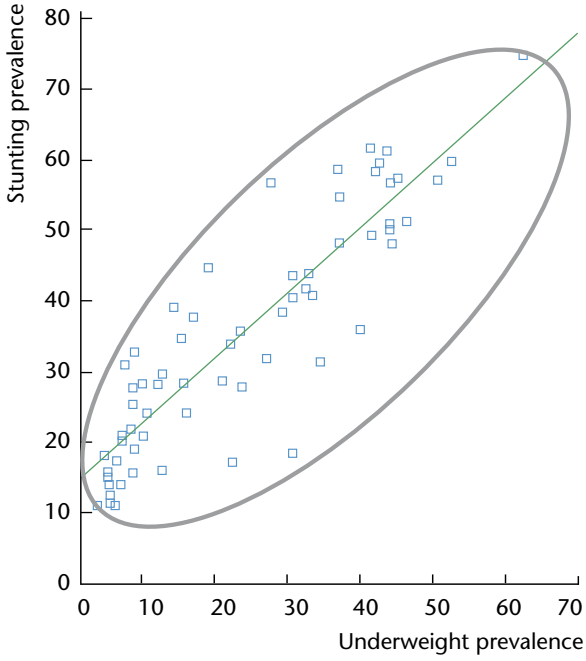
Source: Growth Assessment and Surveillance Unit, Department of Nutrition for Health and Development, WHO.

Figure 10. Association between underweight and stunting, from survey results 1990-2007, by region

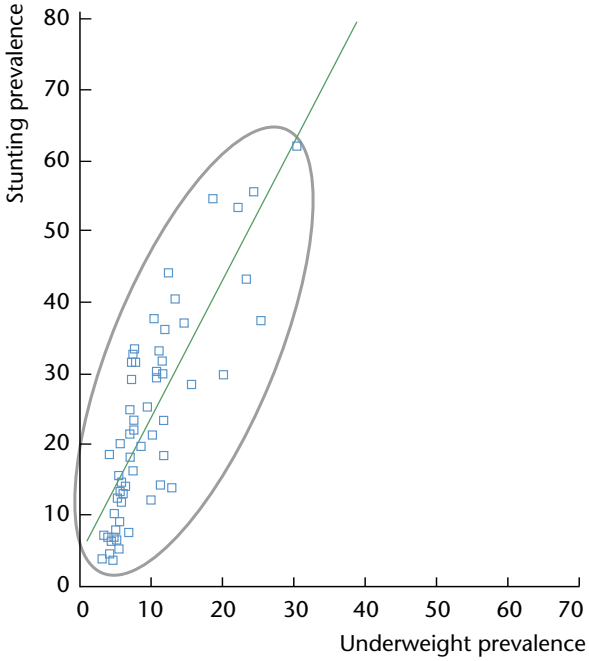
(a) Africa



(b) Asia

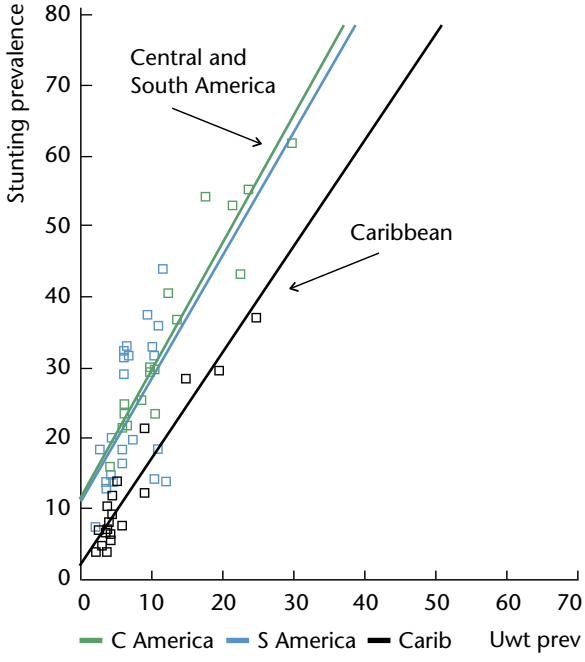


(c) Central and south America & Caribbean



Note: In regression analysis, for the 3 regions together, all coefficients were significant, the interaction term for Asia was not significant

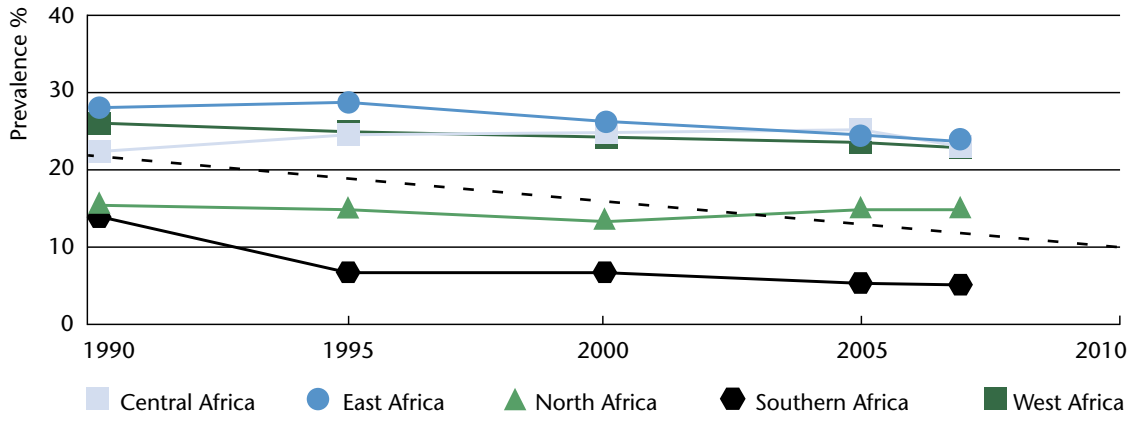
(d) Central and south America & Caribbean



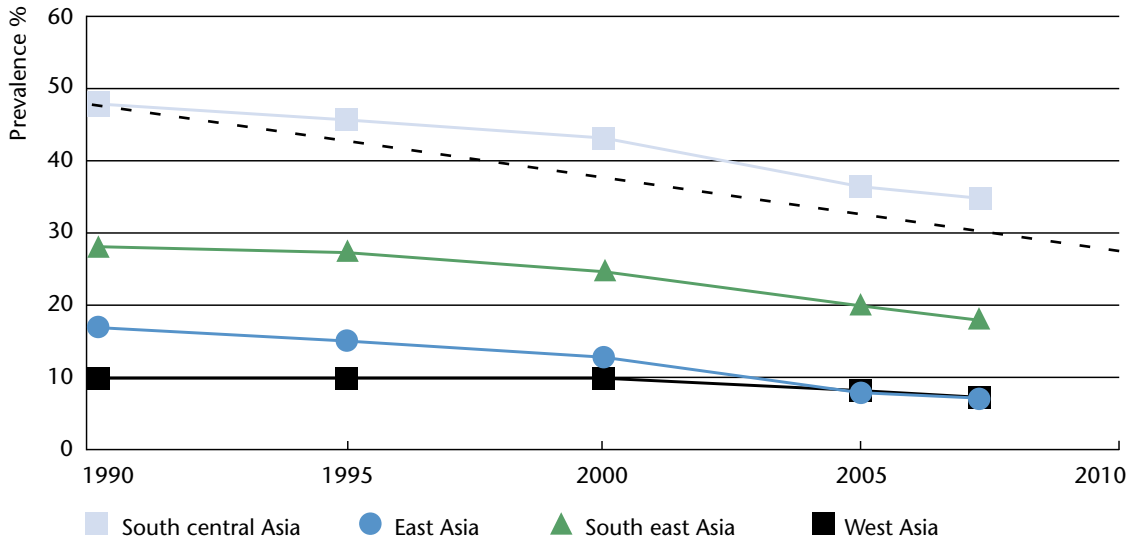
Note: In regression analysis, the dummy variable for the Caribbean was significant and equals 0.59. C America is Central America, S America is South America, Carib is Caribbean, Uwt prev is underweight prevalence

Figure 11.
Trends in prevalence of underweight children by region

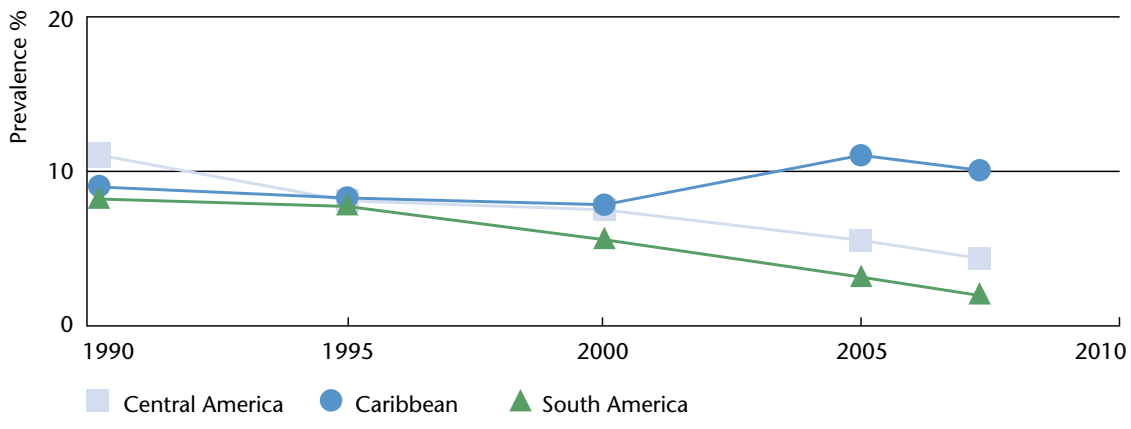
Africa



Asia



Latin America & Caribbean



LOW BIRTH WEIGHT[20]

Low birth weight is defined by WHO as birth weight less than 2500 g. Low birth weight is highly correlated with perinatal, neonatal and post-neonatal morbidity and mortality (McIntire et al., 1999) and is associated with development of chronic diseases in adulthood (Barker et al., 1993; Barker, 1995). The reduction of low birth weight would contribute to the fourth Millennium Development Goal (MDG 4) for reducing child mortality. Reducing the incidence of low birth weight by at least one third between 2000 and 2010 was a major goal of "A World Fit for Children", the Declaration and Plan of Action adopted by the United Nations General Assembly in 2002.[21]

The analysis of global and regional trends in low birth weight is more difficult than other measures of malnutrition reported here, not only because of limited data, but also because data sources have changed over time. Recent data are derived from household surveys, in which birth weights are estimated by recall and corrected from other responses. National estimates are adjusted to allow for variable coverage and other interfering factors, often being adjusted upwards by 24%, as described by UNICEF (2004). Earlier data (see WHO, 1992) came mostly from health system records, which are very incomplete in most developing countries, moreover likely to give results biased downwards, as the better-off are more likely to have deliveries that are attended and recorded. In general, the earlier estimates are low, and the later ones are adjusted upwards. Thus although these estimates are not fully comparable, changes calculated from comparing earlier and later data will tend to underestimate the improvement, thus being conservative. Further details are given in the Annex.

National data are available to allow some examination of trends. Data from 60 countries with two or more national estimates of low birth weight between 1997 and 2007 are shown in Table 24. Of these 60 data sets, 46 data pairs are from nationally representative surveys considered comparable; 5 data pairs are from unadjusted routine data[22]; and 9 data pairs were calculated using different methods, as noted in the footnotes to Table 24.

To summarize the apparent trends, countries are classified in Table 24 as improving or deteriorating on the basis of a difference between surveys of two or more percentage points (column F) or one or more percentage points (column G). Less than such differences between surveys is described as "No change". Further details are provided in the Annex. These findings are summarized by region in Table 25. Using the assessment of change as one percentage point, the overall trend shows improvement: the incidence of low birth weight is decreasing in about half the countries in Asia (5 of 10, with only 2 deteriorating), South America (7 of 15) and sub-Saharan Africa (13 of 28). Using a two percentage points as the criterion for change gives a similar picture for the most affected areas (Asia and sub-Saharan Africa); more countries are improving than not. Taking the above average cases, (incidence of low birth weight 15% or more data not shown), half (10) of the 20 cases are improving.

Summing the figures for all countries suggests, by both criteria, that more countries overall are improving than not: by 2 percentage points, 28% (17 out of 60) are improving; 50% no change (30/60), and 22% deteriorating (13 of 60); by 1 percentage point, 45% (27 of 60) improving compared to 22% (13/60) with no change, and 33% (20/60) deteriorating.

Assessing changes (see Table 24) in India (improvement of 0.4 percentage points per year) and Bangladesh[23] (improvement of 1.1 percentage points per year) is particularly important given that around half of the world's low-birth-weight babies are born in south central Asia (UNICEF/WHO, 2004, Table 2). The trend in Bangladesh is considered likely to be improving even with non-comparable data, as the earlier estimate of 30% is unadjusted, and would only increase if it were. The 1999 and 2005 estimates in India (both from national surveys, adjusted) are thought to be comparable, suggesting a 2.4 percentage points improvement. In south east Asia, the incidence of low birth weight appears to be improving in the Lao People's Democratic Republic, Malaysia and Viet Nam, whereas no change was seen in Nepal, the Philippines and Thailand (the relatively lower incidence of low birth weight in Nepal and Thailand means that less change is expected). Only Cambodia and Timor-Leste show a deteriorating incidence of low birth weight. China (see also Table 26, east Asia) already has low rates for low birth weight, and is estimated to be continuing to improve. The evidence thus points towards improvement in low-birth-weight rates in Asia, both for the overall populations and for a majority of countries.

20 Based on the work of Lisa Saldanha, MPH

21 Available from UNICEF at: http://www.unicef.org/specialsession/docs_new/documents/A-RES-S27-2E.pdf (accessed 5 May 2009).

22 Argentina, Malaysia, Mauritius, Mexico and Panama.

23 The improving trend in Bangladesh should be considered with caution, since the earlier estimate (low birth weight incidence of 30.0%) came from routine data while the second estimate (low birth weight incidence of 21.6%) came from a nationally representative household survey which was adjusted by UNICEF. The estimate here tends to underestimate the improvement.

A second approach uses the regional estimates shown in Table 26, taken from WHO (1992) and UNICEF/WHO (2004). As noted above and described more fully in the Annex, the estimates of low birth weight for the 1980s and 1990s were derived from routine data sources and surveys with low and varying coverage, likely to underestimate rates. Estimates for the 2000s were taken from UNICEF, primarily based upon nationally representative household surveys such as the Multiple Indicator Cluster Surveys and the Demographic and Health Surveys, and often had been adjusted upwards by UNICEF to reduce bias (an average increase of 24% on published data) (UNICEF/WHO, 2004).[24] The trends described in Table 26 are therefore likely to be conservative estimates of an improving trend, since the earlier estimates may be low. (This also applies to the data in Tables 24 and 25).[25]

The incidence in south and south east Asia has fallen by approximately 0.3 percentage points per year over the past two decades: in south Asia from 34% to 27%, and in south east Asia from 18% to 12%. East Asia (mainly China) already had low incidence of low birth weight in the 1980s, and the rate has now fallen to about 6%. In this region, only west Asia shows a deteriorating trend in the past two decades. Overall, this comparison suggests that the incidence of low birth weight in Asia has fallen, from 22% in the 1980s, 21% in the 1990s, to 18% in the 2000s. Despite these improvements, Asia still has the highest percentage of low-birth-weight babies.

Overall, low birth weight in Latin America and the Caribbean was already relatively low in the 1980s and has remained fairly static. The region reached 10% in the 2000s from 11% in the 1990s and 13% in the 1980s (Table 26). Nearly half (46%) of the countries in this region in Table 24 show improvement, but the overall rate of change for the region is slow (0.1 percentage points per year over 20 years). Central America had the highest incidence of low birth weight in the region in 1980 (15%) and has shown the most change (0.25 percentage points per year). Of the four central American countries in Table 24, three are improving: El Salvador, Guatemala and Honduras (Panama shows no change). As a subregion, the Caribbean countries are not improving: the trends over time in Table 26 show no change, and of the countries in Table 24, the rates in the Dominican Republic, Guyana, Haiti and Jamaica are deteriorating (Trinidad and Tobago and Suriname are improving).

In line with trends in underweight and stunting, sub-Saharan Africa has essentially remained static over the past twenty years, perhaps with east Africa showing some improvement.

These average results point to trends in the same direction as implied by the repeated national estimates – distinct improvement in Asia, small improvement in some African and Latin America & Caribbean countries but not in others, but with lower rates in Latin America & Caribbean countries.

Underweight improves in parallel with low birth weight

Underweight tends to move with birth weight through time towards zero rates for each. This is shown in Figure 12 for changes in regional estimates of low birth weight and underweight children, from the 1980s to the 2000s, extending the results first shown in the Second report on the world nutrition situation (ACC/SCN, 1992, Figure 4.11). The data on low birth weight are based upon previously published WHO/UNICEF estimates (WHO, 1992; UNICEF/WHO, 2004). The underweight prevalences for children (aged 0-5 years) are estimated for the same regions used in earlier reports, to allow comparisons with 1990 and 2000. Data for 1980 come from the Second report on the world nutrition situation (ACC/SCN, 1992, Table 1.2). The results were linked at the 1990 estimates to compare data from both sets. All underweight results are adjusted to WHO standards.

The proportional rate of change of low birth weight is similar to that of underweight: the regional trends in Figure 12 are heading towards zero low birth weight and zero underweight. Underweight prevalences are roughly double those of low birth weight at most points on the graph. In part this is because the cut-off points for low birth weight and underweight are not the same – but they are not very different. For example, using the previous National Center for Health Statistics standard, -2SD at birth for girls was 2.2 kg; with the new WHO standards, this is 2.4 kg. This implies that the extent of underweight increases after birth.

24 Available from UNICEF at: http://www.childinfo.org/low_birthweight_profiles.php (accessed 5 May 2009).

25 Tables 24 and 25 contain additional country data that were not available when the 2000 estimates were calculated by UNICEF/WHO in 2004. Tables 24 and 25 therefore provide additional information to interpret the trends in Table 26. For example, the Asia data include comparative data on Bangladesh, Cambodia, India, the Lao People's Democratic Republic, Nepal, Thailand and Viet Nam that was not available when the UNICEF/WHO (2004) report was written.

Low maternal pre-pregnancy body mass index is a known determinant of low birth weight (Allen et al., 1994; Ronnenberg et al., 2003) and persistence of low body mass index from a mother's own low birth weight is likely to contribute to the intergenerational nature of growth failure. Data on body mass index from various sources allowed some examination of the combined trends in low birth weight and women's underweight (see Annex for the method used to derive at these data), again extending results from 1992 (ACC/SCN, 1992, Figure 4.10 B). Regional trends in maternal underweight and low birth weight from the 1980s to the 2000s (Figure 13) show that low birth weight tends to move with the prevalence of low body mass index in women. In the previously described inter-generational cycle of growth failure (ASC/SCN, 1992, p.56), infant girls are born with low birth weight, experience child growth failure, and eventually become small adult women who go on to have low-birth-weight babies.

This has several implications. First, in Asia particularly, these results (Figures 12 and 13) suggest a virtuous cycle of improved birth size leading to better grown children, thence to better grown mothers, and hence further lowered low-birth-weight rates. Second, improvements in women's nutrition and health, growing up and in adulthood, benefits the next generation. Third, other factors that support intrauterine growth have a beneficial effect on this process – of which one of the most important may be preventing teenage pregnancies discussed in the maternal nutrition chapter.

Low birth weight is reduced with increased age at marriage

Adolescent and child marriage continues to be a strong social norm in the developing world, particularly in central and west Africa, and south and south east Asia (Mensch, Singh & Casterline, 2005). Age at marriage is highly correlated with age at first birth (Westoff, 2003). Here the relationships between median age at first marriage (reported by women aged 15-49 years) and low birth weight is examined using national estimates of each from 1997 to 2007. Figure 14 shows that increased median age at marriage is associated with lower incidence of low birth weight overall, and in Africa and Asia.

Asia has more countries with higher incidence of low birth weight and lower median age at first marriage. Bangladesh, India and Nepal are near the top left of the scatter plot, with low-birth-weight estimates of 30, 28 and 21 percent, and median age at marriage of 14.5, 17.1 and 16.7 years, respectively. Africa shows a similar relationship, but with a lower slope; the mean incidence of low birth weight is lower and the median age at first marriage is higher. In southern Africa, median age at marriage is higher (in Botswana, Namibia, South Africa and Swaziland, between 23.7 and 24.3 years), compared to the mean of 18.7 years, but the low-birth-weight rate is similar to the Africa mean. (The associations are stronger when these southern Africa cases are excluded, but they are kept in for the results discussed below.)

Clearly the ecological association between low birth weight and age at marriage could result from confounding factors such as poverty, health environment, women's education or maternal size. Information on some of these indicators is available, and they are seen to act as potential confounders, being significantly associated with both low birth weight and age at marriage. Controlling for gross national income, women's body mass index and girls' education (as secondary school enrolment), the association between low birth weight and age at marriage remains significant overall (see Table 27). Later marriage and, by implication, first birth is associated with reduced incidence of low birth weight. Such associations must be treated with caution – but it is recognized that there is a well-known biological basis for it, through intrauterine growth restriction. This result is reported here to lend support to the discussion in chapter 3 concerning the effects of early pregnancy.

The implications are that policies and programmes – such as helping to keep girls in school and implementing laws to prevent under-age marriage – that postpone first pregnancies until the mother is fully grown will have important benefits for the health of both mother and child. Indeed, this could be a crucial factor in sustainably cutting the intergenerational transmission of malnutrition, and hastening transitions from high levels of low birth weight and malnutrition to those seen in more developed countries, accelerating the progress towards the normal growth and development illustrated in Figure 12.

Table 24.
Incidence of low birth weight: results from repeated national estimates (1997-2007)

Region A	Country B	Survey year C	Incidence of low birth weight (%) D	Change between surveys E	Direction of change (2 percentage points or more) F	Direction of change (1 percentage point or more) G	Rate of change (percentage points per year) H
East Africa	Burundi	2000	16.0				
		2005 (a)	11.2	-4,8	Improvement	Improvement	-1.0
	Ethiopia	2000	15.0				
		2005	20.3	5.3	Deterioration	Deterioration	1.1
	Kenya	1998	11.0				
		2003	10.2	-0.8	No change	No change	-0.2
	Madagascar	2000	14.0				
		2004	17.3	3.3	Deterioration	Deterioration	0.8
	Malawi	2000	16.0				
		2006	12.5	-3.5	Improvement	Improvement	-0.6
	Mauritius	1998	13.0				
		2003	13.9	0.9	No change	No change	0.2
	Mozambique	1997	14.0				
		2003	15.4	1.4	No change	Deterioration	0.2
	Rwanda	2000	9.0				
		2005	6.3	-2.7	Improvement	Improvement	-0.5
	United Republic of Tanzania	1999	13.0				
		2005	9.5	-3.5	Improvement	Improvement	-0.6
	Uganda	2001	12.3				
		2006	14.0	1.7	No change	Deterioration	0.3
	Zimbabwe	1999	11.4				
		2006	11.0	-0.4	No change	No change	-0.1
Southern Africa	Lesotho	2000	14.0				
		2004	12.6	-1.4	No change	Improvement	-0.4
	Namibia	2000	13.7				
		2006	17.4	3.7	Deterioration	Deterioration	0.6
	South Africa	1998	15.1				
		2003	9.9	-5.2	Improvement	Improvement	-1.0
Central Africa	Cameroon	1998	11.0				
		2006	10.8	-0.2	No change	No change	0.0
	Central African Republic	2000	14.0				
		2006	13.0	-1.0	No change	Improvement	-0.2
	Chad	1997	17.0				
		2004	21.7	4.7	Deterioration	Deterioration	0.7

a Unadjusted survey data: Rapport de l'enquête nationale de nutrition de la population (ISTEEBU, 2005, Table 22) as cited by UNICEF at: http://www.childinfo.org, (accessed 3 March 2008).

Table continued on next page.

(table 24 continued from previous page).
Incidence of low birth weight: results from repeated national estimates (1997-2007)

Region A	Country B	Survey year C	Incidence of low birth weight (%) D	Change between surveys E	Direction of change (2 percentage points or more) F	Direction of change (1 percentage point or more) G	Rate of change (percentage points per year) H
West Africa	Benin	2001	16.1				
		2006	15.0	-1.1	No change	Improvement	-0.2
	Burkina Faso	1999	19.0				
		2006	16.2	-2.8	Improvement	Improvement	-0.4
	DR Congo	2000	11.9				
		2007	9.5	-2.4	Improvement	Improvement	-0.3
	Gambia	2000	17.0				
		2006	19.9	2.9	Deterioration	Deterioration	0.5
	Ghana	1998	11.0				
		2006	9.1	-1.9	No change	Improvement	-0.2
	Guinea	1999	12.0				
		2005	12.2	0.2	No change	No change	0.0
	Guinea Bissau	2000	22.0				
		2006	23.9	1.9	No change	Deterioration	0.3
	Mali	2001	23.4				
		2006	19.0	-4.4	Improvement	Improvement	-0.9
	Niger	1998	17.0				
		2000	13.1				
		2006	27.0	10.0	Deterioration (1998-2006)	Deterioration	1.3
	Senegal	2000	18.0				
		2005	18.8	0.8	No change	No change	0.2
	Togo	1998	15.0				
		2006	11.5	-3.5	Improvement	Improvement	-0.4
Middle East/ North Africa	Egypt	2000	12.0				
		2005	14.1	2.1	Deterioration	Deterioration	0.4
	Iraq	2000	15.0				
		2006	14.8	-0.2	No change	No change	0.0
	Jordan	1997	10.0				
		2002	12.4	2.4	Deterioration	Deterioration	0.5
	West Bank and Gaza Strip	2000	9.0				
		2006	7.3	-1.7	No change	Improvement	-0.3

Table continued on next page.

(table 24 continued from previous page).
Incidence of low birth weight: results from repeated national estimates (1997-2007)

Region A	Country B	Survey year C	Incidence of low birth weight (%) D	Change between surveys E	Direction of change (2 percentage points or more) F	Direction of change (1 percentage point or more) G	Rate of change (percentage points per year) H
South Asia	Bangladesh	1998 (b)	30.0				
		2006	21.6	-8.4	Improvement	Improvement	-1.1
	India	1999	30.4				
		2005	28.0	-2.4	Improvement	Improvement	-0.4
	Nepal	2001	21.0				
		2006	21.0	0.0	No change	No change	0.0
South east Asia	Cambodia	2000	11.3				
		2005	14.0	2.7	Deterioration	Deterioration	0.5
	Laos People's Dem. Republic	2000	14.3				
		2006	11.0	-3.3	Improvement	Improvement	-0.6
	Malaysia	1998	10.0				
		2002	9.0	-1.0	No change	Improvement	-0.3
	Philippines	2000	20.0				
		2003	20.3	0.3	No change	No change	0.1
	Thailand	2000 (c)	9.0				
		2006	9.2	0.2	No change	No change	0.1
	Timor-Leste	2002	10.0				
		2003	12.0	2.0	Deterioration	Deterioration	2.0
	Viet Nam	2000	9.0				
		2006	7.0	-2.0	Improvement	Improvement	-0.3
South America	Argentina	1999	7.0				
		2006	7.3	0.3	No change	No change	0.0
	Bolivia	1998	9.0				
		2003	7.3	-1.7	No change	Improvement	-0.3
	Colombia	2000	8.7				
		2005	7.7	-1.0	No change	Improvement	-0.2
	Guyana	2000	12.0				
		2006	19.0	7.0	Deterioration	Deterioration	1.2
	Suriname	2000	12.5				
		2006	11.0	-1.5	No change	Improvement	-0.3
	Venezuela (Bol. Republic of)	2000	7.0				
		2004 (d)	8.8	1.8	No change	Deterioration	0.5

b Unadjusted routine service statistics: Mid-term evaluation 1998 of BINP, MOH and family welfare, Bangladesh, as cited in WHO (2004).
c Unadjusted routine service statistics: Ministry of Public Health, Thailand, annual statistics, as cited in WHO (2004).
d Unadjusted routine service statistics: Sistema Integrado de Indicadores Sociales para Venezuela 2006, Ministerio de Planificación y Desarrollo, as cited by UNICEF at: http://www.childinfo.org, (accessed 3 March 2008).

(table 24 continued from previous page).
Incidence of low birth weight: results from repeated national estimates (1997-2007)

Region A	Country B	Survey year C	Incidence of low birth weight (%) D	Change between surveys E	Direction of change (2 percentage points or more) F	Direction of change (1 percentage point or more) G	Rate of change (percentage points per year) H
Central America & Caribbean	Dominican Republic	2002	11.3				
		2007	13.5	2.2	Deterioration	Deterioration	0.4
	El Salvador	1998 (e)	13.0				
		2003 (f)	7.0	-6.0	Improvement	Improvement	-1.2
	Guatemala	1999	13.0				
		2002 (g)	12.0	-1.0	No change	Improvement	-0.3
	Haiti	2000	21.0				
		2005	24.6	3.6	Deterioration	Deterioration	0.7
	Honduras	2001 (h)	14.0				
		2005	10.2	-3.8	Improvement	Improvement	-1.0
	Jamaica	2001 (i)	9.0				
		2005	12.1	3.1	Deterioration	Deterioration	0.8
	Mexico	1999	9.0				
		2005	8.4	-0.6	No change	No change	-0.1
	Panama	1997	10.0				
		2003	10.2	0.2	No change	No change	0.0
	Trinidad and Tobago	2000	23.0				
		2006	18.8	-4.2	Improvement	Improvement	-0.7
Newly independent States	Armenia	2000	7.0				
		2005	8.2	1.2	No change	Deterioration	0.2
	Azerbaijan (j)	2000	11.0				
		2001	12.0	1.0	No change	Deterioration	1.0
	Tajikistan	2000	15.0				
		2005	9.7	-5.3	Improvement	Improvement	-1.1

e Adjusted for relative birth size only: FESAL 1998 Final Report, CDC, as cited in WHO (2004).
f Unadjusted survey data: National Family Health Survey 2002-03, as cited by UNICEF at: http://www.childinfo.org, (accessed 3March 2008).
g Unadjusted survey data: Materno Infantil 2002, Encuesta Nacional de Salud, Table 7.8A, as cited by UNICEF at: http://www.childinfo.org, (accessed 3 March 2008).
h Adjusted for relative birth size only: Encuesta Demografica y de Salud Materna e Infantil, Informe General, CDC, as cited in WHO (2004).
i Unadjusted routine service statistics: Ministry of Health, Jamaica, annual statistics, as cited in WHO (2004).
j Unadjusted survey data: Reproductive health survey 2001, as cited by UNICEF at: http://www.childinfo.org, (accessed 3 March 2008).

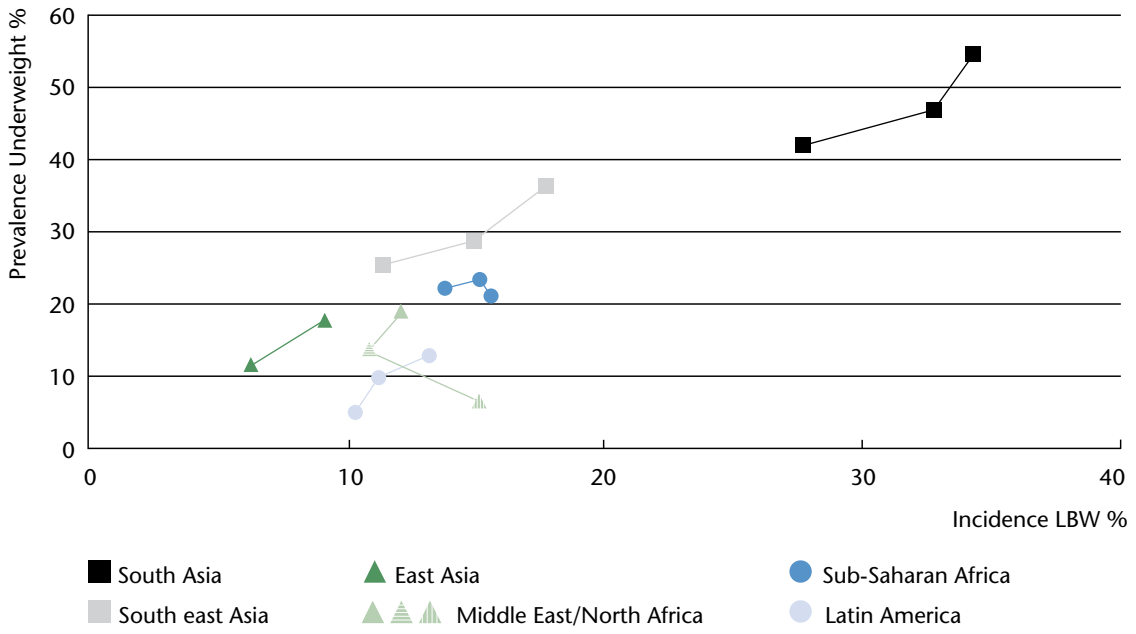
Table 25. Number of countries with changes in incidence of low birth weight: improving, none, or deteriorating, from repeated national estimates, 1997-2007 (summary of Table 24)

Region		Total	2 percentage points			1 percentage point		
			Improving	No change	Deteriorating	Improving	No change	Deteriorating
Sub-Saharan Africa	Number	28	9	13	6	13	6	9
	%	100%	32%	46%	21%	46%	21%	32%
Middle East & North Africa	Number	4	–	3	1	1	1	2
	%	100%	–	75%	25%	25%	25%	50%
Asia	Number	10	4	4	2	5	3	2
	%	100%	40%	40%	20%	50%	30%	20%
Latin America & Caribbean	Number	15	3	8	4	7	3	5
	%	100%	20%	53%	27%	47%	20%	33%
Newly independent States	Number	3	1	2	–	1	–	2
	%	100%	33%	67%	–	33%	–	67%
Total		60	17	30	13	27	13	20
		100%	28%	50%	22%	45%	22%	33%

Table 26.
Incidence of low birth weight, by region

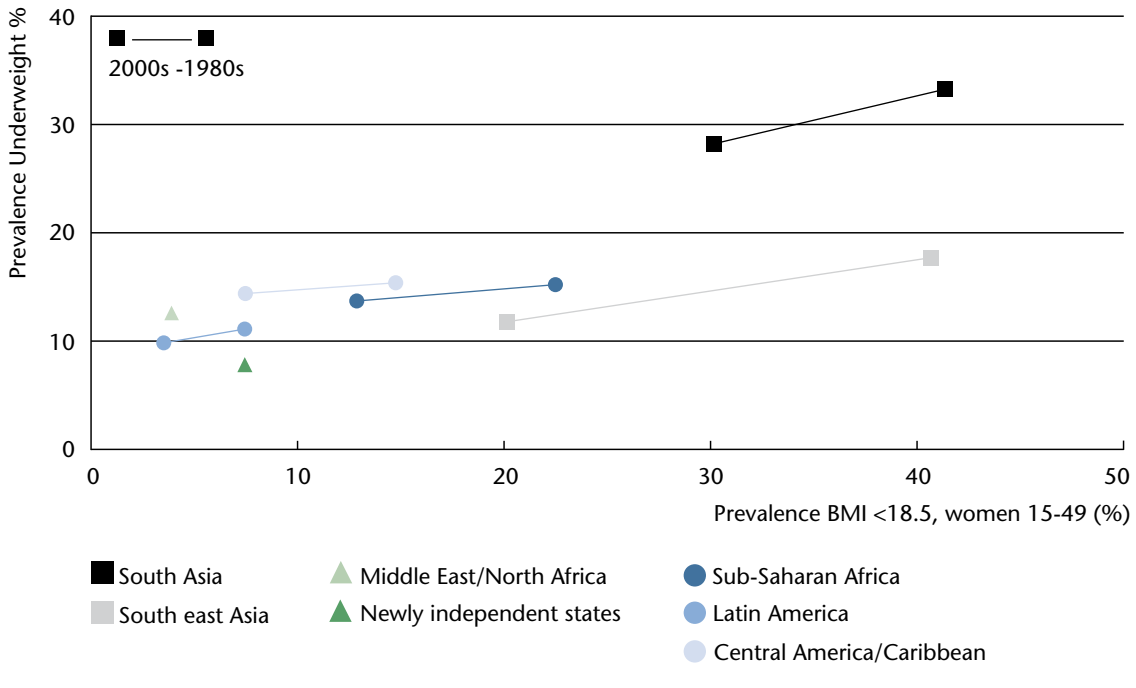
Subregion	Incidence of low birth weight (%)		
	1980s	1990s	2000s
World			
Overall	18	17	15.5
Less developed countries	20	19	16.5
Africa	**15**	**14**	**14.3**
East Africa	15	16	13.5
Central Africa	16	15	12.3
North Africa	12	11	15.3
Southern Africa	15	12	14.6
West Africa	17	16	15.4
Asia	**22**	**21**	**18.3**
East Asia	7	9	5.9
South Asia	34	32	27.1
South east Asia	18	15	11.6
West Asia	12	11	15.4
Latin America & Caribbean	**13**	**11**	**10**
Caribbean	14	12	13.7
Central America	15	12	10.1
South America	12	10	9.6

Figure 12. Change in regional estimates of the incidence of low birth weight and prevalence of underweight children (weighted estimates): 1980s to 2000s (a, b)



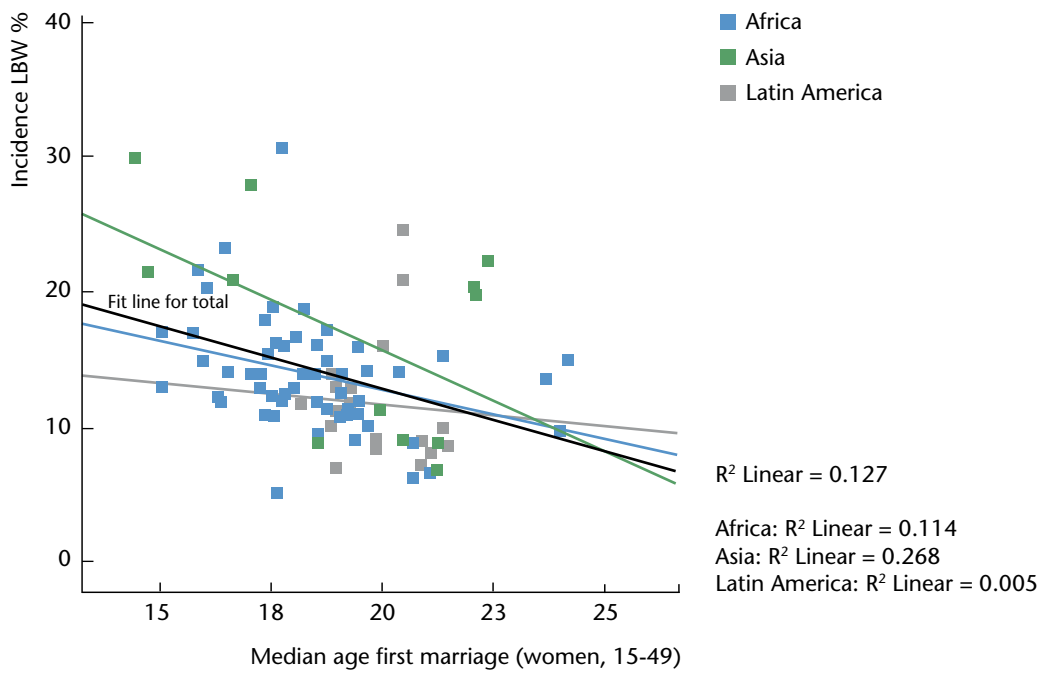
a East Asia: only 2 datapoints (1990-2000).
b All trends have the higher point 1980s, middle point 1990s, lower point 2000s except for Middle East/North Africa: data points ▲ = 1980s, ▲ = 1990s, ▲ = 2000s.

Figure 13. Change in regional estimates of incidence of low birth weight and prevalence of underweight women (unweighted estimates with available data): 1980s to 2000s



Note: for all regions the higher point is the 1980s and the lower point the 2000s.

Figure 14.
Scatter-plot of median age at first marriage and low birth weight, by region (unweighted data)



REGRESSION RESULTS

Region	Coefficient (B)	P	N
Africa	-0.69	0.008	72
Asia	-1.89	0.012	18
Latin America & Caribbean	-0.56	0.58	21
Overall	-1.02	0.000	111

Table 27. Regression coefficients for median age at first marriage and low birth weight, controlling for additional factors

(Dependent variable: % low birth weight (lbw2; N=90)		
Independent variable	Coefficient	p
(constant)	19.856	0.005
Median age at first marriage	-1.151	0.000
ln GNI08	1.234	0.158
ln BMI	3.058	0.000
Female gross enrolment in secondary education	0.031	0.300

Note: ln GNI 08 = logarithm of the Gross National Income for 2008; ln BMI = logarithm of the body mass index < 18.5.

Summary chapter 3
Maternal nutrition and the intergenerational cycle of growth failure

The purpose of Chapter 3 on maternal nutrition and the intergenerational cycle of growth failure is to revisit and review the evidence for intervening in the intergenerational cycle for transmission of growth failure. The aim is to try to understand whether this cycle can be turned into a virtuous one and, if so, how to increase birth weight in order that children grow better and become taller adults. This chapter advocates for a renewed effort to invest in maternal nutrition in a sustainable and holistic manner, and identifies a great need for an expanded research agenda of "delivery science" to improve the effectiveness of programmes and their implementation at full scale.

Previously, the thinking was that rapid reductions in low-birth-weight rates would not be easy to achieve, but would require a commitment to implementing long-term strategies. This chapter shows that gains can be achieved quickly.

THIS CHAPTER ANSWERS FOUR IMPORTANT QUESTIONS:

1. **Can improved maternal nutrition for small adult women during pregnancy improve birth weight and, if so, how quickly?**
   Yes, birth weight can be rapidly improved, even in populations of short adult women.

2. **Can improved adolescent nutrition increase birth weight in adolescent pregnancies and, if so, is this dangerous?**
   Improving the birth weight of babies born to adolescent mothers is best achieved by delaying the first pregnancy beyond 18 years of age. Additionally, tackling anaemia during adolescence and preventing or delaying teenage pregnancy will help to break the intergenerational cycle of growth failure.

3. **What effect does increased birth weight have on child growth faltering and final adult height?**
   Increasing birth weight contributes to reducing child growth faltering in the first 2 years of life, resulting in less stunting at two years of age, which is eventually reflected in increased adult height. Improved cognitive function and intellectual development across the life-course are associated with an increase in birth weight and reduction in stunting.

4. **Why has so little programme guidance emerged for this area?**
   Part of the reason why there has been so little progress in maternal nutrition is because the priority focus has been placed on interventions that produce short-term gains in child survival. An understanding of the importance of growth and development outcomes must be reinforced and revitalized, and a focus on birth weight revived. Furthermore, the importance of maternal nutrition for mothers' own health and development must be emphasized.

There is ample evidence that the intergenerational cycle of growth failure could be turned into a virtuous cycle. Birth weight can be rapidly improved, even in populations of short adult women. Improving the diet in quantity and quality can help achieve this. The effects seem to be greater if the mother is reached either during or preferably before the first semester of pregnancy. Such interventions do not endanger the mother and do not increase the risk of maternal mortality, as there is no increase in cephalopelvic disproportion, even if food supplementation is provided to adolescent mothers whose birth channels are still not mature.

Tackling anaemia during adolescence is an important priority that should get much greater programmatic attention. The advantage is that pre-pregnancy nutritional status is improved, and it is nutrition in the early months of pregnancy that has the greatest benefit on birth outcomes.

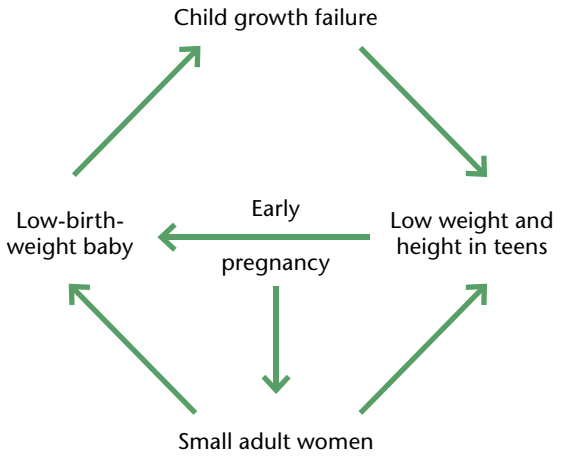
Preventing too early pregnancies is of the highest priority. This programmatic area should include sex education and family planning services for adolescents in order to reduce teenage pregnancy rates. This will be facilitated by a more enabling societal environment, where community norms and values in regard to early marriage, sex education and family planning may need to change. Nutritional and family planning activities will help to break the intergenerational cycle of growth failure and turn it into a virtuous cycle.

Renewed investment in adolescent girl and maternal nutrition will contribute significantly to the progressive realization of the rights of the girl child and of the adolescent mother in the context of the Convention on the Rights of the Child and the Convention on the Elimination of All Forms of Discrimination against Women, as well as making important contributions to achieving Millennium Development Goals 1, 4 and 5.

Chapter 3
Maternal nutrition and the intergenerational cycle of growth failure

The intergenerational cycle of growth failure, first described in 1992 in the Second report on the world nutrition situation and illustrated here in Figure 15, explains how growth failure is transmitted across generations through the mother. The theory is that small adult women are more likely to have low-birth-weight babies, in part because maternal size has an important influence on birth weight. Children born with a low birth weight are more likely to have growth failure during childhood. Thus, in turn, girls born with a low birth weight are more likely to become small adult women. This cycle is accentuated by high rates of teenage pregnancy, as adolescent girls are even more likely to have low-birth-weight babies. The definition of low birth weight is a baby born weighing less than 2.5 kg. Figure 15 shows how low birth weight of individuals and low mean population birth weight are interlinked. The way of breaking the cycle is to improve the whole distribution of birth weights, so that the mean birth weight is increased, and the whole population benefits.

Figure 15.
Intergenerational cycle of growth failure



Source: ACC/SCN (1992).

In subsequent reports, the UNSCN has further refined the life-cycle approach to improving nutrition. Nutrition throughout the life-cycle was the theme explored in the Fourth report on the world nutrition situation (SCN, 2000), which looked at how to intervene at different stages of the life-cycle but did not focus on the critical window of opportunity from conception to two years of age. The authors of UNSCN Nutrition Policy Paper No 18 (Pojda & Kelley, 2000), on low birth weight, found that many questions remain unanswered about how to tackle the problem of reducing low-birth-weight rates. The paper highlights the urgent need to find sustainable practices that will improve women's nutritional status prior to pregnancy, and their weight gain during pregnancy. The paper concludes that reducing and preventing low birth weight requires a commitment to implementing long-term strategies. This leaves a general impression that rapid reductions in low-birth-weight rates would not be easy to achieve.

The regional trends in low birth weight presented in this report suggest that improving birth weight has made an important contribution to reducing child undernutrition, and in doing so has contributed to achieving Millennium Development Goal 1 (MDG 1) to eradicate extreme poverty and hunger. Improving maternal nutrition offers important opportunities to improve both the health and well-being of the mother herself, as well as of her children. Nevertheless, the question of whether the intergenerational cycle of growth failure can be turned into a virtuous cycle still has to be answered.

The purpose of this chapter is to revisit and review the evidence for intervening in the intergenerational cycle of transmission of growth failure. The aim is to try to understand whether this cycle can be turned into a virtuous one and, if so, how to increase birth weight in order that children grow better and become taller adults. The chapter builds on and updates UNSCN News No. 11. It also draws on the efforts of others to develop recommendations in this area, including a report of the March of Dimes (2000) Task Force on Nutrition and Optimal Human Development

and the WHO global consultation on optimal fetal development (WHO, 2006a). Questions to be addressed include:

- Can improved maternal nutrition for small adult women during pregnancy improve birth weight and, if so, how quickly?
- Can improved adolescent nutrition improve birth weight in adolescent pregnancies and, if so, is this dangerous?
- What effect does improved birth weight have on child growth faltering and final adult height?
- Why has so little programme guidance emerged for this area?

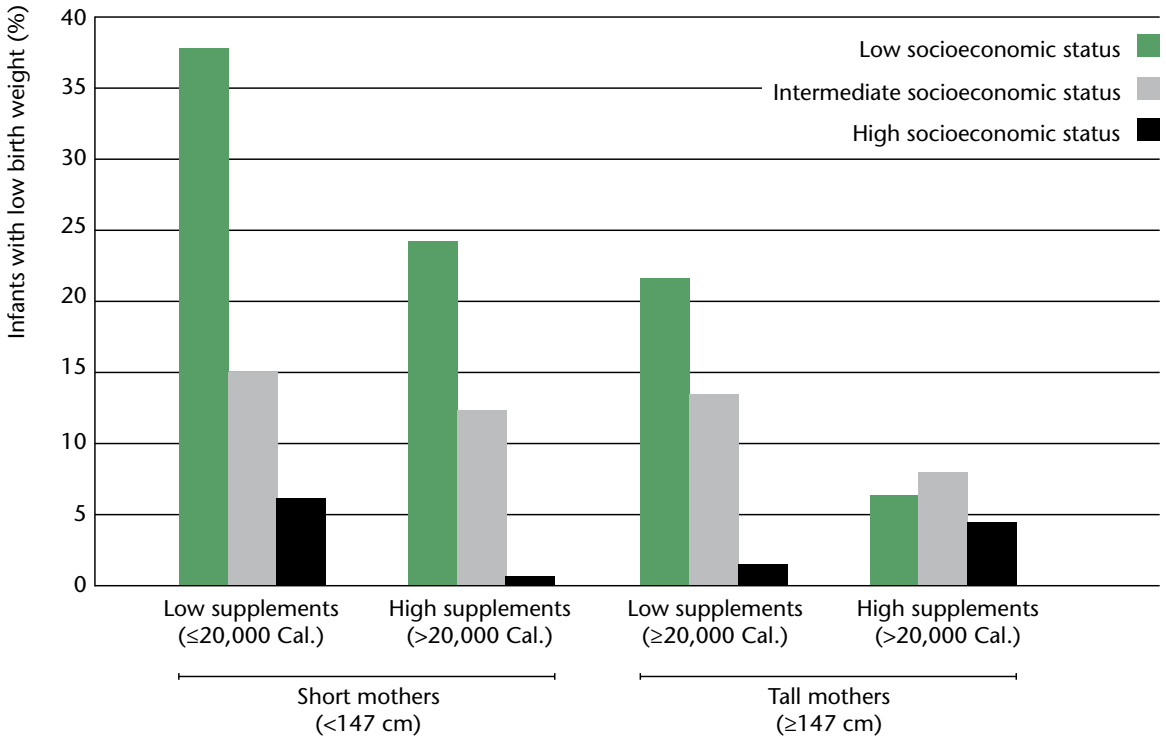
CAN BIRTH WEIGHT BE IMPROVED QUICKLY BY IMPROVING MATERNAL NUTRITION, EVEN IN SMALL ADULT WOMEN?

Evidence from experimental studies suggests that, even in small adult mothers, low-birth-weight rates can be reduced to normal levels within a few years. A systematic review of placebo controlled food supplementation trials found that balanced protein-energy supplementation was associated with modest increases in maternal weight gain and in mean birth weight, and a substantial reduction in risk of small-for-gestational-age birth (Kramer & Kakuma, 2003). Only one of these trials was conducted in a developing country, however. That trial was in the Gambia, where low-birth-weight rates were cut by a third in a few years (Ceesay et al., 1997). Studies in multigravida mothers have shown that nutritional supplementation improves birth weight in malnourished women, whereas for marginally malnourished women, although the mother benefits, there is less effect on birth weight. In well-nourished women, there is no effect on maternal weight gain or birth weight (Winkvist, Habicht & Rasmussen, 1998). In obese mothers, there is an inverse relationship between maternal weight and pregnancy weight gain (Schieve et al., 2000). Results from non-blind non-randomized trials of food supplementation during pregnancy in Guatemala showed that low-birth-weight rates were reduced more in tall than in small Guatemalan mothers (see Figure 16), but this effect was seen only in women of low socioeconomic status. Low-birth-weight rates were already low (6%) in short Guatemalan mothers from the highest socioeconomic group.

Micronutrient supplementation during pregnancy also achieves increases in birth weight, which are as large as those achieved by balanced protein-energy food supplements. A meta-analysis of trials of multiple micronutrient supplementation during pregnancy found an increase in mean birth weight of 22.4 g and a reduction in the prevalence of low birth weight by 10% as compared to iron plus folic acid supplements (Fall et al., 2009). Multiple micronutrient supplements, taken in addition to the regular iron plus folic acid supplements during pregnancy by thin and/or anaemic women in New Delhi, increased birth weight by 98 g, birth length by 0.80 cm and reduced early neonatal morbidity by 50% compared to placebo (Gupta et al., 2007). This increase in mean birth weight meant that the incidence of low birth weight was reduced from 43.1% to 16.2%, which is a large effect in the Indian context where a third of all births are low birth weight. Even in developed country settings, the use of multiple micronutrient supplements during pregnancy seems to improve birth weight. An observational study showed a twofold reduction in low birth weight in mothers taking supplements in the United States (Scholl et al., 1997), and a placebo controlled trial showed an increase in birth weight of 251 g among apparently healthy well-nourished French women taking a multiple micronutrient supplement (Hininger et al., 2004). Furthermore, it seems that these effects of multiple micronutrient supplements are in addition to that already being achieved by the iron plus folic acid supplements often used as "placebo" control, but which probably add around 100g to mean birth weight as compared to a true placebo (Rasmussen & Stoltzfus, 2003).

Further evidence that low-birth-weight rates can be rapidly reduced comes from observational studies in populations that change location. In the refugee camps in Nepal, low-birth-weight rates of 8% were achieved among ethnic Nepali Bhutanese refugee mothers within 5 years of settlement

Figure 16.
Maternal dietary supplements and low birth weight in Guatemala



Source: Lechtig & Shrimpton (1987).

in the camps (Shrimpton et al., 2009). At the same time, among ethnic Nepalese living in the same district but outside the refugee camps, low-birth-weight rates were around 30%. Furthermore, among Asian immigrants to the United States there was a 46% reduction in low-birth-weight rates (15.5% to 8.5%) in the decade to 1987, by which time rates became the same as for White and Hispanic births (Yip, Scanlon & Trowbridge, 1992).

There is growing evidence that improving the quality of the diet of the mother during the first half of pregnancy can have as big an effect on birth weight as providing food supplements later in pregnancy. Certainly, the risk of delivering a low-birth-weight baby can be determined very early in pregnancy (Smith et al., 2002), and the influence of maternal nutritional status on pregnancy outcomes is more important in early rather than late pregnancy (Neufeld et al., 2004). In food supplementation trials in Guatemala, the amount of birth weight associated with each kilogram of weight gain by the mother was twice as great in the second trimester (62 g) as in the third (26 g), and for newborn length it was ten times greater in the second trimester (0.24 cm) than in the third (0.02 cm) (Ruowei, Haas & Habicht, 1998). Evidence from rural India has shown that consumption of micronutrient-rich foods (milk, green leafy vegetables, and fruits) during pregnancy and erythrocyte folate levels at 28 weeks of gestation were independently and positively associated with the size of the infant at birth, even though there was no association with the adequacy of energy or protein intakes (Rao et al., 2001). Across Asian countries the use of iodized salt is associated with increased birth weight and weight for age in young children (Mason et al., 2002), and in Indonesia non-use of adequately iodized salt is associated with a higher prevalence of child malnutrition and mortality in neonates, infants and children less than 5 years of age (Semba et al., 2008).

Although programme guidance exists on when and how to intervene during pregnancy, programme implementation is largely limited to efforts to reduce maternal anaemia. Where anaemia rates in women of reproductive age are greater than 40% then universal supplementation with iron plus folic acid is recommended in addition to infection

control during pregnancy (WHO/UNICEF, 2004). Furthermore, in areas where low-birth-weight rates are greater than 15%, and/or where more than 20% of women of reproductive age are excessively thin (BMI <18.5), the recommendation is to provide "balanced" protein-energy food supplements to women during pregnancy and lactation (WHO, 1995). Rarely, however, do countries have any programmes in place to tackle the problem of low birth weight (Bryce et al., 2008). The landscape assessment of readiness to accelerate action in nutrition (Nishida, Shrimpton & Darnton-Hill, 2009) found that nutrition programmes are often under-resourced in all aspects, especially to deal with preventive community-based nutrition actions. This may well be because anaemia and stunting are not seen as health problems and/or are thought to be genetic, and the role of maternal nutrition in the intergenerational cycle of growth faltering is not recognized (WHO, 2009).

Programme experience with supplementation during pregnancy has shown few successes however, and there is a great need to work on improving effectiveness.

Despite iron supplements being provided during pregnancy through antenatal care in most countries, maternal anaemia rates are still commonly over 40% (see Chapter 2 on regional trends), indicating that these programmes are not working. Reviews of programme experience show that this lack of success most commonly results from the lack of a regular supply of supplements and the lack of attention given to anaemia as a problem (Gillespie, Kevany & Mason, 1991). Furthermore, there rarely is concurrent control of helminth infections, although this has been shown to greatly improve the impact of supplements on anaemia and growth, both during pregnancy (Torlesse & Hodges, 2000; Christian, Khatry & West, 2004) and in childhood (Stoltzfus et al., 2004). Where the supply of micronutrient supplements is ensured, and they are provided together with supportive encouragement from a community-based health worker, high adherence rates can be achieved (Aguayo et al., 2005).

One of the few programmes to implement food supplementation, on a large scale, during pregnancy is the Bangladesh Integrated Nutrition Programme, which showed little or no impact on birth weight, and no difference between mothers who did or did not receive supplements (Nahar, Mascie-Taylor & Begum, 2009). This lack of impact can most likely be explained by the targeting; the mothers who received supplements tended to be worse off economically, and the birth weights of their babies were comparable to those of the better-off mothers who did not receive supplements (Ortolano et al., 2003).

A promising success exists in Mexico, where the PROGRESA programme uses cash transfers as an incentive for parents with economic hardships to invest in their children's health and education, and in part to improve birth outcomes through better maternal nutrition and use of prenatal care. An evaluation has shown that beneficiary mothers had babies with a 127 g higher birth weight than non-beneficiary mothers of similar socioeconomic status (Barber & Gertler, 2008). Another recent success is the "good start to life programme" in Peru which reduced stunting and anaemia dramatically in preschool children by promoting increased food intake and weight gain during pregnancy, exclusive breastfeeding for the first six months and adequate complementary feeding up to 2 years of age (Lechtig et al., 2009). There is a great need for an expanded research agenda of "delivery science" to better understand how to improve the implementation and cost effectiveness of programmes at scale (Heikens et al., 2008).

Very little attention has yet been given to looking at the effect of a more complete nutritional supplement, or of an improved diet, on weight gain during pregnancy, on birth weight and/or length, or on other development outcomes. The trials have tended to be narrow experiments, comparing energy with protein, or comparing iron plus folic acid with multiple micronutrient supplements. The balanced protein-energy food supplements used in the Bangladesh Integrated Nutrition Programme and in the Gambia programme, mentioned above, were made locally from cereals and legumes and had no micronutrients added. A recent trial in Burkina Faso (Huybregts et al., 2009) that looked at the impact of giving a micronutrient fortified fat-rich food supplement as compared to a multiple micronutrient supplement alone, found improved birth length with the fortified fat-rich food supplement, and an even greater effect on birth length and birth weight in underweight and anaemic women. The authors concluded that, for mothers with suboptimal pre-pregnancy nutritional status, multiple micronutrient supplementation should be accompanied by balanced energy and protein supplementation for the greatest benefit in terms of birth size. Adding multiple micronutrient supplementation to the dietary supplement during pregnancy in the Bangladesh Integrated Nutrition Programme led to better cognitive function in children at two years of age (Tofail et al., 2008).

Little attention has been given to the type of fat used in the supplements during pregnancy, even though there is evidence suggesting that providing omega-3 fatty acids might increase birth weight (Mardones et al., 2008), improve infant behaviour (Carlson, 2009), and augment IQ in children at four years of age (Helland et al., 2003).

In general, little or no research findings or clear programme guidance exist on how to improve weight gain during pregnancy by improving the mother's diet.

Improved maternal nutrition has benefits for the mother that in themselves are important and that, regardless of the effect on birth weight, are also likely to benefit child growth and development. Addressing maternal anaemia during pregnancy, in addition to reducing maternal mortality by 20% (Black et al., 2008), would also contribute to improving the mother's emotional and cognitive ability (Beard et al., 2005), with positive effects on her caring capacity (Perez et al., 2005). Omega-3 fatty acid supplements can also help reduce maternal depression during pregnancy (Rees et al., 2009). Furthermore, even if maternal supplementation has little impact on breast milk quantity or quality, for example, mothers who receive supplements get sick less and need less medical attention (Lechtig & Shrimpton, 1987).

In summary, we conclude that birth weight can be rapidly improved, even in populations of short adult women, and that improving the diet, both in quantity and quality, be it through food or micronutrient supplementation, fortification with micronutrients, or both, can help achieve this, especially if the pre-pregnancy nutritional status of the mother is taken into account. These effects seem to be greater if the mother is reached either during or preferably before the first semester of pregnancy. If countries were to direct more effort and resources to this programmatic area, the potential for breaking the cycle of growth failure would be great, with obvious benefits both for the mother and her children.

CAN IMPROVED ADOLESCENT NUTRITION IMPROVE BIRTH WEIGHT IN ADOLESCENT PREGNANCIES?

The major reason for low birth weight in babies of adolescent mothers is that pregnancy occurs before the woman is full grown. Small mothers have lower-birth-weight babies than taller mothers, and this is compounded in adolescents by an immature uterine and hormonal environment. Therefore, the best way to improve birth weight of babies born to adolescent mothers is to postpone the first pregnancy until after the mother has finished growing, or at least until 18 years of age. As recognized by Kurz (1994), the growth hormones of the still-growing adolescent primiparous mother favour the partitioning of growth to her at the expense of the fetus, which ends up 200 g lighter (Scholl et al., 1994). Growth continues long after menarche; in the United States for example, where menarche typically occurs around 12 years of age, growth continues at about a centimetre a year until 18 years.

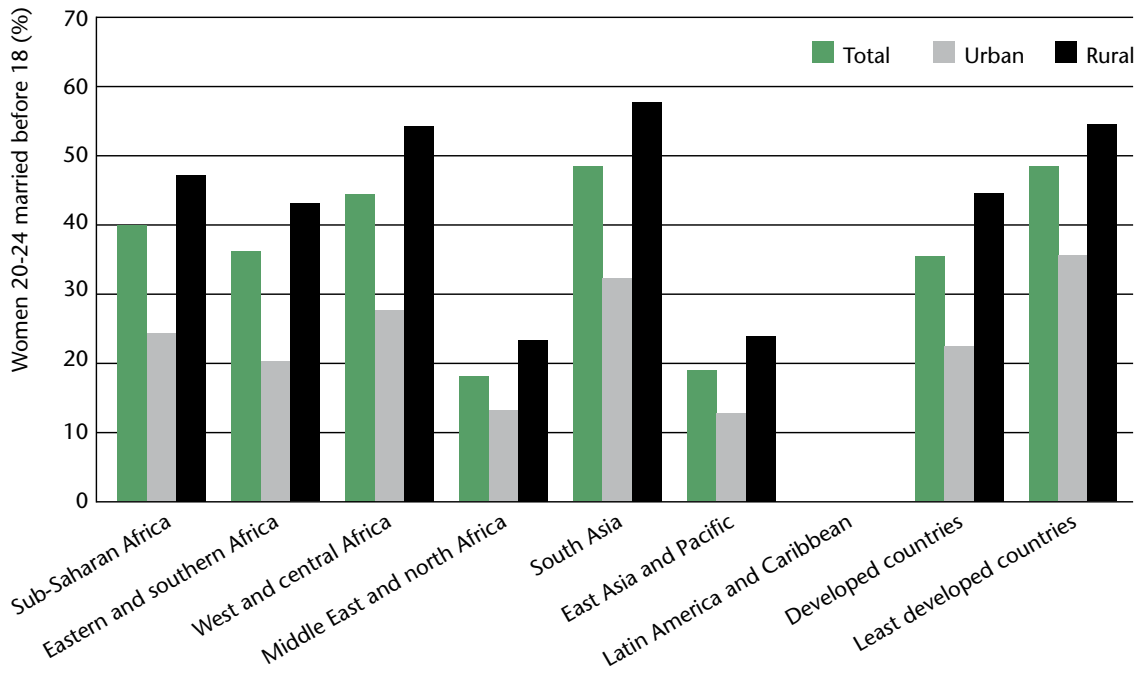
Furthermore, late maturing girls tend to be thinner and grow taller than those maturing earlier (Garn et al., 1986; Demerath et al., 2004). In developing country settings, many girls – especially in rural areas – are menstruating later, at around 16 years of age, but they also continue to grow until they are older; those who do not get pregnant are still growing past 20 years of age (Riley, Huffman & Chowdhury, 1989). Thus, delaying the first birth until at least 18 years of age, so that the mother has herself finished growing, would make an important contribution to increasing birth weight and reducing child undernutrition rates in many developing countries. In India, for example, where 40% of the low-birth-weight babies are born (UNICEF/WHO, 2004), 8% of all women aged 20-24 years in 2006 had become mothers before they were aged 16 years (Moore et al., 2009). As noted by Gopalan (1987) , the percentage of adolescent mothers at obstetric risk in rural Kerala decreased with increasing age: at age 14 years, 68% weighed less than 38 kg and 45% were less than 145 cm tall; by 18 years of age, the corresponding proportions were 24% and 16%, respectively.

A major cause of teenage pregnancies in India is child marriage, which accounts for almost half of all Indian marriages. Child marriage is significantly associated with stunting of offspring, even after adjusting for confounding factors (Raj et al., 2010). The husband of the child bride in India is typically five years older than his wife (Raj et al., 2009) and in these unions there is significantly less contraceptive use before first child birth, higher fertility (three or more births), and more repeated childbirths in less than 24 months, all of which increase the risk of further preterm births and growth-retarded infants (King, 2003) compared to non-child marriages. There are also more unwanted pregnancies, many of which are terminated in ways which increase the risk of maternal death.

The situation of women in rural India is marked by child marriage practices, which in addition to exposing young girls to early pregnancies increases their isolation from their own families, and increases their workloads while decreasing their autonomy. All of this increases their food insecurity and contributes to their excessive thinness (Chorghade et al., 2006). The legal age of marriage in India is 18 years, and child marriages violate the legal rights of these young mothers.

Despite all of the risks, teenage pregnancy is still very frequent in developing countries and is related to early marriage. Information on child marriage from UNICEF (2008), presented in Figure 17, shows that a third of all young women in developing countries are married before they are 18 years of age. The practice is more common in rural areas, where almost half of all women are married

Figure 17.
Child marriage rates by world region and urban/rural area



Source: UNICEF (2008).

before they are 18 years old. The practice is most common in rural areas of south Asia (as discussed above) and west Africa, where 58% and 55% respectively of girls are married before 18 years of age. As reported by Westhoff (2003), there is a strong correlation between age of first marriage and age of first birth, with teenage pregnancy rates being very high in many developing countries. In sub-Saharan Africa for example, two thirds of the countries had rates of over 20%, with Mali and Niger the highest at just over 40%. Other countries with high rates are in south Asia, with Bangladesh at 35%, and Nepal and India at 21%. Involuntary child marriages contravene both the Convention on the Rights of the Child and the Convention on the Elimination of All Forms of Discrimination against Women.

Teenage pregnancy rates are very low in many east Asian countries, such as Cambodia, China and Viet Nam, where societal rules dictate that marriage should occur only after 21 years of age. The Population Reference Bureau (PRB, 2010) also reports that teenage pregnancy rates declined between 1994 and 2006 in countries such as Bangladesh (39% to 33%), India (23% to 13%) and Uganda (43% to 26%), while remaining high in Niger (40%). In contrast, the highest rates of teenage pregnancy in developed countries around 2000 (UNICEF, 2001) were in the United States at 5% and the United Kingdom at 3%, although the rate in the United States has risen to 7% since then (Kost, Henshaw & Carlin, 2010).

Improving pre-pregnancy nutritional status is an important area of work that requires greater programmatic attention. Improving adolescent iron status before childbearing is an example of this approach (Kurz & Galloway, 2000), and is especially appropriate in areas where teenage pregnancy rates are high. Increased iron needs during the adolescent growth spurt, as well as from the onset of menstruation, contribute to the increased likelihood of iron deficiency anaemia during adolescence. This is best tackled as part of the preparation for any early pregnancy. Most pregnant women contact the health service only in the third trimester of pregnancy, making it difficult to channel iron supplementation through health care. Reaching adolescents through schools with weekly iron supplementation is an alternative service delivery route; although use of this route has shown little effect in Indonesia (Soekarjo et al., 2004) and Bangladesh (Ahmed et al., 2005), it has been highly successful in India (Vir et al., 2008). The difference in impact is most likely explained by the counselling and deworming every six months that occurred in the Indian trial but not in the other two.

Whether or not to provide food supplements during pregnancy to thin growing adolescents presents a dilemma. Teenage pregnancies potentially have a much greater risk of fatal outcomes for both mother and child because growth of the pelvic bones, critical for preventing obstructed labour,

occurs for several years after height growth is complete, that is, about seven years after menarche. While the hypothesis that food supplementation of mothers during pregnancy might increase maternal mortality has been raised (Garner, Kramer & Chalmers, 1992), this is not supported by the Gambia trial. This trial showed that although food supplements increased birth weight by 136 g, the increase in cephalic diameter was just 1 mm and there was no increase in birthing difficulties (Ceesay et al., 1997). Furthermore, in a study of births in Malawi and Nigeria, cephalo-pelvic disproportion was not found to be more common in adolescents, and the authors concluded that nutritional supplementation of girls and adolescents should not be discouraged for fear of increasing the risk of cephalo-pelvic disproportion by improving birth weight (Brabin, Verhoeff & Brabin, 2002). While food supplements do not endanger the growing adolescent mother during pregnancy, they may present a danger to her fetus. As noted above, in the growing adolescent mother there is a partitioning of growth in favour of the mother and at the expense of the fetus, which is 200 g lighter at birth.

What was less clear 15 years ago, although it is implied in Figure 15, is that pregnancy stops the growth of the adolescent girl. Recent studies in Mexico (Casanueva et al., 2006) and rural Bangladesh (Rah et al., 2008) found that the growth of adolescent girls ceases when they get pregnant. This cessation of linear growth as a result of early pregnancy is thought to cause a loss of between 0.6 cm and 2.7 cm in attained height in rural Bangladeshi women. As girls typically keep growing at about 1 cm a year for 5 years after menarche, it would seem likely that for each year that the median age of first pregnancy is below 20 years about 1 cm is lost of the potential final adult woman's height. Vir (1990) described how the growth of affluent adolescent girls in India was virtually identical to the National Child Health Statistics curve up to around 12.5 years of age, only then falling behind so that at 18 years of age affluent Indian girls are 5 cm shorter than the NCHS curve. Furthermore, studies among an urban Indian population showed girls of high socioeconomic class to be 8 cm taller and 9 kg heavier than girls of low socioeconomic class at 18 years of age.

Because maternal size has a strong influence on birth weight (Kramer & Kakuma, 2003), where teenage pregnancy rates are high (as they are in India and especially among the poorer classes and castes) the lost growth attributable to adolescent pregnancy must make an important contribution to the intergenerational cycle of growth failure and the perpetuation of small adult stature. This surely represents an important window of opportunity for breaking the intergenerational cycle of growth failure. Renewed and redoubled efforts are most urgently needed to enforce existing legislation on age of marriage and to discourage child marriages, in addition to providing family planning services for adolescents.

The potential role of teenage pregnancy in increasing maternal obesity is also increasingly recognized. While pregnancy and lactation during adolescence resulted in emaciation and fat loss among mothers in rural areas of Bangladesh (Rah et al., 2008), the opposite seems to occur in "energy rich" environments such as the United States where growing adolescents accumulate extra fat at the end of the pregnancy, at the expense of the baby, who is more likely to be low birth weight (Scholl et al., 2000). Cohort studies in Brazil have also shown that pregnancy during adolescence is associated with increases in maternal body fat (Gigante, Rasmussen & Victora, 2005). Perhaps paradoxically, the double burden of undernutrition and overnutrition among women in India increases with the degrees of income inequality across states (Subramanian, Kawachi & Smith, 2009). Of the 77 countries categorized by FAO as low-income food-deficit countries, data on maternal BMI is available for 54, and in three quarters of these there were more overweight (BMI >25) than underweight (BMI<18.5) women of reproductive age. Furthermore, in only 17% of low-income food-deficit countries were more than 20% of women of reproductive age found to be excessively thin, whereas in 44% of such countries more than 20% of women of reproductive age were overweight. That overweight exceeds underweight among women in most developing countries has been considered evidence for a growing double burden of malnutrition (Mendez, Monteiro & Popkin, 2005). Teenage pregnancy is likely to be an important part of this double burden of malnutrition paradox, especially as developing country economies grow and their populations become increasingly urbanized.

In summary, we conclude that improving the birth weight of babies born to adolescent mothers is best achieved by delaying the first pregnancy beyond 18 years of age. Food supplementation of the primiparous, growing pregnant adolescent does little to improve the birth weight of her baby. The control of anaemia, including the provision of micronutrient supplements to pregnant adolescents can contribute to improving birth weight, even in primiparous growing adolescent mothers. Tackling anaemia during adolescence and/or preventing or delaying teenage pregnancy will surely help to break the intergenerational cycle of growth failure and turn it into a virtuous cycle.

Apart from ensuring adequate nutrition for teenage mothers, nutritionists must also recognize that the greatest need is to ensure that adolescents get access to sex education and family planning services in order to prevent teenage pregnancy, and that for this to happen the societal environment needs to be enabling. For each year that

median age of first pregnancy can be delayed beyond 15 years of age, an additional 1 cm is likely to be added to the height of adult women, who in turn will have bigger babies. These combined efforts would be real contributions to the progressive realization of the rights of the girl child and of the adolescent mother in the context of both the Convention on the Rights of the Child and the Convention on the Elimination of All Forms of Discrimination against Women, as well as contributing to cutting the intergenerational transmission of growth failure.

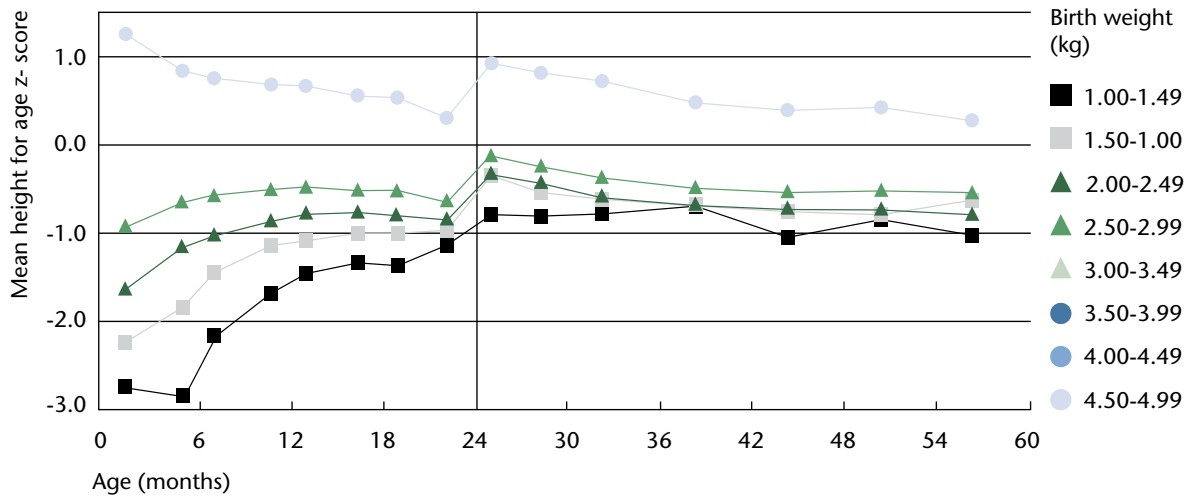
WHAT EFFECT DOES IMPROVED BIRTH WEIGHT HAVE ON CHILD GROWTH FALTERING, INTELLECTUAL DEVELOPMENT AND FINAL ADULT HEIGHT?

Birth weight has an enormous impact on child growth faltering, child development and final adult height. The World Health Organization child growth standard published in 2006 has confirmed that children's potential to grow is the same the world over, and independent of racial makeup (WHO, 2006). It is also now firmly accepted that child growth failure occurs in a critical "window of opportunity" from conception to 2 years of age (Shrimpton et al., 2001), and that from the third year onward children grow in the same way on average no matter who they are or where they are. It is also recognized that the causes of stunting are rooted in inadequate fetal growth and include poor maternal nutrition, and that about half of the growth failure accrued by two years of age occurs in uterus (Karlberg, 1989; Li et al., 2003), although this proportion may vary across countries (Dewey & Huffman, 2009).

Furthermore, the existence of stunting at 2 years of age can be rapidly eliminated, as demonstrated by the 46% reduction of stunting between 1982 and 1989 in children of Asian immigrants to the United States (Yip, Scanlon & Trowbridge, 1992). As shown in Figure 18, longitudinal data on children growing in the United States shows that birth weight is a strong predictor of weight and height in early childhood, not only for low-birth-weight children but also for those of normal and high birth weight (Binkin et al., 1988). Although some catch-up growth occurs among infants born with low birth weight, they never catch up with normal-birth-weight babies. Thus, preventing low birth weight is better than trying to make up for it in early infancy. The variation in adult height seen in different populations across the globe is largely explained by differences in height at 2 years of age (Cole, 2000). Those born with low birth weight are about 5 cm shorter at age 17-19 years than those not born with low birth weight, and the magnitude of these differences is similar in both developed and developing countries (Martorell et al., 1998).

Birth weight also influences the future intellectual development of the child. Differences in IQ later in childhood among twins are determined by growth in uterus and size at birth, rather than any later familial environmental influence (Newcombe, 2007). Cohort studies in the United Kingdom show that birth weight has an influence on childhood cognitive tests and educational achievement that persists into adulthood (Richards et al., 2001). Although the influence of the home environment is stronger than

Figure 18.
Birth weight and subsequent height



Source: Binkin et al. (1988).

that of birth weight, these are independent effects (Shenkin, Starr & Deary, 2004). Furthermore, the effects of social class and birth weight on cognitive development are cumulative, such that children born with lower birth weights in the lower socioeconomic classes show a relative decline in cognitive development with age, whereas those in the higher socioeconomic classes show a relative increase with age, regardless of birth weight (Jefferis, Power & Hertzman, 2002). Pooled analysis of five cohort studies from low- and middle-income countries found that weight gain during the first two years of life, followed by birth weight, were the best predictors of schooling outcomes (Martorell et al., 2010). In Guatemala, psycho-educational tests in adolescence were improved more by a balanced protein-energy supplement than by an energy supplement during pregnancy and the first two years of life, with the former protecting against the effects of socioeconomic status (Pollitt et al., 1995). Other studies in developing countries have shown diet quality, growth and anaemia to be important predictors of attainment of motor milestones by infants (Kuklina et al., 2004; Siegel et al., 2005), pointing to the likelihood of iron deficiency during this critical early period as having long lasting neural and behavioural effects (Lozoff et al., 2006).

Child stunting is now accepted as one of the best indicators of the quality of future human capital (Victora et al., 2008). Damage suffered in early life, associated with the process of stunting, leads to permanent impairments that lower attained schooling and reduce adult income. The success of sustainable actions to alleviate poverty is thus best measured by their capacity to reduce the prevalence of stunting in children less than 5 years of age. Although the indicator for monitoring the progress made towards the achievement of Millennium Development Goal 1 was set as child underweight, it is now recommended that countries and development partners report instead on the prevalence of stunting in children less than 5 years of age (SCN, 2008).

We conclude that improving birth weight contributes to reducing child growth faltering in the first two years of life, resulting in less stunting at two years of age, which is eventually reflected in increased adult height. Improved cognitive function and intellectual development across the life-course are associated with an increase in birth weight and reduction in stunting. The negative effects of lower birth weight on intellectual development are accentuated in lower socioeconomic groups, and can be mitigated by improved home environments.

WHY HAS SO LITTLE PROGRAMME GUIDANCE EMERGED FOR THIS AREA?

A lack of funding for the area of maternal and child health and nutrition is increasingly being recognized and addressed, although the lack of attention to maternal nutrition in particular is not. Efforts to attract attention, and increase momentum and funding for maternal, newborn and child survival interventions have been relatively successful, with the Countdown exercise now leading the way (Zulfiqar et al., 2010). But the focus on mortality reduction, as opposed to growth and development, has meant that several areas of nutrition interventions are not receiving enough support, the most notable example being maternal and child anaemia. The WHO reproductive health strategy (WHO, 2004) mentions the word nutrition only twice in its 65 pages, and anaemia is not even mentioned once. The Lancet Nutrition Series Paper No. 5 noted that current processes for producing normative guidance are laborious and duplicative, and fail to produce guidance that is prioritized, succinct and evidence-based, but the paper failed to note the lack of any guidance in the area of maternal nutrition.

That the focus of nutrition attention in the past few decades has been on child undernutrition, and not maternal undernutrition, in many ways testifies to the effectiveness of UNICEF advocacy, not against maternal nutrition but for child nutrition. The conceptual framework developed by UNICEF back in the 1990s was an important contribution towards a better understanding of the causality of child malnutrition, recognizing the importance of "food", "health" and "care" as each being essential causes of – but alone insufficient to explain – child growth failure (UNICEF, 1990). While it was logical for UNICEF to develop an analytical framework for child malnutrition, it is unfortunate that the framework did not capture the maternal dimensions of the intergenerational cycle of growth failure. This has resulted in interventions directed at maternal nutrition receiving short shrift programmatically. Interventions to prevent child growth faltering have largely concentrated on weight growth faltering in the period after birth, with a heavy emphasis on breastfeeding and adequate complementary feeding.

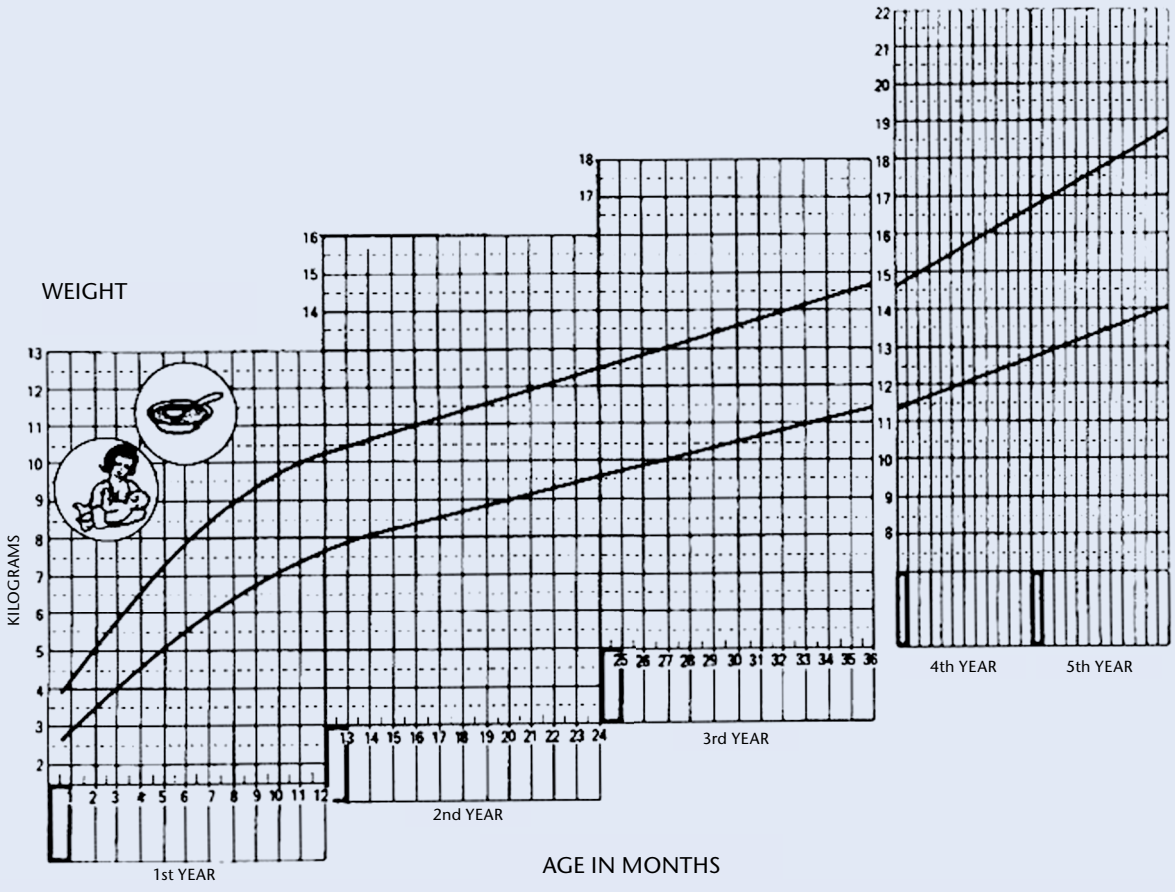
Part of the reason why there has been so little progress in maternal nutrition is because the priority focus has been placed on interventions that produce short-term gains in child survival. The central platform of the UNICEF child survival and development approach in the 1980s and 1990s was community-based growth monitoring, which prioritized the promotion of selective primary health care interventions: oral rehydration, breastfeeding and immunization. The growth promotion message of the "road to health" growth chart (Morley & Woodland, 1979) was that

if children were growing along their expected growth trajectory, as shown in Figure 19, then they were "healthy". Even in the most successful growth monitoring programmes in Indonesia (Priyosusilo, 1988) and the United Republic of Tanzania (Pyle et al., 1993), for example, the biggest impact of growth monitoring was on severe malnutrition, while the rates of moderate malnutrition were reduced much less. Such programmes would have been more successful in elevating the growth trajectory of the child if more effort had been put into improving maternal nutrition during and prior to pregnancy, as well as reducing teenage pregnancy rates. The UNICEF consultation that originally developed the growth-monitoring, oral rehydration, breastfeeding and immunization concept in 1982 actually recommended that the concept should also include food for mothers to improve birth weight, and family planning to reduce family size and increase spacing between pregnancies. It is obviously time to reinstate those ideas.

There is a general lack of comprehension of the enormous impact that small changes during the period in uterus can have later in the life-course. The effects of interventions that improve birth weight are often dismissed as being "small" and of "little or no biological significance". What is little understood, however, is that for most biological outcomes, optimal birth weight is greater than the mean birth weight. While the highest risk of an undesirable outcome is usually found below 2.5 kg, the lowest risk is usually in the 3.5 kg to 4 kg range (WHO, 2006b), in other words two standard deviations above the mean. This means that shifting the mean of the distribution benefits the whole population.

The outcomes that follow the pattern of mean birth weight are many. They include higher infant mortality in populations with high levels of intrauterine growth retardation (Ashworth, 1998). Where mean birth weight is high, however, there will be an improvement in cognitive function.

Figure 19.
The "road to health" growth chart



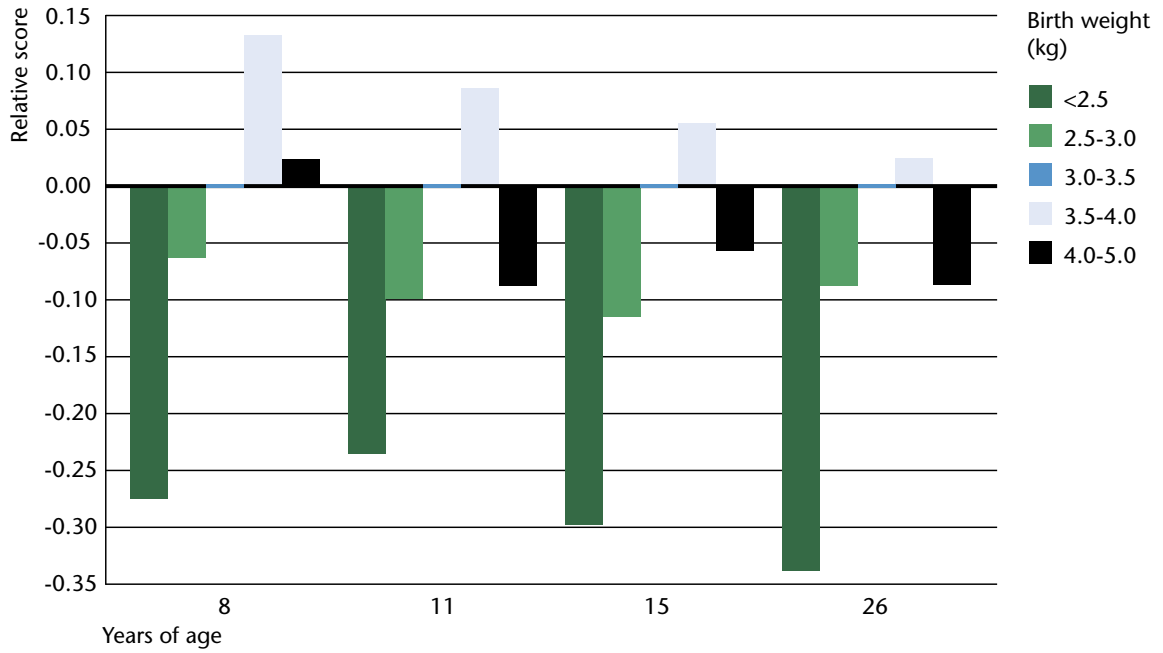
Source: Morley & Woodland (1979).

In the United Kingdom, for example, the cognitive function of those born with a weight of 3.5 kg to 4.0 kg remains the best, even at age 26 years (Richards, 2001), as shown in Figure 20. This outcome is reflected in a greater likelihood to complete schooling and enter university.

Small increments in mean birth weight translate into big population effects later in the life-course. Food supplementation of mothers in Java, Indonesia, provided during the last three months of pregnancy, produced a birth weight increase of just 100 g or so, which was not significant statistically. But this small increase in the mean birth weight turned into a 20% reduction in stunting at 5 years of age (Kusin et al., 1992). In Viet Nam, an effectiveness trial of micronutrient supplementation as compared to iron plus folic acid supplementation during pregnancy produced about a 120 g increase in mean birth weight and a 30% reduction in stunting at 2 years of age (Huy et al., 2009). Although similar results for stunting were not seen in children in Nepal, there were possible benefits in terms of greater weight and body size, and blood pressure (Vaidya et al., 2008). Furthermore, other effectiveness studies have also shown that the weight and height gain of children receiving complementary foods during early childhood are greater in children whose mothers also received food supplements during pregnancy (Mora et al., 1981).

There is an obvious need to revisit and revitalize the area of maternal nutrition. As noted in the Lancet Nutrition Series Paper No. 4, none of the 20 largest countries that account for 80% of the global stunting burden implement maternal food supplementation nationwide, although 13 did so in selected districts (Bryce et al., 2008). In theory, the continuum of care for maternal, newborn and child health often includes family planning, micronutrient supplementation, and adolescent and pre-pregnancy nutrition (Kerber et al., 2007), but these are not included in the costing and scaling up exercises that focus solely on survival outcomes (Darmstadt et al., 2008). Furthermore, the interventions most often missing are community outreach with preventive maternal nutrition interventions, the most important element of the continuum of care for accelerating the reduction of maternal and child undernutrition. There is a need to restate the importance of growth and

Figure 20.
Cognitive function by birth weight across the life-cycle in the United Kingdom



Source: Derived from data provided by Richards et al. (2001).

development outcomes. Birth weight needs to be better valued and its improvement seen as an essential first step in reducing stunting at 2 years of age and increasing the intelligence potential of the child.

Participatory approaches employing community mobilizers to successfully promote neonatal survival (Manandhar et al., 2004) should be built on and broadened to include maternal and child undernutrition interventions. Because of the push for maternal mortality reduction, many countries now have four antenatal contacts and these provide an important opportunity for the delivery of nutrition interventions. However, community mobilizers generally need advice and guidance on: why and how to improve women's weight gain during pregnancy; why it is important for women to achieve an adequate pre-pregnancy weight, and how this can be done by avoiding pregnancy until after 18 years of age; and why and how to get rid of anaemia as a preparation for getting pregnant. It needs to be emphasized that such approaches will benefit the mother as well as the child.

We conclude that there is an urgent need to revisit the neglected area of maternal nutrition, and to provide programmatic guidance in this area, especially for improving weight gain prior to and during pregnancy as a way of improving birth weight. For the past decade or more, health service delivery has concentrated on improving maternal and child survival. Where this has been successful, it provides a tremendous entry point for strengthening nutrition interventions. As part of such a process, an understanding of the importance of growth and development outcomes must be reinforced and revitalized, and a focus on birth weight revived. Furthermore, the importance of maternal nutrition for mothers' own health and development must be emphasized in the participatory approaches employed to help to redress and reverse the effects of the discrimination to which they are subjected.

CONCLUSIONS

In summary, we conclude that there is ample evidence that the intergenerational cycle of growth failure could be turned into a virtuous cycle. Birth weight can be rapidly improved, even in populations of short adult women, and improving the diet in quantity and quality, be it through food or micronutrient supplementation and/or fortification with micronutrients, can help achieve this. The effects seem to be greater if the mother is reached either during or preferably before the first semester of pregnancy. Furthermore, such interventions do not endanger the mother and do not increase the risk of maternal mortality, as there is no increase in cephalo-pelvic disproportion even if food supplementation is provided to adolescent mothers whose birth channels are still not mature.

Tackling anaemia during adolescence is an important priority that should get much greater programmatic attention. It is a way of improving maternal health and well-being, as well as preparing for any future pregnancy. The advantage of tackling anaemia in adolescent girls is that pre-pregnancy nutritional status is improved, and it is nutrition in the early months of pregnancy that has the greatest benefit on birth outcomes. Weekly micronutrient supplements can be given, instead of daily ones, to tackle adolescent anaemia. To be most effective, this approach should be combined with deworming and counselling. All of these aspects make schools an attractive institutional delivery channel.

Preventing too early pregnancies is also of the highest priority. For each year that median age of first pregnancy can be delayed beyond 15 years, an additional 1 cm can be added to the height of adult women, who in turn will have bigger babies. Far greater priority is needed for this programmatic area, which should include sex education and family planning services for adolescents in order to reduce teenage pregnancy rates. This will be facilitated by a more enabling societal environment, where community norms and values towards early marriage, sex education and family planning may need to change.

The nutritional and family planning activities described above will help to break the intergenerational cycle of growth failure and turn it into a virtuous cycle. Such efforts would be tangible contributions to the progressive realization of the rights of the girl child and of the adolescent mother in the context of the Convention on the Rights of the Child and the Convention on the Elimination of All Forms of Discrimination against Women, as well as making important contributions to achieving Millennium Development Goals 1, 4 and 5.

Summary chapter 4 Sustainable food and nutrition security

Chapter 4 discusses current trends in food and nutrition security, explores immediate and long-term challenges, and presents the case for why agriculture is central to improving nutrition. Although both undernutrition as well as over-nutrition are discussed, the focus is on developing countries where food insecurity and malnutrition are most pronounced.

With an estimated increase of 105 million undernourished people in 2009 alone, the most recent projections from FAO put the number of individuals suffering from hunger at 1.02 billion, one in six of all humanity. The proportion of undernourished people in the world began increasing in 2004, three years before the food and financial crises starting in 2007. Thus the crisis did not create the current situation but rather significantly worsened an already existing problem. Each of the global downturn's symptoms – soaring food prices, reduced remittance streams, contractions in trade, and reductions in capital flows and overseas development assistance – have had and are continuing to have an impact on household purchasing power and welfare. Soaring food prices affect poor consumers directly by reducing the amount of food they can purchase; reduced remittance streams reduce the amount of money households can count on receiving; and contractions in trade and foreign direct investment have trickle-down effects that affect households through, for example, reduced government funding for health and social assistance, further increasing the risks of food insecurity and malnutrition in already vulnerable areas.

To cope with these challenges, many households have been forced to reduce the quality of the food they eat. When households replace animal-source foods, fruits, vegetables and other micronutrient-rich foods with cheaper high carbohydrate staples, total energy intake may remain above the minimum requirement, but micronutrient intake is likely to be compromised, increasing risk of malnutrition and associated poor health outcomes. When families are forced to reduce meal frequency and total quantity of food consumed, risk increases further.

In many developing countries, trends in undernourishment are complicated by the nutrition transition, characterized by a shift away from traditional diets towards a more globalized intake pattern that includes increased quantities of processed foods, animal products, sugars, fats and (sometimes) alcohol. For many countries in the middle stages of nutrition transition, continued high rates of food insecurity and undernutrition, combined with increased prevalence of overweight and associated noncommunicable diseases, are resulting in a "double burden" of malnutrition. However, not all nutrition transition effects are negative. Increased consumption of total energy and of animal-source foods are positive trends for food insecure populations with monotonous diets.

Agriculture plays a key role in increasing food availability and incomes, supporting livelihoods and contributing to the overall economy, and is thus central to improving food and nutrition security. Ways in which agriculture can sustainably contribute to improving dietary diversity and nutrition outcomes include support for: agricultural extension services that offer communities information and improved inputs such as seed and cultivars for better crop diversity and biodiversity; integrated agro-forestry systems that reduce deforestation and promote harvesting of nutrient-rich forest products; aquaculture and small livestock ventures that include indigenous as well as farmed species; education and social marketing strategies that strengthen local food systems and promote cultivation and consumption of local micronutrient rich foods; biofortification via research and development programmes that breed plants and livestock selectively to enhance nutritional quality; and reduction of post-harvest losses via improved handling, preservation, storage, preparation and processing techniques.

Creating an enabling environment to fight hunger and malnutrition requires addressing environmental, socio-economic, health, demographic and political challenges, including climate change, demand for biofuel, gender inequity, prevalence of HIV and other infectious diseases, population growth, urbanization, and political instability. Climate change can affect food and nutrition security

through reduction of income from animal production, reduction of yields of food and cash crops, lowered forest productivity, changes in aquatic populations, and increased incidence of infectious disease. Demand for biofuel may divert land away from food cropping and increase risk of harmful production practices and environmental degradation. Reducing gender inequity is an important part of the solution to global hunger. Close associations exist between improved household welfare and empowering women in terms of asset control, education and political participation. Within the agricultural sector, marginalization of female farmers inhibits their economic and political empowerment and is a serious constraint to improved food and nutrition security.

The continued high prevalence of HIV, malaria and other diseases worsen food and nutrition insecurity. At the individual level, the disease impairs absorption of essential nutrients and increases nutritional requirements. At household level, HIV can decrease purchasing power as a result of sickness, absenteeism, the inability to do work, and unemployment, as well as the increased time and money spent on treatment and care.

Population growth drives increased demand for food in terms of both domestic production and imports. The global population grew from around 2 billion in 1950 to just over 6 billion in 2009, and is projected to reach 9 billion in 2050. The proportion of the global population living in urban areas surpassed the population living in rural areas in 2009, and projections are that by 2050 the majority of the global population will be living in the urban areas of developing countries. For the urban poor, low incomes and subsequent inability to access adequate supplies of safe and nutritious food threaten food and nutrition security. Volatile food prices and rising unemployment exacerbate the problem.

Political instability is one of the most common and persistent challenges to food security. Conflict disrupts or prevents agricultural production, transportation and market access, and creates large populations of refugees and internally displaced persons who make heavy demands on local and national food supplies.

Improving the capacity of smallholder production systems should be a primary goal in efforts to overcome these challenges. However, while many of the world's poorest people are smallholders, and while in a number of developing countries domestic food production occurs predominately through small-scale farming, promoting food and nutrition security requires looking beyond smallholders to other vulnerable demographics such as landless labourers and the urban poor. Provision of livelihood support, creation of social safety-nets and an explicit focus on maternal and child health are essential to improving the food and nutrition security of all these groups. At the policy level, making improved nutrition outcomes central to national development, protecting and expanding smallholder rights, increasing incentives to produce and market micronutrient-rich foods, prioritizing the needs of poor net consumers, and mainstreaming food and nutrition security concerns into policy frameworks and development agendas increase programme efficacy as well as chances for scaling-up. Regional and international policies, regulatory frameworks and agreements should support standard-setting initiatives that promote food and nutrition security within a global context.

Solutions to the challenges to food and nutrition security are complex and not the responsibility of agriculture alone. Nevertheless agriculture plays a crucial role in mitigating each challenge. Some of the most important emerging themes for nutrition-friendly agriculture, essential as part of a broader nutrition-sensitive development framework, include:

Pro-poor food production systems: Providing direct support to rural smallholder production and urban and periurban food systems to expand, enhance and sustain people's ability to procure and use the amount and variety of food required to be active and healthy.

Environmental sustainability: Improving agricultural production practices to address environmental concerns such as biodiversity, sustainable use of resources, and livestock sector reform.

Community-based capacity building to improve nutrition: Strengthening local food systems and promoting education and social marketing efforts that encourage balanced diets.

Setting higher standards in foreign direct investment: Developing regulatory frameworks to promote responsible foreign direct investment in agriculture and in food production, processing and marketing, in order to improve food and nutrition security, either directly through higher quality local food sources or indirectly via increased purchasing power.

In conclusion, agriculture is fundamental to reducing global hunger and, along with the health and care-based approaches discussed in other chapters of this report, is integral to improving nutrition outcomes worldwide.

Chapter 4
Sustainable food and nutrition security

THE CURRENT FOOD AND NUTRITION SECURITY SITUATION

With an estimated increase of 105 million undernourished people in 2009 alone, FAO projects that approximately 925 million individuals are currently hungry in 2010. Although this number is down from the 1.02 billion estimate made during the aftermath of the food and financial crises (Figure 21), it remains shockingly high. This means that Aalmost one in six people are still not getting enough to eat on a daily basis (FAO, 2010a).

As shown in figure 22, the highest prevalence of undernourishment, one in three persons, is in sub-Saharan Africa. The greatest absolute number of undernourishment is in Asia and the Pacific (578 million), followed by sub-Saharan Africa (239 million), Latin America and the Caribbean (53 million) and the Near East and north Africa (37 million) (FAO, 2010a).

A total of 28 countries (19 of them in Africa) are moving in the right direction to achieve the hunger indicator for Millennium Development Goal 1[26], but current rates of progress are insufficient to meet the 2015 target (FAO, 2009b). Eighteen countries, mostly in Africa, have levels of hunger that are worse than they were in 1990 (UNICEF, 2009).

26 Eradicate extreme poverty and hunger by 2015. The associated Target 1.C is: Halve, between 1990 and 2015, the proportion of people who suffer from hunger (indicator 1.9 Proportion of population below minimum level of dietary energy consumption).

Figure 21.
Number of undernourished people in the world, 1969-1971 to 2010

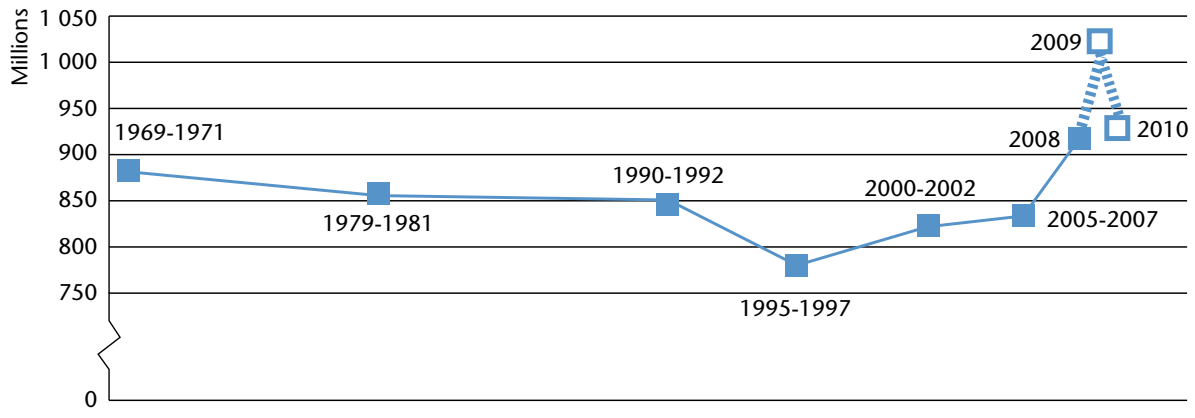
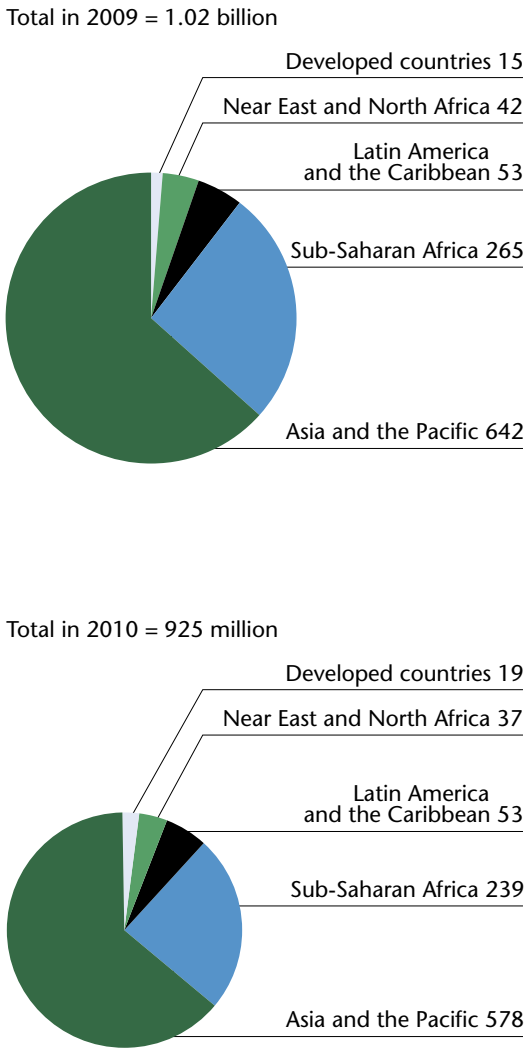


Figure 22. Undernourishment in 2009 and 2010, by region (millions of people)



Source: FAO

Effects of the global economic downturn on food and nutrition security

Although the proportion of undernourished people declined between 1969 and 1971, the trend reversed between 2004 and 2006, and thereafter began to rise, as shown in Figure 23 (FAO, 2010a).[27]

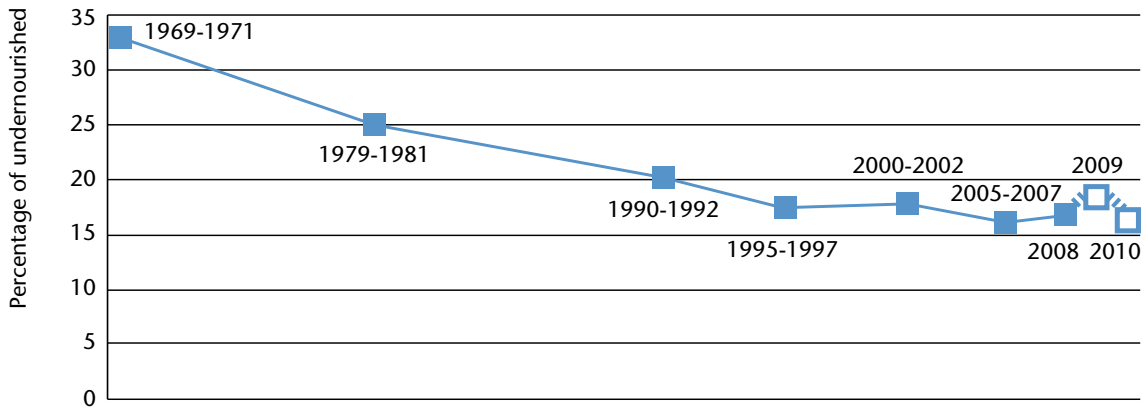
This trend continued through 2009 and shows that progress towards achieving the World Food Summit hunger reduction target and MDG 1 faltered prior to the recent food and financial crises. Food and nutrition insecurity were on the rise before 2008. Thus the impacts of the global downturn – soaring food prices, reduced remittance streams, contractions in trade, accelerated reductions in foreign direct investment and decreased official development assistance – on developing countries did not create the current situation, but rather significantly worsened an already existing problem.

The sections below explain how impacts of the global downturn exacerbated food and nutrition insecurity (see Box 1 for definitions of the terms used here), and discuss the harmful coping mechanisms that many households have had to engage in as a result.

Although global prices for food commodities have decreased since their peak in 2008, they are still high by historical standards. Moreover, prices on local markets have not fallen nearly as sharply as international food prices, because of lags in price transmission from global to domestic markets. For example, in June 2009, domestic staple foods cost, on average, 22% more in real terms than in June 2007 (FAO, 2009c). An FAO analysis in July 2009 showed that domestic prices in 58 developing countries remained "generally very high" and in some cases were at record levels (FAO, 2009d). Out of the 780 domestic price quotations for all the food

27 FAO estimates that a total of 925 million people are undernourished in 2010 compared with the 1.023 billion statistic of 2009. This decline is largely attributable to a more favourable economic environment in developing countries and the fall in both international and domestic food prices since 2008. However, the 2010 estimate is still higher than those made before the food and economic crises of 2008-2009. Moreover, the recent increase in food prices, if it persists, will create additional obstacles in the fight to further reduce hunger. The fact that nearly a billion people are still hungry even after the recent food and financial crises have largely passed indicates a deeper structural problem that threatens the ability to achieve internationally agreed goals on hunger reduction, and supports the relevance of the coping mechanisms discussed in this section.

Figure 23.
Trend in the proportion of undernourished people in developing countries



commodities included in the analysis, the July 2009 quotations were the same or higher than in the pre-food price crisis period in 94% of the cases (FAO, 2009c)[4]. Although the cost of purchasing food on the international market place for least developed countries is expected to fall, it is projected the decrease will be less than 25% of what it was last year (FAO, 2009d). The deteriorating economic environment in which the decrease is taking place is, however, likely to outweigh much of the benefit (FAO, 2009e). For individuals, these effects of the economic downturn will lead to a considerable reduction in purchasing power and subsequent decrease in food and nutrition security, especially for net food buyers, who may spend up to 80% of their income on food. These consumers currently constitute a large portion of the population in many parts of the world. For example, FAO data from nine developing countries[28] show that about three-quarters of rural households and 97% of urban households are net food buyers (FAO, 2008a).

Decreased purchasing power caused by high food prices has been compounded by reduced remittance streams. In many developing countries, a large proportion of households rely on remittances for income. For example, in Egypt, Ethiopia and Senegal, remittances accounted for between 5 and 10% of GDP in 2009 (FAO, 2009b). The figure jumped to 25% in Honduras and 46% in Tajikistan (FAO, 2009b). The multiplier effects that remittances have on the local economy through increased demand for goods and services have also been reduced, further decreasing purchasing power and subsequent food and nutrition security.

Trickle down effects from contractions in trade and reductions in foreign direct investment also affect individual purchasing power and local economies, and thus affect household food and nutrition security (Horton et al., 2010). Global decreased demand for exports in 2009 was especially damaging for developing economies that are export driven (FAO, 2009b). Reduced export earnings further constricted already tight government budgets and decrease funding for health and social protection programmes, which for many households are crucial to food and nutrition security. For rural households, the drop in demand for agricultural exports has decreased purchasing power through reduced prices and quantities of goods sold. In urban as well as rural areas, lay-offs and other ripple effects may have further reduced incomes incomes and hence the ability to purchase food. Market instability has also increased risk premiums for loans at international and national levels (FAO, 2009b). In terms of purchasing power and subsequent food and nutrition security, this translated to reduced credit at district and household levels. For example, microfinance institutions, often the only source of liquidity for women and other vulnerable groups, have been experienced difficulties in procuring sufficient funds because of bank rationing (FAO, 2009b).

For countries most vulnerable to poverty and food and nutrition insecurity, reductions in official development assistance are of particular significance. Foreign aid is the principal source of capital inflows for many of the world's poorest countries and constitutes a significant proportion of GDP in much of sub-Saharan Africa, for example 40%

28 Albania, Bangladesh, Ghana, Guatemala, Malawi, Nicaragua, Pakistan, Tajikistan, Viet Nam.

Box 1
Key definitions and use of terminology in this report

- **Food security** exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Household food security is the application of this concept to the family level, with individuals within households as the focus of concern (FAO, 2009b)[2].
- **Food insecurity** exists when people do not have adequate physical, social or economic access to food as defined above (FAO, 2009b).
- **Nutrition security** exists when food security is combined with a sanitary environment, adequate health services, and proper care and feeding practices to ensure a healthy life for all household members. This chapter refers to food and nutrition security throughout, because achieving nutrition security is imperative to reducing malnutrition (Shakir, 2006a).
- **Undernourishment** measures aspects of food security and exists when energy intake is below the minimum dietary energy requirement, which is the amount of energy needed for light activity and a minimum acceptable weight for attained height (FAO, 2009b)[2]. Although undernourishment is based on national level data, it may be used as a proxy for food consumption in contexts where regional or household level data are unavailable or unreliable. It varies by country and from year to year, depending on the gender and age structure of the population. Throughout this chapter, the words "hunger" and "undernourishment" are used interchangeably.
- **Undernutrition** exists when insufficient food intake and repeated infections result in one or more of the following: underweight for age, short for age (stunted), thin for height (wasted), and functionally deficient in vitamins and/or minerals (micronutrient malnutrition).
- **Malnutrition** is a broad term that refers to all forms of poor nutrition. Malnutrition is caused by a complex array of factors including dietary inadequacy (deficiencies, excesses or imbalances in energy, protein and micronutrients), infections and socio-cultural factors. Malnutrition includes undernutrition as well as overweight and obesity (Shakir, 2006a).

in both Burundi and Liberia (FAO, 2009b). Since official development assistance decreases when donor GDP decreases, and since the recession was global, 2009 has been marked by decreased development assistance. International Monetary Fund projections for 2009 predicted an overall drop in official development assistance of approximately 25% for the poorest 71 countries in the world (IMF, 2009). Even before the downturn, the share of official development assistance going to agriculture was decreasing, down to approximately 4% in 2006 compared to 15% in 1979 (FAO, 2009f). Taken together, overall reductions in official development assistance and decreased investment in the agricultural sector have increased and will continue to increase the risk of food insecurity and malnutrition in already vulnerable areas.

Coping mechanisms

Volatile food prices, reduced remittance streams, contractions in trade, and reductions in foreign direct investment and official development assistance all contribute to reductions in purchasing power. To cope with declining incomes, many households have been forced to change their consumption patterns and reduce expenditures on health, education and goods, and some have been forced to resort to extreme strategies, such as street begging, prostitution and child labour, to maintain access to food. Many have reduced expenditures on food with consequent declines in the quality and quantity of their food intake. Although the impact varies according to context-specific variables (e.g. degree of price transmission, access to safe water, transport and handling costs, consumer preferences) these coping mechanisms generally increase risk of malnutrition both of micronutrient deficiencies and, in severe cases, of overall energy deficiency.

Shifting from a varied diet rich in micronutrients to one that is derived predominantly from starchy staples is a common response to declines in income. In five country case studies (FAO, 2009b) of the effects of the global downturn on food and nutrition security, Food and Agricultural Organization of the United Nations and World Food Programme cited dietary changes as the primary coping mechanism in each country.[29] Most staple foods (e.g. rice, maize, cassava) are much cheaper than fruits, vegetables and animal source foods. However, when eaten on their own or with very small amounts of other foods, the result is a poor-quality monotonous diet that is likely to be nutritionally inadequate in proteins, fats and micronutrients. This is because while staples are high in carbohydrates they are typically low or very low in lipids, protein, vitamins and minerals. For example, cassava root, one of the cheapest and hence most popular staple foods in much of sub-Saharan Africa, is particularly low in protein, with 0.8 g protein/100 edible grams (Wargiono, Richana & Hidajat, 2002) compared to 6.4 g for rice, and 9 g for both maize and wheat (FAO, 1972). Demand for cassava increased among many cash-strapped households in sub-Saharan Africa in 2008 (FAO, 2009b; FAO, 2009g).

When households replace animal source foods, fruits, vegetables and other micronutrient-rich foods with high carbohydrate staples, their energy intake may remain above the minimum requirement, but both macro and micronutrient intake is compromised, thus increasing risk of malnutrition and associated poor health outcomes. For instance, vitamin A deficiency and iron deficiency anaemia – two of the most common nutritional deficiencies – are caused by diets low in animal source foods, fruits and vegetables [30]. Vitamin A deficiency is associated with impaired immunological function, increased risk of maternal and infant death, and impaired eyesight (Shakir, 2006a). Iron deficiency anae-mia affects physical productivity in adults, and cognitive and physical development in children (Horton & Ross, 2003; FAO, 2004a). Both deficiencies are associated with increased health-care costs and compromised human capital (Horton & Ross, 2003; FAO, 2004a; Shakir, 2006a).

It is also important to note that in many developing countries consumption of local unrefined staples has declined as a result of competition from refined staple foods (Kuhnlein & Johns, 2003). Refined staples may appeal more to consumers' preferences, but are often inferior in nutrient content (e.g. fibre, vitamin E and protein). Even in countries that have seen significant overall increases in food production and incomes, such as India, there has been a decline in the production of many widely consumed nutritious foods like pulses (hundreds of varieties of peas, lentils and beans). India's production and consumption of pulses has fallen 53% over the past five decades. Per capita annual consumption of pulses has fallen from 27 kg per person to 10 kg per person in 2010. With both the area under production and yields declining or stagnant, prices for these traditional nutrient-rich foods are increasing, and there are few alternatives protein sources available for low-income communities (Commodity Online, 2009).

Risk of malnutrition increases further if dietary energy supply falls below the minimum dietary energy requirement. This is most likely to happen among very poor households that are unable to afford enough food even after substituting starchy staples for more expensive items. Many of these households – even in periods of relative food security – subsist on diets that are too high in carbohydrates and too low in micronutrient-rich foods. Young children, whose gastric capacity is too small for them to consume the large amounts of low energy dense staples needed to meet energy requirements, are especially vulnerable. Given the current situation, these groups are at elevated risk of both malnutrition caused by prolonged lack of dietary diversity and undernourishment caused by inadequate total energy intake.

When combined with reduced expenditures on health care, education and basic necessities, the threat of compromised intake is compounded. For example, HIV and malaria – diseases with very high prevalence rates in many low-income and food insecure areas – both increase requirements for nutrients and inhibit their absorption. If food-insecure households are forced to forgo drug treatment or are unable to afford insecticide-treated bed nets and other simple preventative measures, infected individuals become more susceptible both to the disease and to specific micronutrient deficiencies, such as anaemia, which is closely associated with malaria. Further, since many nutritional deficiencies (e.g. vitamin A deficiency) impair immunological function , the effects of malaria, HIV and other infectious diseases are themselves exacerbated by malnutrition. Finally, as individuals in food insecure households often suffer from chronic nutritional deficiencies, overall susceptibility to infectious diseases even among individuals who are "healthy" (i.e. not exhibiting overt signs of malnutrition) is increased.

29 Armenia, Bangladesh, Ghana, Nicaragua, Zambia.

30 Animal source foods contain haem iron and vitamin A. Many fruits and vegetables contain beta-carotene (a vitamin A precursor) and non-haem iron.

It is usually women who are the first to compromise dietary quality and/or reduce total energy intake in household-level efforts to cope with food insecurity (Shrimpton, Prudhon & Engesveen, 2009). That is, women are usually the first to make sacrifices in terms of their own food consumption when the financial situation deteriorates. The impacts of reduced energy intake and compromised dietary diversity on women during pregnancy and lactation are discussed in detail in chapter 3 of this report.

How trends in undernourishment affect progress towards the Millennium Development Goals

As discussed in chapter 1and 2, the first Millennium Development Goal (MDG) calls for the eradication of extreme poverty and hunger by 2015, and its achievement is crucial for national progress and development. One of the indicators used to assess progress towards MDG 1 is the prevalence of children less than 5 years old who are underweight for their age. A second indicator is the prevalence of hunger in a population, that is, the proportion of the population whose dietary intake is below the minimum dietary energy requirement.

High levels of undernourishment and subsequent coping mechanisms have negative implications for both these indicators. As undernourishment is considered synonymous with hunger, it serves as a direct measure for the hunger indicator. But undernourishment does not include information regarding the "quality" aspects of food intake, nor does it account for the impact of infectious disease. Thus it cannot, on its own, be used to predict nutrition outcomes and hence cannot be used as a direct measure for the underweight indicator. However, it can serve as a proxy for whether individuals are getting enough to eat in terms of total energy intake. Where prevalence of undernourishment is high, the probability of diets being adequately diversified is low, as the first response in food insecure households is often to save on food costs by cutting down on non-staple food consumption. And dietary diversity is considered to be directly associated with nutrition outcomes, as it is associated with improved child anthropometric status (Arimond & Ruel, 2004). For example, statistics from past crises indicate that malnutrition is a result of undernourishment and subsequent coping mechanisms. In Cameroon during the economic crisis of the 1990s, the proportion of underweight children less than 3 years of age increased by 7-8 % among the poorest half of the population (FAO, 2009b). Similarly, during the drought in Zimbabwe in the mid 1990s, which reduced purchasing power at a rate comparable to that experienced during the current global crisis, stunting among lower-income quintiles increased substantially (FAO, 2009b). Thus undernourishment levels are closely related to the MDG 1 nutrition indicator (underweight), as well as having direct implications for the hunger indicator.

According to FAO (2009b), over the past 20 years, 22 countries have made encouraging progress on reducing undernourishment, and are likely to meet or exceed the hunger target for MDG 1 by 2015. Most of these countries are in east Asia and Latin America (FAO, 2009b). In Africa some countries have made progress, with Ghana, Mozambique, Namibia and Nigeria all likely to achieve the hunger target in terms of undernourishment but not necessarily in terms of underweight (FAO, 2009b). However, challenges remain. As mentioned above, global progress towards MDG 1 has faltered. The percentage of undernourished people in the world began to increase in 2004 (Figure 23), and total absolute numbers for undernourishment have been increasing slowly but steadily for over a decade (Figures 21 and 22).

In terms of underweight, 63 countries out of 117 with available data are on track. This compares with 46 countries out of 94 with available data on track just three years ago, based on trend data from around 1990 to around 2004 (UNICEF, 2009). However, in 34 countries, progress is currently insufficient, and 20 have made no progress at all. Most of these 20 countries are in Africa (UNICEF, 2009). A detailed discussion of the underweight indicator can be found in chapter 2.

That more children may become undernourished as a result of the global downturn and its ripple effects focuses greater attention on both the hunger and nutrition indicators for MDG 1. As good nutrition is key to good health, cognitive development and productivity, slow progress on MDG 1 jeopardizes the achievement of the other MDGs (see chapter 1).

Nutrition transition and the double burden of malnutrition

Trends in undernourishment are complicated by the nutrition transition in many developing countries (Popkin & Gordom-Larsen, 2004). The nutrition transition is characterized by a shift away from diets based on staples, legumes, and fruits and vegetables, and towards more globalized intake patterns that include increased quantities of animal source foods, sugars, fats and (sometimes) alcohol (Popkin & Gordom-Larsen, 2004). Nutrition transition is also associated with increased intake of processed, calorie-dense, nutrient-poor foods (Popkin & Gordom-Larsen, 2004), sometimes referred to as "FMNVs" or foods of minimal nutritional value.

For many countries in the middle stages of nutrition transition, continued high rates of food insecurity and under-

nutrition combined with increased prevalence of overweight and associated non-communicable diseases are resulting in a "double burden" of malnutrition (Doak et al., 2005; Mendez, Monteiro & Popkin, 2005). There is clear evidence that this burden is shifting rapidly towards low-income groups (Arimond & Ruel, 2004). When combined with other trends such as urbanization, the nutrition transition has implications for food and nutrition security and public health at both household and national levels (Mondez & Popkin, 2004).

At household level, rising incomes, increased female labour force participation, increased exposure to mass media, and increasingly sedentary work patterns encourage consumption of convenient processed foods, which are easy to prepare and to consume (FAO, 2006a). Since many processed foods are low in nutritional value, implications for the "quality" aspects of food and nutrition security, as well as associated health outcomes, are negative (Mendez & Popkin, 2004; FAO, 2006a). Such diets may be inadequate in micronutrients but high in sodium, sugar and saturated or trans fat, excessive amounts of which are associated with increased risk of non-communicable diseases (Popkin, Horton & Kim, 2001). The issue of quality is of particular importance in regard to the "double burden" which can exist at household level as well as nationally (Popkin & Gordom-Larsen, 2004). A considerable proportion of households that have undergone the nutrition transition suffer from both overweight and underweight simultaneously. For example, stunted children have been found in the same families as overweight and obese adults (Doak et al., 2005). In these households, nutrition transition diets that are sufficient in terms of energy but insufficient in terms of micronutrients will reduce undernourishment, but may not improve health or nutrition. The risk of poor health outcomes may actually be increased if intake patterns include excessive sodium, sugar and saturated or trans fat. Also, the presence of these double burden households may confound attempts to identify demographics where food availability is an issue. That is, if double burden households occur in the same community as households suffering only from undernutrition, identification of truly food insecure households – as opposed to households where undernutrition is occurring because of consumption of unhealthy diets and/or poor caring and hygiene practices – may be difficult. At household level, disaggregating data where possible by income, rural-urban, geographic region, ethnicity and gender is one way to help distinguish between issues of food availability and other practices that may be causing malnutrition.

At the national level, nutrition transition and its drivers affect food security via their impact on food systems, food supplies and subsequent availability (Mendez & Popkin, 2004). One of the most notable contributors to changing intake patterns is foreign direct investment (FDI) in food processing, which has risen steadily since the 1980s (Wei & Cacho, 2001). As with urbanization, increased female labour force participation and other trends are affecting food and nutrition security at household level, and the increased presence of transnational food corporations in low- and middle-income countries is shaping consumption options at country level. Foreign direct investment makes more processed foods more available to more people by lowering prices and introducing new purchasing channels, e.g. supermarkets (Hawkes, 2005). It also affects the food supply chain. For example, entry of transnational food companies into local markets in China introduced new products and concepts, technologies, quality standards and marketing innovations that challenged local companies. Although many local companies went out of business or saw their market share decrease, others rose to the challenge and increased their own production and marketing of processed foods (Wei & Cacho, 2001). The overall result of increased competition from transnationals in a number of countries has thus been to increase the visibility and availability of processed foods (Hawkes, 2002), some of which may be of low nutritional content.

Foreign direct investment is also affecting food systems because it increases "vertical integration". Vertical integration refers to the degree to which a company owns or controls both its upstream suppliers and downstream buyers. Within the food industry, it typically occurs when agribusiness and food corporations create integrated large-scale commercial operations that control the production, processing and sale of food products. It is common in developed countries, e.g. the United States poultry industry, and it can have a significant impact on product cost, quality and market penetration. Vertical integration of the food chain is increasing in developing countries. A related trend is increased trade in processed foods. Although foreign direct investment was traditionally considered both an import and an export substitute, more recent evidence indicates that foreign direct investment and trade in processed foods is symbiotic (Bolling & Somwaru, 2001; US International Trade Commission, 2001; Mattson & Koo, 2002). For example, foreign direct investment in fast food has stimulated the spread of fast food chains internationally, leading to increased worldwide consumption of fried potatoes. In a related shift, the market for frozen fried potatoes has expanded, with the amount imported associated with the degree of foreign direct investment in a country's fast food sector. Increased vertical integration has subsequently affected the local food-supply chain; processors affiliated with foreign direct investment corporations have introduced written contracts for local suppliers favouring large commercial producers over smaller farmers (Hawkes, 2005).

Taken together, trends in foreign direct investment and trade are affecting food supply chains in many developing countries via the types of foods which are available, and the prices at which they are sold.

Not all nutrition transition effects are negative. Increased consumption in total energy and animal source foods are positive trends for many people in low- and middle-income countries. Nevertheless the line between improved intake patterns and over-consumption is increasingly fine among a growing number of demographics, most notably low-income populations with a history of food insecurity (Popkin & Gordom-Larsen, 2004; Mendez, Monteiro & Popkin, 2005). At the national and international level, insisting on public sector accountability and including both under- and over-nutrition in food and nutrition policy frameworks is therefore imperative. In the UNSCN's common agenda for the double burden of malnutrition (SCN, 2006), the private sector is urged to "support the achievement of the MDGs by adopting responsible marketing practices for energy-dense, nutrient-poor foods and drinks" and civil society is urged "to advocate and adopt policies and practices that tackle the double burden of malnutrition and hold governments accountable at all levels."

AGRICULTURE'S ROLE IN IMPROVING FOOD AND NUTRITION SECURITY

Agriculture plays a central role in increasing food availability and incomes, supporting livelihoods and contributing to the overall economy (World Bank, 2008), and is thus a key actor in efforts to improve food and nutrition security. Development of the agricultural sector is especially crucial to alleviating poverty in developing countries, where a large proportion of gross domestic product is generated within the primary sector by smallholders. For example, agricultural development has been shown to be up to four times more effective in reducing poverty relative to growth in other sectors, and growth in smallholder agricultural productivity has been shown to have a positive impact on both urban and rural populations in three key ways: lower food prices for consumers; higher incomes for producers; and growth multiplier effects through the rest of the economy as demand for other goods and services increases (Alston et al., 2000; FAO, 2004b). Each of these effects increases purchasing power and thus reduces the need to adopt harmful coping practices. In addition, agricultural policies focused on sustainable development practices have great potential to reduce some of the most harmful effects of the nutrition transition, for example by reducing resource-intense mono-cropping in favour of more ecologically and environmentally sustainable practices focused on maintaining biodiversity and intercropping.

Challenges facing current production systems

The remarkable increases in global food production that have occurred over the past four decades have been a major achievement but they have also created serious environmental problems. These include the cumulative effects of soil erosion and salinization on land productivity, chemical fertilizer and pesticide hazards, the loss of cropland to desertification, and accelerated conversion of cropland to non-farm uses. Large-scale industrial agriculture is also a driver of genetic erosion, species loss and degradation of wildlife habitat, with over 4000 plant and animal species threatened by agricultural intensification (FAO, 2010). The food and agricultural sector is also responsible for about a third of global greenhouse gas emissions. Many of these trends are described in detail in a report by UNEP (2007).

Reforming the industrial livestock sector is integral to sustainable food security (FAO, 2010). As demand for animal source foods increases, global production of meat is projected to more than double between 1990 and 2050 (FAO, 2006b). However, current industrial livestock production practices may not be sustainable. Livestock is currently the single largest user of land in the world, accounting for 70% of all agricultural land and 30% of total land surface (IAASTD, 2009). It is a key contributor to deforestation, and is responsible for 18% of all greenhouse gas emissions (IAASTD, 2009). It is responsible for 65% of man-made ammonia emissions, which contribute significantly to acid rain and acidification of ecosystems; it is also a major source of water pollution (IAASTD, 2009).

Improved production practices and their contribution to sustainable food and nutrition security

In addition to environmental problems, current production practices can lead to increased marginalization of smallholders who are unable to acquire the technology or economies of scale to compete on global markets. In its 2009 report, the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) took stock of the state of global agriculture and concluded that improving access of the rural low-income groups, namely landless labourers and smallholders, to food, land, water, seeds and improved technologies was essential to ensuring sustainable food security (IAASTD, 2009). The report also found that investments in agricultural knowledge, science and technology were needed to maintain productivity in ways that protect the natural resource base and ecological provisioning of agricultural systems. These two conclusions both point towards the need for increased investment in small-scale agriculture, small-scale irrigation, food processing and other strategies that empower poor subsistence farmers and encourage environmental stewardship.

Sustainable agriculture is important not only for ensuring the economic welfare of smallholder and other vulnerable groups; it is also linked to improving dietary diversity and nutrition outcomes. Indeed, many of the production practices that are currently being promoted as ways to improve environmental viability also represent strategies to improve dietary diversity, and vice versa. Examples include:

- agricultural extension services that offer communities information and improved inputs, including seed and cultivars for better crop diversity and promotion of biodiversity, e.g. intercropping cereal crops with drought-resistant legumes such as cowpea or pigeon pea;
- integrated agro-forestry systems that reduce deforestation and promote harvesting of nutrient-rich forest products, e.g. the Quesungual system in Honduras which promotes maintenance of forest canopy in conjunction with crop cultivation;
- education and social marketing strategies that strengthen local food systems and promote cultivation and consumption of local micronutrient-rich foods, e.g. pulses and millet, as well as agricultural extension services that provide nutrition education at the community level;
- promotion of aquaculture and small livestock ventures that include indigenous as well as farmed species, e.g. polyculture fish farms that include both *tilapia* and smaller, local species such as *darkina*;
- biofortification via research and development programmes that breed plants (including local and traditional cultivars) and livestock selectively to enhance nutritional quality, e.g. increasing protein content of mung bean;
- reduction of post-harvest losses via improved handling, preservation, storage, preparation and processing techniques, e.g. solar drying of fruits and vegetables that are rich in beta-carotene.

CHALLENGES TO FOOD AND NUTRITION SECURITY

Balancing a long-term concern for the environment over the short-term needs of smallholders and other vulnerable groups cannot be at the expense of their immediate survival and livelihoods. For example, while deforestation has serious consequences for the environment, the short-term survival of many populations depends upon slash and burn cultivation, or sale of firewood and charcoal. Attempts to prevent deforestation that do not take this conflict into account will either fail or have disastrous social consequences (Thompson, 2006). Similarly, creating an enabling environment to fight hunger and malnutrition requires addressing a wide variety of constraints. Many of these constraints impinge upon agriculture-based approaches to improving food and nutrition security, either directly, as in the case of marginalization of female farmers, or indirectly, as in the case of population growth.

Although the effects of the global downturn are related to these constraints, and in some cases have exacerbated them, it is important to note that the constraints existed prior to the crisis, driven by longer-term problems of marginalization and inequality. In addition to long-term socioeconomic, demographic, and political challenges, climate change and demand for biofuel are relatively recent developments whose repercussions pose serious challenges to achieving sustainable food and nutrition security.

Socioeconomic and health-based challenges: gender inequity, HIV

Evidence based on household-level data shows that reducing gender inequity is an important part of the solution to global hunger. The resources and income flows that women control have repeatedly been shown to wield a positive influence on household health and nutrition (World Bank/IFPRI, 2007). A series of studies have found close associations between female primary school attendance and decreases in country-level poverty rates (Von Grebmer et al., 2009). Empowering women in terms of education, political participation, and control of assets and resources has great potential to improve purchasing power, the management of scarce household resources, and self respect, as well as knowledge of good habits regarding food consumption, which are all crucial to improved nutrition outcomes. Within the agricultural sector, marginalization of female farmers inhibits their economic and political empowerment, and is a serious constraint to improved food and nutrition security. For example, although women may carry a very heavy workload, their work may not be valued as highly as that of men. Gender bias and gender blindness persist: policymakers, development planners and agricultural service deliverers still tend to perceive farmers as being male. Women therefore find it more difficult than men to gain access to the resources – land, credit, agricultural inputs, technology, and extension and training services – that enhance productive capacity. In most developing countries, smallholders of both genders lack access to adequate resources, but women's access is further constrained by cultural, traditional and sociological factors (Viatte et al., 2009).

The continued high prevalence of HIV, especially in many countries of sub-Saharan Africa challenges food and nutrition security at multiple levels. At the individual level, the disease impairs absorption of essential nutrients and increases nutritional requirements. At the household level, HIV can decrease purchasing power because of sickness, absenteeism, the inability to do work and unemployment, as well as increase the time and money spent on treatment and care. In the agricultural sector, the reduced ability to do the kind of physical work required for farming leads to reduced productive capacity and subsequent decreased purchasing power. For smallholders who are primarily subsistence farm-

ers, this may have direct consequences on their food supply. Ripple effects for many agricultural households may include children being removed from school and further crop losses, resulting from reduced ability to till, purchase inputs, weed or harvest.

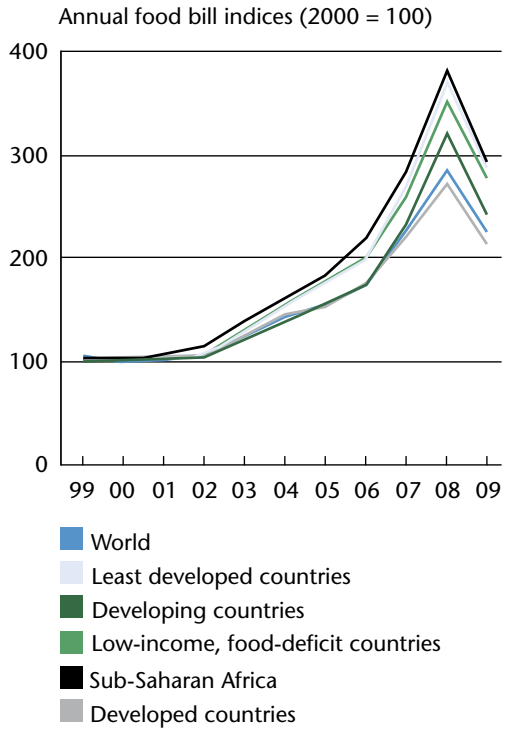
Demographic and political challenges: population growth, urbanization, political instability and conflict

Population growth affects food and nutrition security because it drives increased demand for food in terms of both domestic production and imports. The global population grew from around 2 billion in 1950 to just over 6 billion in 2009, and is projected to grow to about 9 billion in 2050 (UN Population Division, 2009b). Population growth over the next four decades is predicted to occur mostly in the least developed countries of Africa and Asia, with the population of Africa rising from 1 billion to 2 billion, and the population of Asia rising from 4 billion to 5 billion (UN Population Division, 2009b). Although the fertility rate in developing countries as a whole fell from 5 in the seventies to less than 3 today, it was still 4.8 in the least developed countries in 2005, and in the least developed countries of sub-Saharan Africa it was 5.8 (UN Population Division, 2009b). Adolescent pregnancies are also high in the least developed countries, with 117 births per 1000 women aged 15-19 years as compared with 37 per 1000 in the developing countries as a whole (FAO, 2009h). These high rates of population growth increase the probability of food deficits, especially for countries where yield gaps are wide and/or where food imports constitute a considerable proportion of domestic food supply. This is of particular concern in sub-Saharan Africa, which has the lowest yields in the world, one third of the global average, and where 90% of production growth over the past 20 years has been the result of expansion of the area cultivated (FAO, 2009b). Sub-Saharan Africa endured the largest rise in food import costs, as measured from 2000 to the peak of the food price crisis in 2008, but the expected decline in the overall bill between 2009 and 2010 – from USD 28.4 billion to USD 21.3 billion – is among the smallest of any geographic or economic group, as illustrated in Figure 24 (FAO, 2009h). Political instability is also a major challenge to food and nutrition security. Conflict disrupts or prevents agricultural production, transport and market access, and creates large populations of refugees and internally displaced persons who make heavy demands on local and national food supplies. Political instability can also destabilize support systems, such as input distribution and subsidy programmes, and can destroy market and other infrastructure. Political instability is one of the most common and persistent challenges to food security. For example, of the 31 countries categorized by FAO's global information and early warning system (FAO, 2009i) in December 2009 as "in crisis and requiring external assistance", 19 listed conflict-based reasons for their high levels of food insecurity (Table 28).

The proportion of the global population living in urban areas surpassed those living in rural areas in 2009. Projections indicate that by 2050 the majority of the global population (just over 5 billion people) will be living in the urban areas of countries that are currently considered developing, with a third of the global population living in rural areas (Figure 25). For low income groups living in urban areas, food insecurity is caused primarily by their low incomes and consequent inability to acquire adequate supplies of safe and nutritious food. Volatile food prices and rising unemployment exacerbate the problem.

For many urban populations facing food insecurity, an important source of food is urban and periurban agriculture. Production and processing of crops – mostly fruits and vegetables – and of livestock is frequently part of urban and

Figure 24. Sub-Saharan Africa's expenditure on food imports (index = 100 in 2000)



Source: FAO (2009h)

On the back of falling international quotations and freight rates, import bills look set to decline sharply in 2009. While good news for vulnerable countries, their burden, however, of purchasing food commodities on the international market place remains higher than that on the world at large and indeed on developed countries.

periurban livelihood strategies, and the food produced forms a large part of informal-sector economic activity.

While urban and periurban agriculture has great potential to increase both total energy and nutrient intake, there are also major health hazards associated with its practice (IFPRI, 2006). These include contamination of crops from air pollution and industrial effluents, and the risk of infectious diseases posed both by keeping livestock and by using biological wastes as fertilizers. Moreover, in areas

Table 28. Effect of conflict and political instability on food supply: countries in crisis requiring external assistance, December 2009

Nature of food insecurity	Main reasons
Exceptional shortfall in aggregate food production and/or supplies	
Kenya	Adverse weather, lingering effects of civil strife
Lesotho	Low productivity, HIV/AIDS pandemic
Somalia	Conflict, economic crisis, adverse weather
Swaziland	Low productivity, HIV/AIDS pandemic
Zimbabwe	Problems of economic transition
Iraq	Conflict and inadequate rainfall
Widespread lack of access	
Eritrea	Adverse weather, internally displaced persons, economic constraints
Liberia	War-related damage
Mauritania	Several years of drought
Sierra Leone	War-related damage
Democratic People's Republic of Korea	Economic constraints
Severe localized food insecurity	
Burundi	Internally displaced persons and returnees
Central African Republic	Refugees, insecurity in parts
Chad	Refugees, conflict, inadequate rainfall
Congo	Internally displaced persons
Côte d'Ivoire	Conflict-related damage
Democratic Republic of the Congo	Civil strife, returnees
Ethiopia	Adverse weather, insecurity in parts of the country
Guinea	Refugees, conflict-related damage
Guinea-Bissau	Localized insecurity
Sudan	Civil strife (Darfur), insecurity (southern Sudan), localized crop failure
Uganda	Localized crop failure, insecurity
Afghanistan	Conflict and insecurity
Bangladesh	Cyclones
Myanmar	Past cyclone
Nepal	Poor market access, floods and/or landslides
Pakistan	Conflict, internally displaced persons
Philippines	Tropical storm
Sri Lanka	Internally displaced persons, post-conflict reconstruction
Timor-Leste	Internally displaced persons
Yemen	Conflict, internally displaced persons

Sorce: FAO

where the value of land is on the rise, urban and periurban agriculture may subsequently decline because of pressure to use the land for other, more lucrative ventures. As urbanization rates increase throughout the developing world (UN Population Division, 2009c), improving food and nutrition security for the urban poor poses a challenge in terms of economic access and food safety.

Environmental challenges: climate change and demand for biofuel

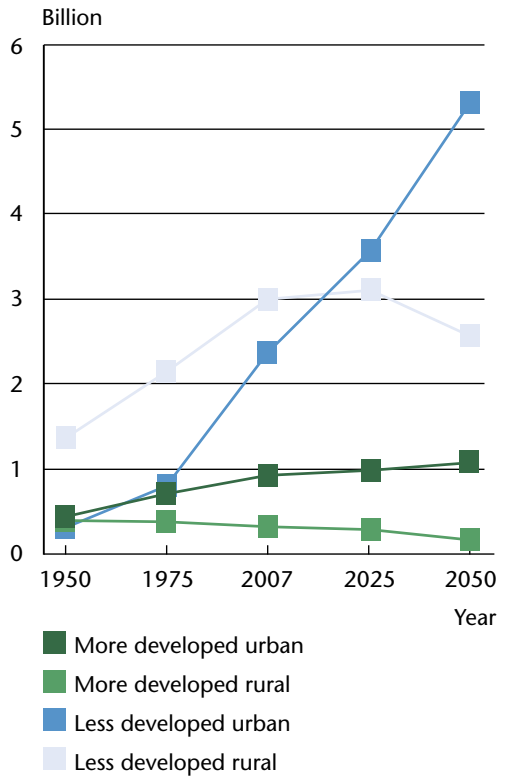
Several recent UN agency and other reports conclude that even if practical steps are taken now to try to mitigate the effects of climate change, the world will become increasingly food insecure over the next few decades (Easterling et al., 2007; IFPRI, 2009; Inter-Agency Standing Committee, 2009; UNEP, 2009). Climate change will exacerbate existing threats to food security. By 2050, the number of people suffering from hunger is projected to increase by 10-20%[31] (Parry et al., 2009), and child malnutrition is anticipated to be 20% higher compared to a scenario of no climate change (Inter-Agency Standing Committee, 2009). In addition, a UNEP report predicts that up to 25% of the world's food production is likely to be lost by 2050, as a result of "environmental breakdowns" (IFPRI, 2009). These breakdowns include the melting and disappearing glaciers of the Himalayas, which supply water for irrigation for nearly half of Asia's cereal production – one quarter of world production (IFPRI, 2009). They also include accelerated threats from invasive insects, diseases and weeds, which are projected to reduce yields by up to 6% worldwide (IFPRI, 2009), as well as increased water scarcity, which is projected to reduce crop yields by up to 12% worldwide (IFPRI, 2009). These examples are included in the pathways outlined below:

- increased frequency and intensity of extreme climatic events such as heat waves, droughts, desertification, storms, cyclones, hurricanes, floods;
- sea-level rise and flooding of coastal lands, leading to salination and or contamination of water, agricultural lands and food;
- hygiene and sanitation problems leading to increased burden of infectious disease;
- reduced forest productivity;
- proliferation of pest species, plant and livestock diseases.

Although these pathways will negatively affect food and nutrition security, it is important to note that some impacts of climate change, such as CO2 “fertilization”, may be positive.[32]

Changes in the patterns of extreme weather events such as floods, droughts, cyclones and hurricanes affect food production as well as stability of and access to food supplies. Both access to irrigation water and rainfall are threatened by extreme weather events, seriously disrupting production cycles, reducing yields and increasing livestock losses. Temperature rises of 1-2 °C have been shown to reduce yields in agro-ecological zones that are seasonally dry and tropical. Further warming has been shown to have negative impacts on global food production in all regions (Easterling et al., 2007). Smallholders and landless labourers who cannot afford to engage in risk management strategies, e.g. crop insurance, are especially vulnerable to these weather-

Figure 25. Growth of rural and urban populations in developing and developed countries



Source: UN Population Division, 2007.

31 Scenario based on a pathway of continuing high population growth, regional disparities of income and high global temperatures (IPCC Special Report on Emissions Scenarios – SRES A2).

32 This list of pathways is not exhaustive. For an extended discussion of the ways that climate change is affecting food and nutrition security, please see: The impact of climate change and bioenergy on nutrition,. Rome, FAO, 2010 (http://www.fao.org/docrep/010/ai799e/ai799e00.htm, accessed 30 March 2010).

induced shocks. Rural to urban migration rates may increase for these populations, thus increasing demand for food in cities. In low-lying areas such as Bangladesh, a rise in sea level may further reduce food and nutrition security via salination, inundation, erosion of cultivated land, and fishery contamination (FAO, 2003).

Climate change can further negatively affect nutrition through its effects on hygiene and sanitation, namely increased incidence of diarrhoea and other infectious diseases (Confalonieri et al., 2007). Associations between monthly temperature and diarrhoeal episodes, and between extreme rainfall events and monthly reports of water-borne disease outbreaks, have been reported worldwide. Higher temperatures have been associated with increased episodes of diarrhoeal disease in adults and children in Peru, where diarrhoeal incidence reports increased 8% for each degree of temperature increase (Checkley et al., 2000). Climate change is projected to increase the burden of diarrhoeal diseases in low-income regions by approximately 2-5% by 2020 and will disproportionately affect low-income populations already experiencing a large burden of disease (McMichael et al., 2004). Like HIV, diarrhoea simultaneously increases nutrient requirements and impairs absorption of nutrients. For populations suffering from multiple shocks induced by climate change and/or other variables, an increase in diarrhoeal and other infectious diseases could pose a serious threat to nutrition security.

Elevated risk of fires, insect outbreaks, wind damage and land degradation from accelerated slash and burn practices will impact both physical food availability and purchasing power for those whose livelihoods are partially or fully dependent on forest products. Wood, honey, cane and grass products, nuts, bushmeat, mushrooms and medicinal herbs are all examples of forest products (FAO, 1998) threatened by climate change.

Climate change is also likely to increase risks created by the spread of plants and plant pests, animal diseases and invasive species across international borders. For example, the wind-borne Ug99 wheat rust fungus spread from Uganda to Kenya, Ethiopia, Yemen and the Islamic Republic of Iran, and by 2008 had threatened crops in south and central Asia. As up to 80% of African and Asian wheat varieties are susceptible to wheat stem rust, this disease has the potential to exacerbate current high wheat prices and harm rural livelihoods, reducing purchasing power and posing a threat to food and nutrition security (FAO, 2008b).

In summary, climate change will affect food and nutrition security through reduction of income from animal production, reduction of yields of food and cash crops, lowered forest productivity, changes in aquatic populations, and increased incidence of infectious disease (Cohen et al., 2008).

In addition to climate change, the growing demand for biofuel poses a challenge to food and nutrition security. Although it creates potential opportunities for increased income among smallholders and other members of the rural sector, biofuel demand can also be a threat in terms of decreased food availability (Figure 26). Land previously used for cultivation of food crops may be diverted to biofuel production, and food availability may subsequently be reduced, leading to shortages and associated price effects (Viatte et al., 2009). In terms of nutrition security, it is important to note that women farmers, who are often in charge of food crop cultivation, may be further marginalized by the substitution of biofuel crops for food crops.

The resources and income flows that women control have repeatedly been shown to have a disproportionately positive impact on household health and nutrition (Von Grebmer et al., 2009). In some cases, increased biofuel production may decrease the purchasing power and assets controlled by women, with negative implications for household level nutrition outcomes. In addition, demand for biofuels may accelerate unregulated or poorly regulated foreign direct investment (otherwise known as "land grabs"), as well as the clearing of land for cultivation, including tropical forests and wetlands. Finally, intensified production of energy crops such as sugarcane, as well as increased cereal production to meet competing demand for food, feed and fuel, may raise use of chemical fertilizers to dangerous levels, increasing risk of illness and environmental deterioration, both of which have negative implications for nutrition (Viatte et al., 2009).

ACTIONS TO PROMOTE FOOD AND NUTRITION SECURITY AT HOUSEHOLD AND COUNTRY LEVEL

Improving smallholder production systems and capacity should be a primary goal in efforts to promote food and nutrition security. Many of the world's poorest and most vulnerable are smallholders, and in many developing countries – and all least developed countries – domestic food production occurs predominately through small-scale farming. However, projects and programmes that aim to improve food and nutrition security through increased yields will be most successful if they are implemented in tandem with efforts to improve crop and dietary diversity.

Since many of the world's most vulnerable populations are landless and/or urban, promoting food and nutrition security requires looking beyond smallholders. Actions to improve food and nutrition security among these groups, as well as smallholders, include raising incomes, providing

livelihood support, creating social safety-nets and focusing on maternal and child health. In addition, increasing dietary diversification through nutrition education and social marketing is essential to improving food and nutrition security, regardless of population group. Poverty reduction – at national, regional and international levels – is required. Other requisites are frameworks for agricultural policy, and for food and nutrition security policy, that promote improved nutrition outcomes as central to national development goals and include explicit nutrition programmes.

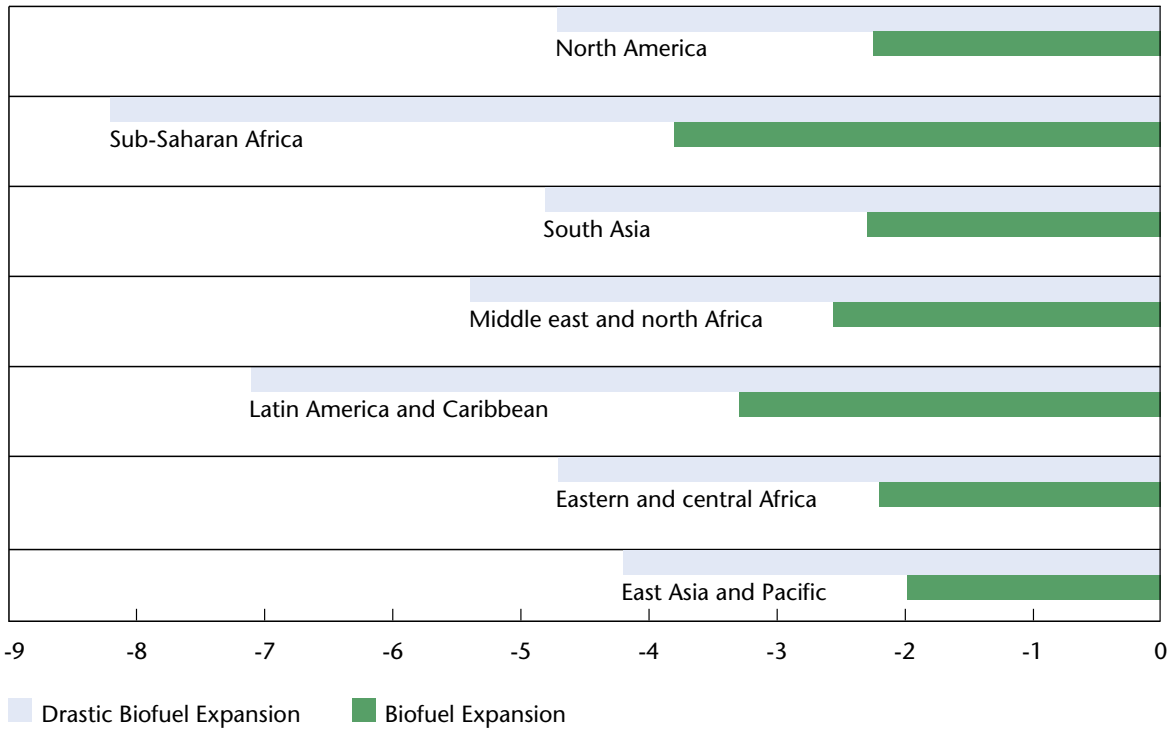
Enhancing smallholder productivity

Enhancing smallholder production and productivity can be an economically viable way to increase agricultural system diversity, contributing to the resilience of food systems and promoting the nutritional quality and diversity of local foods. Increasing smallholder production to improve food and nutrition security requires investment in the following:

- improving availability of seeds and other inputs;
- developing water resources;
- strengthening and expanding agricultural cooperatives and farmers' organizations;
- measures for sustainable resource management and conservation of biodiversity;
- programmes for animal production and fisheries inputs;
- reducing post-harvest losses;
- research to improve understanding of how to link agriculture with nutritional knowledge.

One of the primary constraints smallholders face is access to seeds and other inputs. Subsidy schemes, programmes that promote soil fertility and sustainable land management, input market development, and support for farm equipment and structures can increase access to inputs for small farmers. For seeds, early generation multiplication and strengthened distribution systems are measures that can be taken at municipal and district level, while seed production can be undertaken by farmers' organizations at village level. Bangladesh, Lao People's Democratic Republic, Lesotho and Uganda are examples of countries working to strengthen the capacity of farmers' organizations for seed production (FAO, 2009j). When community seed production is working well, it can facilitate the adoption of improved and locally adapted varieties, reduce transaction and trans-

Figure 26.
Projected impact of biofuel demand on food energy availability, 2010-2020 (% change)



Source: IFPRI.

port costs, and reach even the smallest and most vulnerable smallholders.

According to FAO, 20 of the 33 countries that required external food assistance in December 2008 were affected by drought or flood (FAO, 2009j). Most of these countries have avoided large-scale irrigation and water resource projects, focusing instead on rehabilitating or promoting small-scale irrigation schemes appropriate for smallholders. Countries such as Jamaica, Madagascar, Mali, Nepal and Swaziland propose investments in small-scale irrigation (FAO, 2009j). In Nepal, farmers are encouraged to invest in micro-irrigation, comprising low-cost drip systems, rainwater harvesting tanks, treadle pumps, rower pumps and dug wells, which irrigate up to 0.5 hectares of land (FAO, 2009j). These systems suit smallholders, whose productivity and cropping intensity can be doubled if access to irrigation is assured.

Strengthening and expanding agricultural cooperatives and farmers' organizations is key to improving productivity as well as enhancing smallholders' livelihoods more generally. The former is achieved when cooperatives and farmers' groups are able to access credit, information and other important goods and services better than individuals. The latter can occur in a number of ways, including granting small farmers sufficient political power to protect themselves and benefit from the long-term leasing of their agricultural land by foreign investors, as well as increased opportunities for post-harvest value addition, e.g. food processing. Both of these capacities are important in developing countries where foreign direct investment poses a threat to smallholders who may not have well-defined property rights, and who cannot on their own afford the equipment and training required for food processing and other activities that add value to their crops. Cooperatives and farmers' groups empower smallholders by creating informal "unions" which increase their bargaining power as well as granting farmers a louder political voice. For example, in Indonesia and Mexico the national plans for food security include forming farmers' groups that develop their own farmer group development plans. Farmers learn how to prioritize, cost and manage their own activities. The groups are financed via a revolving fund system, and although they are provided with start-up capital, they become responsible for their own funding once the initial financing is spent. Another example is Sierra Leone, which has developed a community-based extension and capacity-building programme which uses community-based farmer field schools as the primary instrument for improving rural food security and livelihoods within the framework of the national recovery strategy. Collective action by small food producers can also help to orient and shape markets to better capture and increase the availability of nutritious local foods, and can increase the availability of affordable fruits and vegetables for urban consumers.

Strategies aimed at boosting production should include actions that protect natural resources. Integrated pest management attempts to control pests through the influence of natural predators and parasites, thereby reducing the need for pesticides. Integrated soil fertility management combines the use of both inorganic and organic fertilizers, such as composts, manures and nitrogen-fixing plants, to increase yields, rebuild depleted soils, improve moisture retention and protect the natural resource base (FAO, 2009j). In addition, promotion of traditional cropping systems and crop diversification can protect the natural resource base via decreased use of chemical fertilizers and improved soil fertility. For example, reintroduction of the traditional *milpa* system – intercropping of maize, beans and vegetables – in central America is gaining increased attention as a sustainable alternative to maize monocropping (FAO, 2009j; Viatte et al., 2009). Diversity in food production is also important for adapting to climate change. For example, many traditional but neglected "orphan" crops, e.g. sorghum and millet, are resistant to drought and other stresses related to climate change.

Support to programmes for animal production and fisheries can be adapted to smallholders, and provide important contributions to household food and nutrition security. For example, in Tajikistan, home-based livestock husbandry, including poultry, sheep and goats, is being promoted. The programme aims to increase the purchasing power and food and nutrition security of some of the most vulnerable and food-insecure households in rural areas. The main features are distribution of improved laying hens, training on better poultry management, improved veterinary services, and the rehabilitation of sheep and goat stocks through improved management and husbandry practices (FAO, 2009j).

Reduction of post-harvest losses contributes significantly to improved food and nutrition security in many developing countries, and deserves more attention from policymakers and government. Significant proportions of fresh produce, animal-source foods and cereals are lost to spoilage and infestation on their journey to the consumer. For example, dairy losses in the United Republic of Tanzania amount to about 60 million litres a year, more than 16% of total dairy production in the dry season and 25% of production in the wet season. In Uganda, approximately 27% of all the milk produced is lost, equivalent to US$ 23 million per year (FAO, 2009j). Reduction of post-harvest losses has great potential to increase rural income and employment, reduce food prices in urban areas and improve food safety. Although some measures require economies of scale and are not adaptable to smallholder contexts

(e.g. large, refrigerated storage facilities), others are quite simple and are appropriate for even very low-income farmers. For example, a review of projects in the Dominican Republic, Haiti and Niger concluded that solar drying of fruits and vegetables rich in beta-carotene was an appropriate technology for preserving these sources of vitamin A. Solar dried fruits and vegetables maintain high levels of beta-carotene for up to 6 months (FAO/ILSI, 1997).

Beyond smallholders: actions to improve food and nutrition security among urban and landless populations

Many low-income urban and rural households are net food purchasers (FAO, 2008c). With purchasing power being reduced by the global economic downturn, many vulnerable households have been pushed deeper into poverty and food insecurity, increasing the risk of malnutrition. Increasing incomes, focusing on maternal and child health, and providing livelihood support and social assistance programmes are integral to improving food and nutrition security among these consumers as well as for smallholders.

Increased purchasing power is a direct result of livelihood diversification, which broadens household income sources thereby strengthening resilience to the sorts of shocks experienced during the global downturn. Examples of livelihood diversification for both rural and urban populations include community-based, in-kind revolving funds and cottage industries that add value to raw agricultural products, e.g. oil seed processing. In addition to generating income, food processing initiatives can help to meet urban food needs, especially in areas where storage facilities are inadequate and where food safety is an issue. The in-kind revolving funds are similar to the farmers' cooperative revolving funds described in the preceding section. However, in this case, seeds and/or small livestock, as opposed to credit, are provided, and beneficiaries do not have to be smallholders.

Social assistance measures such as social safety nets address many of the entrenched socioeconomic issues that challenge food and nutrition security. They are also important for reducing the harmful effects of coping mechanisms used in times of crisis, such as those that were observed during the recent global downturn. Social safety-nets are transfer programmes targeted to low-income groups or those vulnerable to poverty and shocks. They can be cash-based, in-kind, conditional or unconditional, and they allow vulnerable households to cover their most essential needs. When safety nets are in place before a crisis, they decrease the requirement for emergency relief, prevent or at least reduce distress sales of productive assets such as livestock and seed, and encourage recipients to undertake slightly riskier behaviours e.g. crop diversification, investing in new technologies that may result in sustainable increases in income and food security. Safety nets offer many households the opportunity to progressively graduate from poverty, and they decrease dependency on aid. In many cases, women and children are the primary beneficiaries of these policies. For example, the majority of conditionalities for Opportunidades, one of the largest cash transfer programmes in the world, are targeted at mothers and their children.

The positive impact of social assistance measures increases when combined with livelihood diversification initiatives. For example, Save the Children in the Amhara province of Ethiopia recorded significant progress in building livelihoods, assets and resilience after implementation of a government programme that combined a productive safety-net initiative with livelihood investment activities. After three years of a food or cash safety-net and livelihood support (e.g. inputs, and technical and organizational skills transfers), poor families significantly increased their cash income – often doubling it – and were able to invest in new productive assets, including oxen, water pumps, and bee-hives, further broadening their income base (Save the Children UK, 2009a). A Save the Children study in Niger found growth in food production among low-income families as a result of a 3-month cash transfer programme that enabled households to spend more time working their own land instead of working as hired labour for wealthier farmers (Save the Children UK, 2009b).

Safety nets may also directly improve nutritional status and maternal and child health. For example, conditional cash transfer programmes in Colombia, Mexico and Nicaragua decreased stunting rates by 7, 10 and 5.5 percentage points, respectively (Adato & Hoddinott, 2007). Save the Children documented improved dietary intake among some of the beneficiaries of the Amhara programme mentioned above.

Increasing dietary diversification through nutrition education and social marketing

The concept of nutrition security, which refers in part to the "quality" component of food production, consumption and physiological need, is a crucial consideration in efforts to reduce malnutrition. Although many of the actions cited above include inherent nutrition components, often an explicit focus on nutrition security is required to "activate" these aspects of the project or programme. For example, reducing animal mortality rates and increasing production of small livestock may not be enough to actually improve intake patterns. This is because many low-income households tend to use livestock as an asset base, as opposed to an immediate source of food. Similarly, increases in purchasing power resulting from livelihood diversification do not guarantee improved intake patterns. This is because direct

reductions in income poverty do not generally result in proportional reductions in malnutrition (Shakir, 2006).

Extension advice, especially that geared towards women and school-based nutrition services, is thus necessary to "activate" the latent nutrition aspects of many agricultural development projects and programmes. For example, promotion of traditional cropping systems should be accompanied by extension-based education services stressing the importance not just of growing, but also of consuming a diversity of foods. Extension services which encourage crop diversification, for example via distribution of high-nutrient foods such as orange-fleshed sweet potatoes, must be accompanied by education and social marketing efforts to encourage increased intake of these foods (Low et al., 2007). Promotion of gardens in schools, communities or individual households increases awareness regarding the importance of good nutrition, building local capacity, and increasing the physical availability of fruits and vegetables (see Box 2). Education programmes that are extension or school-based can also promote food safety. Promotion of preservation techniques to maintain micronutrient levels in foods not only reduces post-harvest losses but, when coupled with education services that emphasize the importance of dietary diversity, may also improve intake patterns.

As the double burden of malnutrition increases in developing countries, educating consumers regarding the health risks of highly processed foods low in micronutrient content is increasingly important. This type of nutrition education is of particular relevance for low-income urban households consuming a high percentage of their meals outside the home, and for those populations who are exposed to and consume excessive amounts of processed foods of low nutrient content.

Appropriate policy and programme frameworks

The fact that hunger was increasing even before the food and economic crises suggests that policy and programme frameworks are and remain insufficient, and that a right-to-food approach has an important role to play in improving food and nutrition security. To lift themselves out of hunger, the food-insecure need control over resources, access to opportunities and improved governance at the international, national and local levels. The right to food is, first and foremost, a basic human right enshrined in international law (UN Economic and Social Council, 1999). It is the right of every person to have continuous access to the resources necessary to produce, earn or purchase enough food, not only to prevent hunger, but also to ensure health

Box 2. Keyhole gardens for improved food and nutrition security: an example of extension-based nutrition education

- A keyhole garden (so-called because of its shape) is a raised stone-walled garden. Keyhole gardens can be built in places where it is difficult to build normal gardens (rocky areas, with shallow arid or compacted soils, etc.), and are often placed near the entrance of dwellings to facilitate their watering with household wastewater. They maintain their soil fertility for 5 to 7 years; produce food all year round, even under harsh temperatures; and are prolific, supporting production of at least five varieties of vegetables at a time. Keyhole gardens have a simple drip-irrigation system using a lined basket placed in the centre of the garden, which disperses water throughout. This innovation allows these gardens to use significantly less water than more conventional gardens.

- Building and maintaining a keyhole garden requires seeds, tools and horticultural knowledge, all of which can be provided by agricultural extension staff, often in collaboration with local and international non-governmental organizations. Extension workers trained in nutrition education can provide information regarding the preparation and preservation of the garden's produce. Extension staff are often well-positioned to follow up on communities' attempts to create keyhole gardens and other horticulture ventures. They are able to provide seed and other inputs at regular intervals, as well as to provide continued coaching regarding the importance of dietary diversity. This is of particular importance in areas where extension staff may have long-standing relationships with the community.

and well-being. The recommendations below are all made within a right-to-food framework, with the ultimate goal of reducing marginalization and disempowerment of the poorest.

"Mainstreaming" food and nutrition security initiatives into national development agendas increases programme efficacy as well as the impact of such programmes on nutrition. Poverty reduction strategy papers, United Nations development assistance frameworks, and five- or ten-year plans are all examples of national policy frameworks into which food and nutrition security objectives need to be incorporated. Mainstreaming requires convincing policy-makers that reduction in income poverty and yield gaps do not guarantee proportional reductions in malnutrition, and that specific policies and targeted interventions for improving nutrition outcomes are therefore necessary if the Millennium Development Goals are to be achieved. Promotion of social protection, equitable land tenure regulations, national food fortification programmes, monitoring and evaluation of food and nutrition situations, and capacity-building measures are some of the most important aspects of such frameworks.

As discussed above, social protection measures enable a variety of vulnerable population groups to engage and invest in productive activities that they could not have otherwise initiated and/or sustained. An integrated policy approach that combines social protection measures, such as safety nets, with livelihood diversification strategies that broaden income streams allows households in both rural and urban areas to manage risk, increase resilience to shocks, and create opportunities for increased food and nutrition security.

Land tenure is an issue throughout the developing world, and female smallholders and urban farmers are two groups whose access to land is often threatened, especially in situations where documentation of holdings is insufficient or informal. Foreign direct assistance, for example, can threaten local production systems in terms of ownership rights. Whenever possible, improving vulnerable communities' land tenure rights through statutory recognition and recording of informal and tenure systems should be encouraged. However, in situations where rules, procedures and registration fees may prove prohibitive, recognizing temporary rights per cultivation season and/or recognizing and administering – in an equitable way – rights of access to idle cultivable land are alternatives.

Lack of technical and institutional capacity in assessing the local food and nutrition situation, prioritizing needs, designing intervention strategies, and providing operational and managerial support is a serious constraint to achieving food and nutrition security in many developing countries. There is a shortage of qualified personnel at every level – national, district, municipal and local. Community nutrition workers are often limited or non-existent. Agricultural extension workers and health staff receive either basic or no training in nutrition, and have weak skills in communicating nutrition information to specific population groups. Procuring funding for training nutrition specialists at all levels of government should thus be a priority.

Monitoring and evaluation of food and nutrition security projects and programmes improves service delivery and increases government accountability. Early warning systems, such as the Integrated Food Security Phase Classification, increase awareness of pending shocks and can thus help prepare for and mitigate their impact. The data generated by such systems can increase policy-makers' awareness of threats to food and nutrition security, and may help raise nutrition's "profile" on national policy agendas, especially if nutrition information is collected along with other indicators. For example, vulnerability assessments are often based primarily on fluctuations in the market price of staple foods, and current production and yield levels. Supplementing these reports with information from household dietary diversity scores can increase awareness regarding the importance of consuming a varied diet, and highlight the distinction between the quantity and quality aspects of consumption. Whenever possible, surveillance data should be disaggregated by income, demographic, ethnicity, gender and other criteria relevant to food and nutrition security.

National food fortification programmes can be appropriate where there is a strong cash economy, an effective food marketing system, an appropriate vehicle, centralized processing and a population with a specific deficiency that can be effectively reached by such a programme. Where these requirements are not met, combating micronutrient deficiencies through wider food-based approaches is strongly recommended.

In addition to country-level recommendations, regulatory frameworks and agreements should support standard-setting initiatives that promote food and nutrition security

Box 3.
The reformed Committee on Food Security: Working together to reduce food insecurity

The vision of the Committee on World Food Security (CFS) is to be the most inclusive international and intergovernmental platform for all stakeholders to work together to ensure food security and nutrition for all. In 2009 the CFS underwent a reform to make it more effective by including a wider group of stakeholders and increasing its ability to promote polices to reduce food insecurity. The CFS now has a structure that allows input from all stakeholders at global, regional and national levels.

The thirteen member Bureau is complimented by an Advisory Group made up of representatives from UN agencies and other UN bodies, civil society and non-govern mental organizations, international agricultural research institutions, international and regional financial institutions, private sector associations and philanthropic foundations.

A High Level Panel of Experts – Food Security and Nutrition (HLPE-FSN) of internationally recognized experts in a variety of food security and nutrition-related fields will provide scientific and knowledge-based analysis and advice on policy-relevant issues and also identify emerging trends.

within a global context (see box 3). Areas of focus should include:

- preservation of biodiversity, and conservation, sound management and sustainable use of natural resources, e.g. promotion of integrated agro-forestry systems;
- incorporation of hunger reduction and nutrition objectives into climate change negotiations, e.g. funding for innovative technologies to improve the adaptive capacity of production systems;
- promotion of pro-poor food and agricultural development policies that support low-income groups and are conducive to nutrition security and encourage positive spillovers, e.g. responsible foreign direct investment that includes smallholders and leads to improvements in local food processing technologies;
- promotion of fair and transparent global markets, e.g. border policies that do not restrict developing countries' access to global markets.

CONCLUSION: EMERGING THEMES IN AGRICULTURE AND FOOD SECURITY

At the global level, undernourishment has been increasing since 1995. Coping strategies employed by households to deal with increased food insecurity, including reduced expenditures on food with consequent declines in the quality (micronutrients) and quantity (calories) of food intake, have increased the risk of poor nutrition outcomes. Global trends in production, trade and foreign direct investment as well as changing patterns of consumption have complicated the food and nutrition security picture in many developing countries. A combination of both short- and long-term socioeconomic, health, political, demographic and environmental challenges affect food and nutrition security. These are all critical factors to consider when designing policies and programmes for improving nutrition outcomes.

Solutions to these issues are complex and not the responsibility of agriculture alone. Nevertheless agriculture plays a crucial role in mitigating each challenge. First, agriculture increases access to food, and is thus key to improving food and nutrition security. Second, agricultural development is crucial to alleviating poverty in developing countries where a large proportion of low-income communities depend upon the primary sector for their livelihoods. Third, agricultural policies focused on sustainable development practices have great potential to reduce some of the most harmful effects of the nutrition transition and other global trends. Fourth, nutrition-sensitive agricultural development is central to efforts to mainstream food and nutrition security considerations into national development agendas.

Some of the most important emerging themes for nutrition-friendly agriculture, essential as part of a broader nutrition-sensitive development framework, include:

- *Food production systems, social assistance, and other supportive policies and programmes in favour of low-income groups:* Increasing rural smallholder production and urban and periurban food systems are direct routes to improving food and nutrition security. The most important aspect of agricultural development in favour of low-income groups is that it expands, enhances and sustains people's ability to procure and use the amount and variety of food required to be active and healthy.

- *Environmental sustainability:* Improved agricultural production practices are essential to addressing environmental concerns such as biodiversity, sustainable use of resources, and livestock sector reform. Intercropping, integrated agro-forestry systems and cultivation of locally adapted varieties are examples.

- *Capacity-building to improve nutrition:* Agriculture is key to reducing both overnutrition and undernutrition. Strengthening national, municipal and community capacities to support local food systems and promote nutrition education and social marketing efforts is imperative to reducing all forms of malnutrition.

- *Setting higher standards in trade and development:* Agriculture has an important role to play in improving the international food and nutrition security environment. Responsible regulatory frameworks should include standard-setting for responsible foreign direct investment, as well as policies designed to protect and expand smallholder rights, increase incentives to produce and market micronutrient-rich foods, and prioritize the needs of low-income groups who are net consumers.

In conclusion, agriculture is fundamental to reducing global hunger, and along with the health and care-based approaches discussed in other chapters of this report, is integral to improving nutrition outcomes worldwide.

Chapter 5 Conclusions

As part of its mandate to raise awareness of nutrition problems and mobilize commitment to solve them, the United Nations System Standing Committee on Nutrition (UNSCN) periodically produces reports that describe and analyse the global food and nutrition situation. This sixth report on the world nutrition situation returns to some of the themes and regional trend analyses which were pioneered in the first three reports, and focuses on developing countries. The main conclusions of the sixth report are highlighted below.

Vitamin A deficiency affects some 160 million pre-school children in low-income countries, with prevalence estimated at about 30%. This prevalence – measured as low serum retinol – is improving at somewhat less than 0.5 percentage points per year. At that rate, it will take low-income countries more than 50 years to get to levels typical of industrialized countries. Eye signs of the deficiency have a prevalence of about 1–2%. By both measures, more countries (with repeated comparable surveys) are improving than not. More effective intervention, including expanded fortification with vitamin A, will be needed to reduce vitamin A deficiency at an accelerated rate.

The extent of **anaemia** is not changing substantially, and affects more than half the women of reproductive age in large parts of Asia. Prevalence in children, as has recently been recognized, is even higher in many populations – in Africa it is estimated to be up to 60%. Some 500 million women and 250 million children are anaemic.

Control of **iodine deficiency** is a success story, although one still in progress – iodized salt now covers an estimated 70% of households. Without iodized salt, it can be calculated that some 2 billion people would show signs of iodine deficiency; whereas the actual number is around 700 million. But the 30% of households without iodized salt are likely to be more vulnerable and difficult to reach, living in remote areas, or with multiple salt sources. Elimination of iodine deficiency, with its risks to cognitive development and function, requires sustained efforts.

Growth retardation in children – measured as *stunting* or *underweight* – starts before birth, and substantially affects growth in childhood. Differences in rates of *low birth weight* between populations and over time have been tracked, in relation both to maternal thinness, measured as low body mass index (a determinant), and to child underweight (a result). For example, low-birth-weight rates in south Asia of around 30%, which are double those of Africa, have fallen substantially since the UNSCN's first estimates in the 1980s, and child underweight prevalence is falling in proportion. In contrast, low birth weight in Africa remains around 15%, and underweight has changed little. In parallel, prevalence of low maternal body mass index (<18.5) has fallen in south Asia, but is still double that of African women. African children's higher birth weight and lower underweight prevalence is in part a result of the greater body size of their mothers.

Child underweight and stunting prevalence are falling significantly in most countries, except in Africa. This indicator is used to assess progress towards MDG1 (on hunger and malnutrition), and a number of countries are improving fast enough to meet this goal. Overall, African countries show insufficient progress to achieve MDG1, whereas many Asian countries as well as Latin American (and Caribbean) countries are on track to achieve it (or have already achieved it). In central and south America, stunting is the more widespread form of child growth retardation – whereas in other regions the prevalences of stunting and underweight move in parallel. Globally, 17% of preschool children are underweight, with 28.5% stunted.

Transitions from steady high prevalence of underweight, falling at 1–2 percentage points per year, to sustained low prevalence (less than, say, 10%) over a few decades have now been observed in a number of countries, from Brazil to China to Thailand. Some countries are in mid-transition – Indonesia and Viet Nam are examples. There are signs that some African countries are beginning this process, judging by recent results from, for example, Ethiopia and the United Republic of Tanzania. It is important to understand how such transitions happen, so that they can be replicated.

This sixth report on the world nutrition situation calls for a renewed effort to invest in **maternal nutrition** in a sustainable and holistic manner. The intergenerational cycle of growth failure continues to claim and compromise lives: it needs to be turned into a virtuous cycle. Improving birth weight contributes to improving child growth in the first two years of life. This results in less stunting at two years of

age, which is eventually reflected in increased adult height. Improved cognitive function and intellectual development across the life-course are associated with an increase in birth weight and a reduction in stunting.

The good news is that turning the intergenerational cycle of growth failure into a virtuous one can be done, as seen in the close tracking of low women's body mass index, low birth weight, and child underweight.

Improved maternal nutrition, even for small adult women during pregnancy, improves birth weight. Improving the diet in quantity and quality can help achieve this. The effects seem to be greater if the mother is reached either during or preferably before the first semester of pregnancy. Such interventions do not endanger the mother and do not increase the risk of maternal mortality as there is no evidence of increase in cephalo-pelvic disproportion even if food supplements are provided to adolescent mothers whose birth channels are still not mature.

For adolescent mothers, improving the birth weight of their babies benefits greatly by delaying the first pregnan-cy beyond 18 years of age. Nutrition in the early months of pregnancy has the greatest benefit on birth outcomes. Tackling anaemia during adolescence should get much greater programmatic attention. Together such interventions would go a long way towards breaking the intergenerational cycle of growth failure.

So why has there not been more progress in maternal nutrition? Part of the answer lies in the focus on interventions that produce short-term gains in child survival.

The sixth report on the world nutrition situation calls for: improved understanding, reinforcement and revitalization of the importance of growth and development outcomes:

- revival of a focus on birth weight;
- renewed attention to maternal nutrition for mothers' own health and development;
- increased programmatic support for prevention of teenage pregnancies, including sex education and family planning services for adolescents, together with an enabling societal environment – where community norms and values concerning early marriage, sex education and family planning need to change.

Renewed investment in maternal nutrition and nutrition for adolescent girls will contribute significantly to the progressive realization of the rights of the girl child and of the adolescent mother in the context of the Convention on the Rights of the Child and the Convention on the Elimination of All Forms of Discrimination against Women, as well as making important contributions to achieving Millennium Development Goals 1, 4 and 5.

Achieving **sustainable food and nutrition security** is the only viable and long-term solution for ending hunger and improving levels of nutrition. Although food and nutrition problems are complex and not the responsibility of agriculture alone, the sector plays a fundamental role in their solution. This is because of the essential role food has for good nutrition, as well as the importance the food and agriculture sector has for reducing poverty and improving livelihoods in many countries, especially those where a large proportion of low-income groups continue to depend upon farming and related activities for their survival.

In these countries, supporting smallholder production systems is one direct route to improving food and nutrition security. Essential actions include increasing availability of seeds, tools and other inputs, and improving knowledge and application of technologies for sustainable development of land and water resources, conservation of biodiversity, and reducing post-harvest losses. Additional measures include promoting smallholder cooperatives, improving access to credit, and supporting small-scale animal production and fisheries. Especially when coupled with "nutrition-sensitive" initiatives such as cultivation of local micronutrient-rich foods, these strategies represent a significant improvement over current production systems in terms of both social welfare and environmental viability.

However, if food and nutrition security is to be achieved, policies and programmes must also target landless labourers, low-income groups in urban areas, and other vulnerable populations who are net food purchasers. Broadening the income base of these groups through livelihood support and job creation, and establishing and strengthening social assistance programmes with a focus on maternal and child health, is integral to improving food and nutrition security for all.

For all populations, education and social marketing are crucial components of national, municipal and community efforts for sustained improvements in food and nutrition security. These activities are often essential to realizing the potential for nutrition improvement of many agricultural development projects and programmes. They are also important in countries where obesity and non-communicable diseases are increasing.

Lack of technical and institutional capacity in monitoring and evaluation, assessing needs, designing and delivering interventions, and providing operational and managerial support is a serious constraint in many developing countries. There is a shortage of qualified personnel at every level – national, district, municipal and local. Community nutrition workers are often limited or non-existent. Agricultural extension workers and health staff receive either basic or no training in nutrition, and typically have weak skills in communicating nutrition information to specific population groups. Building capacity at all levels of government should thus be priority.

The report concludes that nutrition-friendly, sustainable agricultural development is key to improving food and nutrition security. Regulatory frameworks should reflect this, as well as setting standards for responsible foreign direct investment, promoting policies designed to protect and expand smallholder rights, increasing incentives to produce and market micronutrient-rich foods, and prioritizing the needs of low-income groups who are net consumers. Important emerging themes for nutrition-friendly agriculture as part of a broader nutrition-sensitive develop-ment framework include pro-poor food production systems, social assistance, livelihood diversification and other supportive policies and programmes, environmental sustainability, capacity building to improve nutrition, and setting higher standards in agricultural trade and development.

Annex

METHODS USED TO ESTIMATE REGIONAL TRENDS

The data used to analyse the levels and trends reported here have been accumulated over several iterations and decades, including for earlier UNSCN reports on the world nutrition situation,[1] and for an extensive update and analysis in 2004 supported by the Micronutrient Initiative and UNICEF (see Mason, Rivers & Helwig, 2005). These compilations drew most of their data from WHO's databases, and from Demographic and Health Surveys (DHS)[2], UNICEF (State of the World's Children[3], ChildInfo[4]) and similar sources. For the present update, starting in 2008, new outcome data were sought and introduced primarily from WHO's current databases, adding to the existing files; other sources are given under the respective deficiencies. Almost all the outcome data used here are in WHOSIS,[5] the WHO online database. The data used for interpolation (independent variables) are described later in this Annex. The country groups are those used by the UN, the same as in the fifth report on the world nutrition situation (SCN, 2004), and are given in Table A3. The focus here is on developing countries and regions. Europe and north America have not been included. For Oceania, repeated data were available only for Papua New Guinea, and regional estimates are not included except for underweight and stunting.[6]

The main objective is to assess trends. Estimates of average prevalence levels are published periodically by WHO: for anaemia, (WHO, 2008), vitamin A deficiency (WHO, 2009) and iodine deficiency (WHO, 2004). These are generally given as averages by period (e.g. 1993-2005 for anaemia and 1995-2005 for vitamin A deficiency), although point estimates were given for iodine deficiency disorders for 1993 and 2003. Trends are analysed to a lesser extent than levels. As discussed in Chapter 2, hardly any substantial differences are seen when comparing the prevalence level estimates presented in this report with WHO's estimates by country group (region or subregion) and time. In any event, the main purpose here is to estimate and comment on trends rather than levels.

Three methods are used to assess trends, as follows.

Method 1. Repeated national surveys at different times are compared, when these are considered to have comparable samples in terms of national coverage, and when biological groups (e.g. age groups, pregnancy) are similar. In commenting (in the last column of the tables reporting results from repeated national surveys), a difference of 2 percentage points between surveys is used as a guide for likely significant change. This stems from a difference of the prevalence estimates likely to be about two standard errors given usual sample sizes (e.g. 2000). Rates of change are also estimated as percentage points per year, by subtracting the earlier from the later prevalence and dividing by the number of years; thus a negative rate means improvement.[7]

Method 2. Available survey results can be aggregated by region and averaged, to give a first view of possible regional trends. Such estimates are limited since the same countries may not appear in each time period. The datapoints might be regarded as a sample for that period and region, and the averages are thus not population-weighted. This method is used here for micronutrients, as a check on other findings – it would be a reason for concern if the direction of change from the first and third methods by region was substantially different from the crude averages. In practice, as seen here, all three methods almost always show changes in the same direction. This method also provides a convenient display of the numbers of surveys available by region and time period.

Method 3. Regression models are used to estimate trends and levels with a similar approach for vitamin A deficiency, anaemia, and underweight and stunting (for some purposes).[8] Iodine deficiency disorders are different (because the main predictor is use of iodized salt) and details are given below in the corresponding methods section.

1 http://www.unscn.org/en/publications/index.php#RWNS
2 http://www.measuredhs.com/
3 http://www.unicef.org/sowc/
4 http://www.childinfo.org/index.html
5 http://www.who.int/whosis/
6 Papua New Guinea is included for country level data in certain Annex tables.
7 This use of percentage points per year in estimating changes is an alternative to using percentage changes – e.g. 2.7% per year needed to halve prevalences in the period 1990-2015 to meet MDG goals. It is preferred here, and in other similar reports, for several reasons, including being much easier to calculate by inspection and hence lends itself to policy discussions; because expected rates are known (e.g. 0.5 ppts/yr is average for underweight); it stresses the larger reduction required in high prevalence countries.
8 Country-year estimates derived from interpolation models were used to identify outliers in the survey estimates of underweight, and check the likelihood of results used in estimating trends, e.g. as in table 20.

This modelling approach is necessary as the majority of country-years do not have an estimate – for example, for the 107 countries included for 1990-2007, there are 1926 possible country-years, but for underweight (for which there is the most data) there are only about 410 survey data points, i.e. 20%, so 80% are missing. The procedure in principle (for details see Mason, Rivers & Helwig, 2005, pp. 65-74) is to establish associations of outcome prevalence estimates (a case being a country-year estimate) with independent variables (potential predictors of missing data) that are available for all countries and years; the values of these are matched by time (e.g. a survey result for country X in 1999 is matched with the GNI for that country for 1999). In the survey result database (in Statistical Package for Social Sciences: SPSS) regression models are then developed to provide the best fit, including regional dummy variables, and interactions where needed (not usually). Outliers are identified by extreme values, by highly inconsistent results (e.g. ranging from 20% to 80% over a few years), and by examining residuals from near-final models to flag unlikely cases for further examination. The criteria for deciding which variables should be included in the final models (especially regional dummies) depended on the significance of coefficients (as usual) but also on consideration of reducing the spread of residuals (e.g. by their standard deviation). Year (of survey) was always tested, and in no case remained signi-ficant in the final model (i.e. changes in outcome variables through time are absorbed in the changes through time of the independent variables, e.g. GNI).[9] This allows the models to show a response to changing external factors, rather than forcing a direction of change based on year.

Once the model is established for each deficiency, the relevant independent variables are looked up for the reference years (2000, 2005, 2007 here) for each country, and the algorithm from the regression equation used, in Excel, to predict the prevalence for each country for the reference year. Population data (by country, for the relevant age or biological group and year) are entered and the number affected (e.g. number of children underweight) calculated (prevalence/100)* population). This is summed for the subregions and regions, and divided by the population for that region or subregion (also summed). Dividing these two gives the population-weighted subregional or regional prevalence. Extending estimates back to 1990, where applicable, was done as described for vitamin A deficiency, see below.

VITAMIN A DEFICIENCY[10]

Data compilation

Xerophthalmia prevalence was calculated as the sum of the prevalences of night-blindness (XN) and Bitot spots (X1B). Data exist for multiple biological groups, and in extracting the data the age ranges for which prevalences were given were recorded. For xerophthalmia, the commonest groups were described as ages 6 to 72 months, 24 to 72 months, and 0 to 72 months. Age groupings were aggregated into 0 to 72 months and no age adjustments were made. Most data for xerophthalmia were reported as the prevalence of night-blindness. Where both night-blindness and Bitot spots were recorded, prevalence of xerophthalmia was determined by XN + X1B. In most cases only XN or X1B was available. In line with previous estimates in the database, for cases with only night-blindness (XN) results, xerophthalmia was determined as XN * 1.5; where only Bitot spots (X1B) prevalence was reported, xerophthalmia was determined as X1B * 2.

Only national data were used for xerophthalmia prevalences. Although sub-national results were available, it was uncertain as to whether projecting sub-national results onto the national population was applicable. Seven new national data points were found and added to the data available from the previous report (Mason, Rivers & Helwig, 2005).

Vitamin A deficiency was reported in terms of serum retinol (SR), with prevalences defined as serum retinol levels below 0.7 µmol/l, or 20 µg/dl ("low serum retinol"). The most common age ranges were 6 to 60 months and 12 to 60 months. The age groups were aggregated to analyse all data falling within 0 to 72 months. No age adjustments were made. Thus the results from any subgroup within the set of children aged 0 to 72 months old were treated as the same biological group. For example, if one survey assessed vitamin A deficiency in children 12 to 72 months of age, it was treated as comparable, for the purposes of analysis, to that for children aged 0 to 59 months.

9 Except iodine deficiency disorders, see below.

10 Based on the work of Bibi Al-Ibrahim, MPH.

New low SR data entered since 2005 were national data only. Low SR prevalences greater than 70% were not used for developing the model. A total of 21 new datapoints for low SR were added for developing the model, for a total of 104 data points.

Database description

The vitamin A database is available as an SPSS file containing the results of vitamin A surveys and a set of independent variables. Cases are defined by country-year, with each case containing one survey result; thus for example xerophthalmia and serum retinol survey results from the same survey would be in the same row (case); if from different surveys or different age groups from the same survey (the more usual situation) each result is entered as a different case. Results for children aged 0 to 72 months were added to the previous database of the previous report. A code for national and sub-national data is included.

Each case has regional codes and indicators used in interpolation models as independent variables, including infant mortality rates, female literacy rates, and measles immunization coverage. The values for these independent variables were entered for the year of the vitamin A deficiency survey with which they were included; e.g. if the vitamin A deficiency result was for 1994, then the independent variables were for that year. Where the exact year was not reported, a linear interpolation for the independent variable was made from the nearest years reported.

Regional dummy variables,[11] to represent different country groups, were created taking the value 1 if the country is in that region, otherwise 0; from previous experience, India and China were treated as regions in some analyses. Interaction terms between independent variables were created by multiplying the two interacting variables, for use in the regression analysis.

Analytical methods

Repeated national surveys

National surveys in the same country at different times were compared where these existed, as the first method of examining trends. After including new data, there were 12 cases with national equivalent repeated surveys for xerophthalmia and 13 cases for vitamin A deficiency assessed as low serum retinol.

Unadjusted averages by region and time period

The unadjusted average was calculated by computing an unweighted mean for all the prevalence datapoints for a particular region and time. The time periods used to calculate the means were before 1990, 1990-1994 (centered on 1992), 1995-1999 (centered on 1997), 2000-2004 (centered on 2002), and 2005 and later. The regions are the same as those used throughout this report, shown in Table A3. For xerophthalmia, only national results were included. For low serum retinol, both national and sub-national results were included, to raise the number of surveys.

Interpolations of prevalences by country to reference years

Regression models were developed for both xerophthalmia and low serum retinol, however only the low serum retinol results are used in this report – in line with the shift from clinical to biochemical assessment (which is also a reason that there are few recent xerophthalmia results).

The final model used was:

Prevalence of low serum retinol = 22.049 + 0.192 (IMR) - 0.168 (Femlit) + 8.500 (DAfr) + 28.591 (DIndia) + 23.350 (DOther) + 8.282 (DSEAsia) where IMR is infant mortality rate, Femlit is % women literate, and DAfr, DIndia, DOther and DSEAsia are regional dummy variables; more details are given below in the section on independent variables. In the regression, n=105, adjusted $R^2 = 0.480$, and $p<0.05$ for all coefficients except those for DSEAsia and DOther, where $p<0.1$. Seven cases were excluded as outliers: six with prevalences >70; and one (Jamaica 1997, at 58.8%) as having outlying high residuals. Both national (n=63) and sub-national (n=42) cases were included.

This equation allowed prevalences to be predicted for each country and reference year based on the values for the independent variables included in the regression model, for the reference years (2000, 2005 and 2007). The subregional and regional averages were then estimated, for these years, by calculating the numbers of children with low serum retinol in the population less than 5 years old; then summing these numbers for subregions and regions; summing the total populations less than 5 years old; and dividing the numbers with low serum retinol by the total population. This procedure allowed flexible re-aggregation by different subregions and regions.

Estimating trends 1990-2007

Subregional and regional estimates for 2000, 2005 and 2007, calculated as described in the previous paragraphs, were linked to estimates for 1990 and 1995 in order to calculate longer-term trends, and relate these to analogies to the MDG goals for underweight. This was done based on the estimates made previously, for 1990-2000, as given by

11 For definitions see independent variables section.

Mason, Rivers & Helwig (2005, Table 7); these used models similar to those described here. Both estimates included 2000, and minor differences in prevalence estimates by subregion – typically around 1 percentage point – resulted from some differences in coefficients and in the series of independent variables (which are regularly updated, and were updated during the five years since the previous calculations). The two trends, 1990-2000 and 2000-2007, were joined based on the new 2000 estimate, by adjusting the 1990 and 1995 estimates by the difference between the two 2000 result sets, by subregion. For example, if the previous estimates for 1995 and 2000 were 32% and 30%, and the new estimate for 2000 was 29%, then the 1995 estimate would be adjusted to 31%; and similarly for 1990. The trend estimate was thus not affected. The purpose of adjusting the level was to avoid a discontinuity.

Trend estimates are then expressed in percentage points per year, e.g. (prevalence in 2007 – prevalence in 1990)/17. For comparison with analogous MDG goals, of halving the prevalence from 1990 to 2015, the required rate was calculated as (prevalence in 1990/2)/25 in percentage points per year.

Comparison with WHO data

The prevalence levels calculated here are in line with WHO's estimates, for example comparing these data for 2000 with WHO data for 1995-2005, considering the slightly different regional groupings, as seen in Table A4.

IODINE DEFICIENCY DISORDERS[12]

Data compilation

Outcome variables

Two measures of iodine deficiency were studied: goitre prevalence and urinary iodine (the main indicator being prevalence of urinary iodine < 100 µg/l). The database used for the present analysis built on that used and described by Mason, Rivers & Helwig (2005). Updated data on iodine deficiency were extracted from the WHO global database on iodine deficiency, part of the Vitamin and Mineral Nutrition Information System (VMNIS).[13] Information on the data sources and inclusion criteria for the data-base on iodine deficiency[14] is summarized below.

For the WHO global database on iodine deficiency, survey reports and publications reporting on goitre and/or urinary iodine are requested or collected from: ministries of health, through WHO regional and country offices; national research and academic institutions; nongovernmental organizations; organizations of the United Nations system; regular searches of online databases, such as PubMed, Medline, Ovid, and Embase; WHO regional databases (African Index Medicus, Index Medicus for the WHO Eastern Mediterranean Region, Latin American and Caribbean Center on Health Sciences Information, Pan American Health Organization Library Institutional Memory Database, Index Medicus for South-East Asia Region). Survey data are extracted and included in the WHO database only from complete original survey reports and publications that provide details of the sampling methods. Data from all administrative levels and all population groups cited are included. Studies included must have a population-based sample frame and must use standard measuring techniques for urinary iodine and total goiter prevalence.

To be included in the WHO database, a survey must report on at least one of the following criteria:

- Goitre prevalence investigated by palpation and classified according to WHO recommendations.
- *Grade 1:* A goitre that is palpable but not visible when the neck is in the normal position, even when the thyroid is not visibly enlarged. Thyroid nodules in a thyroid, which is otherwise not enlarged, fall into this category.
- *Grade 2:* A swelling in the neck that is clearly visible when the neck is in a normal position and is consistent with an enlarged thyroid when the neck is palpated.

  A thyroid gland will be considered goitrous when each lateral lobe has a volume greater than the terminal phalanx of the thumbs of the subject being examined.

  Only total goitre prevalence data measuring goitre by palpation are includ ed. Until recently, no international reference values for thyroid size in iodine-replete populations measured by ultrasonography were available. Thus results from surveys using this technique have not yet been included.

- Urinary iodine reported by at least one of the following categories:
- Distribution: the percentage of the population falling within the categories < 20 µg/l, 20-49 µg/l, 50-99 µg/l, 100-299 µg/l, > 300 µg/l.
- Prevalence: the percentage of the population falling below the cut-off level of 100 µg/l.
- Median and/or mean (µg/l, µg/g creatinine or µg/24h).

12 Based on the work of Katie Robinette, MPH

13 http://www.who.int/vmnis/iodine/data/database/countries/en/index.html (accessed 15 September 2008).

14 http://www.who.int/vmnis/iodine/data/sources/iodine_data_sources/en/index.html (accessed 6 February 2009).

Household consumption of iodized salt
Updated data on the percentage of households consuming adequately iodized salt at the country level from 2000-2007 were extracted from the UNICEF global database on iodized salt consumption.[15] Country-level data were compiled for this database from several population-based surveys, including those administered by the Multiple Indicator Cluster Survey (MICS) programme, by Demographic and Health Surveys (DHS), by UNICEF, or by a country's ministry of health.

Selection criteria for outcome data
Age group: data for school-aged children (aged 6-12 years) were included in the analysis for each country-year case when available. If not available, data for other age groups were included in the analysis in the following order of priority: closest age group of children, adults (including pregnant women), general population, preschool-age children (WHO, 2004).

National versus sub-national: data were included for analysis only if they were nationally representative. Iodine deficiency indicator: country-year cases were included if there was a value for either total goiter rate, prevalence of low urinary iodine (<100 µg/l), and mean or median of urinary iodine.

Household consumption of iodized salt
Updated data on the percentage of households consuming adequately iodized salt at the country level from 2000-2007 were extracted from the UNICEF global database on iodized salt consumption.[16]

Country-level data were compiled for this database from several population-based surveys, including those administered by the Multiple Indicator Cluster Survey (MICS) programme, by Demographic and Health Surveys (DHS), by UNICEF, or by a country's ministry of health.

To increase the number of cases with a value for household consumption of iodized salt, values for household iodine were extrapolated for those cases without a value in that specific year, based on methods described by WHO (2004). A country-year case was given the closest value for household iodine measured within 4 years of the survey. If there was more than one value before and after the case within 4 years before or after the survey, these values were averaged.

Updating database
New data on iodine deficiency indicators and on household consumption of iodized salt were added to the 159 country-year cases in the iodine deficiency dataset described by Mason, Rivers & Helwig (2005). Cases were added to the dataset, and information on the related survey was recorded, including survey year, survey administrator, sample size, and whether it was national or sub-national. Iodine deficiency indicators, including total goitre rate, percentage of the population with low urinary iodine, and median urinary iodine, were included as available for each case. The percentage of households with adequate consumption was recorded, as well as relevant information on the data, including iodine cut-off points. Although the most recent cases were the most helpful in providing an update on iodization status, data from before 2005 were also added to the data set if not already present.

The previous analysis used only total goitre rate as the indicator for iodine deficiencies, because it was the most historically available and therefore better for comparisons over time. However, surveys are now changing from total goiter rate to urinary iodine measures (prevalence of low urinary iodine, mean and median urinary) as indicators for iodine deficiency disorders. Consequently, upon searching through the WHO global database on iodine deficiency, the majority of the more recent surveys provided data on urinary iodine, and fewer surveys included data on total goitre rate. In total there were 197 datapoints for total goitre rate, and 91 for low urinary iodine prevalence.

Endogenous (pre-iodization) total goiter rate
The calculation of goitre prevalence depended on estimates of the pre-iodization prevalence of goitre ("endemic goitre rate"). Values for endogenous total goitre rate were taken from previous estimates, derived from research linking en-dogenous goitre prevalences to soil characteristics (from FAO data) and other factors (Mason, Rivers & Helwig, 2005, pp. 70-72), and then imputing endogenous rates from these characteristics to fill in missing data. The two regression equations used (n = 46 and n = 53 countries) showed highly significant associations, with adjusted R^2 of 0.65 and 0.46. A listing of estimated endogenous total goitre rates by country is given in Table A5. These values were not needed in the final models for urinary iodine.

Calculating prevalence of low urinary iodine from median urinary iodine
Values for median urinary iodine were converted to prevalence of low urinary iodine with an equation based on WHO

15 http://www.childinfo.org/idd_profiles.php (accessed 6 February 2009).
16 http://www.childinfo.org/idd_profiles.php (accessed 6 February 2009).

methods. According to WHO (2004, p. 16): "If the proportion of population with UI values below 100 µg/l was not presented, it was computed from median UI, using the simple linear regression equation based on the data points presented in Figure 2.2: % UI <100 µg/l = 86.3 – 0.324* Median".

A regression was run on the prevalence of low urinary iodine with median urinary iodine in our database, resulting in an equation very similar to that above and specific to the data included in this analysis:
*% urinary iodine <100 µg/l = 83.156 – 0.296*median*

This equation was used to estimate the prevalence of low urinary iodine for countries that only had values for median urinary iodine. A variable was added to denote whether the value for the prevalence of low urinary iodine was derived from the equation or as reported. One estimate for the prevalence of low urinary iodine came out negative because the value for median urinary iodine was so high. This case was recorded as having a zero prevalence of low urinary iodine. Adding 13 estimates of the prevalence of low urinary iodine to the spreadsheet, derived by using the formula, made a total of n = 89 cases that have values for the prevalence of low urinary iodine (and n = 73 with values for median urinary iodine).

Regression models
The model for total goiter rate used here was as follows: *TGR = 16.616 – (0.113 * hhiod) + (0.321 * endtgr) – (2.707 * lnyrsiod)* where TGR = goitre prevalence (%), hhiod = % households with iodized salt (p = 0.004), endtgr = estimate or pre-iodization (endogenous) total goitre prevalence (p = 0.000), and lnyrsiod is the natural logarithm of (years since iodization started) (p=0.026). Cases where iodization had not started, i.e. hhiod=0 or yrsiod=0, were excluded. This model had n = 83, and adjusted R^2 = 0.256. As can be seen, in this case the time was important, and including the period since iodization started (as a logarithm) found to give the best fit.

The key to this model working is the estimate of pre-iodization (or endogenous) goiter prevalence, which is a value calculated for each country based on a series of characteristics, developed in previous work (Mason, Rivers & Helwig, 2005, pp. 17-20 and 86-95). These values were only previously provided as ranges, so are included here in Table A5.

Using these factors, estimates were calculated for countries, in Excel, inserting values for 1995-2000 and 2001-2007 for household iodine, endogenous total goitre rate, and years from start of iodization, centred on 1998 and 2004. Household iodine data were extracted from UNICEF (2009, p. 125). (Data refer to the most recent year available during the 2000-2007 period.) To estimate numbers of people affected, population data for 2005 were used (see independent variables section).

The model for low urinary iodine was as follows: *UI = 73.911 – (0.380*hhiod) – (11.224*DAmer) – (4.895*lnyriod)* where UI = prevalence of urinary iodine < 100 µg/l, hhiod = % households with iodized salt (p = 0.000), DAmer = regional dummy for Americas (p = 0.077) and lnyrsiod is the natural logarithm of (years since iodization started) (p = 0.066). The model had n = 68, and adjusted R^2 = 0.46.

Using these factors, prevalences of low urinary iodine were estimated for periods centred on 1998 and 2004, as described above for total goiter rate.

ANAEMIA[17]

Data compilation

This analysis of anaemia includes the data used in the previous report (Mason, Rivers & Helwig, 2005), supplemented by additional data from various sources. New data since the previous report were primarily found through Demographic and Health Surveys (DHS) and the WHO anaemia database[18]. The WHO anaemia database is a repository of anaemia data from multiple organizations, including Helen Keller International, UNICEF, national research and academic institutions, and ministries of health. DHS data were specifically queried from STATcompiler,[19] an online tool for searching across indicators using DHS data. Prevalence of anaemia is found under the Maternal and Child Nutrition category in STATcompiler. In each survey used from DHS and the WHO anaemia database, the sample size was at least 100. In addition, only surveys that were nationally representative were included in the analysis.

Three biological groups are most commonly used to assess the prevalence of anaemia in a population. These are: pregnant women; non-pregnant women of reproductive age (15-49 years); and children less than 5 years of age. In some cases, children less than 5 years of age were categorized as 0-5 years old; in other cases, the age range was indicated as 6-60 months. The criteria for anaemia vary by biological group. For pregnant women and children, the cut-off point is 11 grams per decilitre (g/dl) of haemoglobin concentra-

17 Based on the work of Amit Wadhwa, MPH.
18 http://www.who.int/vmnis/anaemia/data/en/index.html
19 From Measure/DHS: http://www.statcompiler.com

tion in the blood. For non-pregnant women, the cut-off point is 12 g/dl. Only surveys using these definitions of anaemia were included in the analysis.

Some available survey data from both DHS and the WHO anaemia database also reported anaemia prevalence in other biological groups, such as adolescents and adult males. However, these groups are not frequently assessed, creating too small of a set of data for analysis.

Database description

The anaemia dataset was created with case definition as a country-year. Each country-year case can have prevalence values for each of the three biological groups – pregnant women, non-pregnant women, and 0-5 year old children. The dataset contained a total of 675 cases. (The database built up from previous work included sub-national surveys, thus a filter variable was created to select only national surveys.) For pregnant women, n = 228; for non-pregnant women, n = 191; and for children less than 5 years old, n = 129.

Analytical methods

Repeated national surveys

Analysis was conducted on countries where results from repeated national level surveys were available. A total of 40 countries had repeated national surveys allowing for analysis of trends in non-pregnant women. For pregnant women, 43 countries had repeated national surveys, while the number of countries with repeated national surveys for children less than 5 years old was 30. In analysing the trend over years, differences of two percentage points were considered likely to be significant.

Unadjusted averages by region and time period

Regions were grouped into: Africa, Asia, and Latin America & Caribbean. Time periods were defined as: before 1990; 1990-1994; 1995-1999; 2000-2004; and 2005 or after. Each biological group was analysed separately. It should be noted that even with the large geographical groupings used, child datapoints before 1990 and in the period 1990-1994 were limited in number.

Survey results from countries having prevalence data in a given time period were averaged by region as one method for tracking regional trends. This method is fairly crude, as countries represented in one time period are not necessarily represented in subsequent or previous periods. The average calculation is not weighted. Weighting by population combined with inconsistent country reporting over time periods would make interpretation increasingly complex.

Interpolations of prevalences by country to reference years

Regression models for prevalence of anaemia were developed for each biological group to allow for prediction of values for the years of interest: 2000, 2005 and 2007. As a starting point, the same regression model from the previous report was tested, with variables added and removed to improve the model with newly added data points. Changes in reporting of some independent variables used in the previous analysis required the substitution of equivalent indicators. Specifically, grams of meat consumed per day was used as an indicator (instead of using percentage of calories from meat). Also, gross national product (GNP) per capita was replaced by gross national income GNI per capita (and log GNP per capita was replaced by log GNI per capita).

In some cases, independent variables were not available for each country-year combination. In each of these cases, a best guess was made by interpolating values from years for which data were available or by estimating a value based upon values for neighbouring countries with similar conditions.

Interactions between logical candidates were again tested, and those found to be significant were included in the final models. In the case of anaemia, the only model that had a significant interaction term was in the non-pregnant women model. In this model, the interaction between grams of meat consumed and GNI per capita was found to be significant. In addition, regional variables were tested in each model, and those holding significance were included in the final model, as described below.

After rigorous models were found to predict anaemia prevalence in each biological group, the required independent variables and country-year cases were added to an Excel worksheet. Columns were added with data for the independent variables required per model. Population data were also added as a weighting factor for calculating regional averages.

The regression model yielded a constant value and coefficients for each independent variable to predict prevalence of anaemia. The regression model for each biological group is given below.

Regression model for anaemia in pregnant women (15-49 years)

ANAEMIA = 89.165 + (-0.0746 * grams of meat consumed per day) + (13.956 * regional variable for India) + (-14.372* log GNI per capita) + (-17.335 * regional variable for China)

In the regression, n = 188, adjusted R^2 = 0.261, and for the coefficients: grams of meat consumed per day, p = 0.040; regional variable for India, p = 0.014; log GNI per capita, p = 0.000; regional variable for China, p = 0.004.

Regression model for anaemia in non-pregnant women (15-49 years)

ANAEMIA = 45.166 + (-0.124 * grams of meat consumed per day) + (19.152 * regional variable for India) + (-0.00121 * GNI per capita) + (0.000008972 * interaction of meat and GNI per capita) + (7.684 * regional variable for south Asia) + (5.224 * regional variable for sub-Saharan Africa)

In the regression, n = 157, adjusted R^2 = 0.308, and for the coefficients: grams of meat consumed per day, $p<0.05$; regional variable for India, $p<0.05$; GNI per capita, $p<0.05$; interaction of meat and GNI per capita, $p<0.05$; regional variable for South Asia, $p<0.05$; regional variable for sub-Saharan Africa, $p<0.05$.

Regression model for anaemia in children (0-5 years)

ANAEMIA = 98.303 + (-15.582 * log GNI) + (-0.190% female literacy) + (25.834* regional dummy variable for India) + (-23.238* regional dummy variable for China) + (18.838* regional dummy variable for south America) + (18.258* regional dummy variable for sub-Saharan Africa).

In the regression, n = 112, adjusted R2 = 0.553, and for the coefficients: log GNI, p = 0.000; female literacy (%), p = 0.001; regional dummy variable for India, p = 0.010; regional dummy variable for China, p = 0.019; regional dummy variable for south America, p = 0.000; regional dummy variable for sub-Saharan Africa, p = 0.000.

UNDERWEIGHT AND STUNTING[20]

Data compilation

The results given in Tables 21 and 23 were based on data compiled by WHO as follows. Cross-sectional data on the prevalence of underweight and stunting were obtained from national nutrition surveys included in the WHO global database on child growth and malnutrition.[21] A total of 608 surveys were available with underweight prevalence and 576 with stunting prevalence data. For 22 countries, national survey data were available from only one survey, 29 countries had two surveys, and the remaining countries had three or more surveys. Around two fifths of the data included is based on surveys conducted in the period 2000-2008. The earliest survey dates back to 1966 (from Nicaragua), while the most recent surveys were conducted in 2008 (Bhutan, Cambodia, Chile, Egypt, Mauritania and Viet Nam). All surveys included boys and girls, and the age groups ranged from birth to 5 years.

Database description

The database used for all estimates except those shown in Tables 21 and 23 was set up with each country survey result as a case; there were 419 valid cases for underweight. Data for selected countries were plotted to show time trends in Figure 11. Stunting prevalences were included in the database, for which there were 236 valid cases.

Analytical methods

Repeated national surveys

The method used to compare repeated national surveys is straightforward and similar to that used for micronutrients. A country was included when more than one national prevalence estimate was available for that country, and the latest survey was in the 2000s. The difference between two consecutive estimates was calculated and divided by the number of years between the datapoints, to give the change in percentage points per year for the period between the two surveys. For more than two surveys, the rate was calculated for each interval. Using the same calculation as for vitamin A deficiency, but estimating the sample sizes as likely to be around 2000, a difference of 2 percentage points between surveys was considered likely to be significant; less than this was noted as static. This assessment was made regardless of the number of years between surveys.

Analysis by subregion and region

The subregional and regional analyses, and the results given in Tables 21 and 23, were provided by WHO Department of Nutrition for Health and Development. The data file was constructed with the following variables: region; subregion; country; survey year; sample size; prevalence <-2 standard deviation (SD) below the weight-for-age median; prevalence <-2SD below the height-for-age median; and population of children younger than 5 years of age during the survey year. To obtain comparable prevalences across countries, surveys with available raw data (344 out of 608 for underweight) were analysed following a standard format using the WHO Child Growth Standards. For the other 264 surveys (43.3%) for which raw data were not available, a conversion method was applied to transfer underweight prevalences based on the National Center for Health Statistics reference to prevalences based on the WHO standards (Yang & de Onis, 2008). The steps followed to check for quality control and analyse the surveys in a standard way have been described elsewhere (de Onis & Blössner, 2003). Linear mixed-effects modeling was used to estimate prevalence rates and numbers of affected children by region from 1990 to 2007. This method has been used in previous trend analyses (de Onis et al., 2004[a]) and described in detail elsewhere (de Onis et al., 2004[b]).

20 Based in part on the work of Emily Cercone, MPH.
21 http://www.who.int/nutgrowthdb/en/ (accessed 23 June 2010).

Countries were grouped into regions and subregions following the UN classification system (as used elsewhere in this report), which includes territories according to their geographical distribution. The numbers of affected children aged less than 5 years were estimated using data from the 2008 revision of World population prospects (UN Population Division, see data sources).

"The method used to derive these regional and global estimates has some limitations. Like any trend analysis, it relies on the data available and no country has survey data for every year. Also, depending on where and when surveys were conducted, this may have biased our trend estimates. The method furthermore does not control for uncertainty in each survey's prevalence estimate nor for different age ranges in the survey data used. With reference to the latter, it is important to note that the vast majority of data points, however, cover the age group 0-5 years with a few – mainly earlier surveys – that cover a smaller range. Despite these limitations, the 95% CIs should accommodate most of the uncertainty around the presented estimates. All efforts will be made to continue improving the method applied."[22]
The linear mixed effect models used to derive the estimates in Table 21, according to the logit transformation ln ((1-P) /P) = A + B (year), where "p" is the prevalence expressed as a proportion and "year" the calendar year , yield the results given in Table A1.

Analysis by country-year: interpolations
Underweight prevalences were also interpolated for each country for 2000, 2005 and 2007. While these results were not used in the regional and subregional estimates (Table 21), they acted as a check for plausibility of the country survey data. Briefly, this method was as follows. The results of 419 national surveys from 106 developing countries, carried out between 1975 and 2007, were used for this report, building on the previous data compilations (Mason, Rivers & Helwig, 2005; Mason et al., 2001) used for earlier ACC/UNSCN reports (ACC/SCN, 1993). A number of independent variables were used to develop a regression model, an update of that described by Mason, Rivers & Helwig (2005, p. 22). Underweight prevalence in children aged 0-59 months was the outcome indicator. This analysis made use of the new WHO Child Growth Standards, converting from NCHS-based results as needed using the method of Yang & de Onis (2008).

22 Statement provided by WHO, February 2010.

Table A1.
Linear mixed effect model parameters (on log-odds) used to derive Table 21 estimates

UN region and subregions	Coefficient (log odds B)	t-test degrees of freedom	t-test p-values
Africa(a)	-0.01056	97	0.1054(b)
Eastern	-0.01056	97	0.1054(b)
Middle	-0.01960	97	0.1272(b)
Northern	-0.01794	97	0.0654(b)
Southern	0.00825	97	0.4884(b)
Western	-0.00851	97	0.2361(b)
Asia(a)			
Eastern	-0.07881	156	<0.0001
South-central	-0.04289	156	<0.0001
South-eastern	-0.03973	156	<0.0001
Western	-0.03911	156	<0.0001
Latin America & Caribbean(a)			
Caribbean	-0.04452	108	<0.0001
Central America	-0.04868	108	<0.0001
South America	-0.03989	108	<0.0001

a Models were run by region to estimate subregional trends; prevalence estimates for regions and aggregated levels were derived using subregional prevalence estimates weighted by populations (de Onis et al., 2003).
b Non-significant p-values, reflecting stagnation.

The final model was as follows:
*ln ((1-P)/P) = -0.508 + (0.00988 * FemSecF) + (0.00504 * UrbPopF) + (0.00642 * PedFinJ) + (-0.00205 * IMRF) + (0.263 * lnLAGGNI) + (-1.262 * dSAsia) + (-1.694 * dSAmeri) + (0.260 * intSMgnF) + (-0.757 * dSEAsia) + (0.657 * dNewInd)*
where P = prevalence of underweight (%), n = 411, and adjusted R^2 = 0.790. For all coefficients, $p<0.05$. The independent variables are defined below. This model was then used, like the models for vitamin A deficiency and anaemia, by entering values of the independent variables by country-year.

Stunting and underweight
Regression results for three regions (Africa, Asia, central and south America & Caribbean) together (Figure 10 a-c): Stunting = 20.502 + (0.894 * uwt) – 5.495 (dummy for Asia) – 14.261 (dummy for SC Amer/Caribb) + 1.036 (interaction: dummy for SC Amer/Caribb * uwt) where n = 232, adjusted R2 = 0.764, and all coefficients are significant, p = 0.000; interaction for Asia NS when in model.

Regression results for three subregions (Caribbean, central America, south America) together (Figure 10 d): Stunting = 11.261 + (1.710 * uwt) – 10.894 (dummy for Caribbean) + 1.378 (dummy for C Amer) where n = 59 and adjusted R^2 = 0.806. The coefficients for underweight (uwt) and dummy for Caribbean are significant, p = 0.000; the coefficient for dummy for central America is not significant; interaction for Caribbean NS when in model.

LOW BIRTH WEIGHT[23]

Repeated national surveys

Data compilation
National estimates from the same country at different times were compared when data were available for the period between 1997 and 2007. Since the majority of births occur outside health facilities in most developing countries, birth weight data from health services and routine national reporting systems tend to underestimate the incidence of low birth weight. Thus, the majority of data points presented here were collected from nationally representative household surveys: Multiple Indicator Cluster Surveys (MICS), Demographic and Health Surveys (DHS), and the reproductive health surveys supported by the Centers for Disease Control and Prevention.

Low birth weight is considered to be the proportion of infants born in a certain period who weighed less than 2500 g at birth. One limitation of this data is that, on average, in national surveys nearly half (48%) of infants are not weighed at birth (Blanc & Wardlaw, 2005). To reduce bias in nationally representative surveys, UNICEF/WHO have adopted different adjustment procedures depending upon the data available: when possible, reported birth weights are adjusted for underreporting and heaping at 2500 g. An analysis of 114 MICS and DHS surveys found an average increase of 24% once adjustments were made for relative birth size and heaping at 2500 g; in cases where data files are not available for further analysis, estimates are adjusted for underreporting and for maternal assessment of relative birth size, where possible. Otherwise, an average adjustment of 24% is applied to published data (UNICEF/WHO, 2004).

A total of 120 datapoints on incidence[24] of low birth weight in the period 1997-2007 were retrieved from the UNICEF global database on low birth weight[25] and the UNICEF/WHO (2004) report. Of these, 95 datapoints had been adjusted by UNICEF/WHO using the method described above, except where shown as indicated in Table 24. Five datapoint pairs were compared using routine data for: Argentina, Mexico, Panama, Malaysia, and Mauritius. An additional four datapoints were compiled from DHS reports and adjusted upwards by 24%, following the UNICEF method described above. These four datapoints were included to allow for additional comparisons. Eight pairs of estimates (as indicated in the footnotes to Table 24) should be interpreted with caution because they were derived using different methods.

Analytical methods
For each country listed in Table 24, the difference between the earlier and the later estimates was calculated and divided by the number of years between the data points to give the rate of change between surveys (in percentage points per year). Absolute differences (i.e. irrespective of interval) of either one or two percentage points were noted as indicating improvement, no change, or deterioration between the observations. The number of countries "improving," "deteriorating," or with "no change" were summed by region (Table 25).

Database description
The low-birth-weight database is available as an SPSS file containing the results of household surveys and independent variables. Cases are defined by country-year, with each case

23 Based on the work of Lisa Saldanha, MPH.

24 The UNICEF/WHO (2004, p. 4) report states: "The incidence of low birth weight in a population is defined as the percentage of live births that weigh less than 2,500 g out of the total of live births during the same time period." One reviewer noted that the correct term should be point prevalence rather than incidence, however the UNICEF/WHO terminology is kept here.

25 http://www.childinfo.org/low_birthweight_profiles.php

representing one survey result. The data source and method of adjustment is included in the database for each case.

Associations between trends in low birth weight, and prevalences of underweight children and low body mass index (BMI) in women.

Data compilation

The regional averages used come from different sources. The low-birth-weight estimates for the 1980s and 1990s were derived from a WHO report on low birth weight (WHO, 1992), as used in the Second report on the world nutrition situation (ACC/SCN, 1992). The regional estimates of low birth weight for the 2000s were derived from UNICEF/WHO estimates (UNICEF/WHO, 2004, p. 8, Table 2). For underweight, results were taken from calculations provided elsewhere in the present report, using WHO growth standards. These were made compatible with 1980s estimates from the Second report on the world nutrition situation by comparing 1990 estimates calculated for the sixth and second reports. The data from the second report were adjusted to WHO standards using the WHO algorithm, as described in the section on underweight and stunting.

For women with low BMI, unweighted regional estimates for the 1980s were taken from the Second report on the world nutrition situation (ACC/SCN, 1992). For the 2000s, national estimates of prevalence of females aged 15-49 years with BMI less than or equal to 18.5 were taken from the WHO global database on BMI.[26] Of the 86 cases, 4 included a broader age range (India, Pakistan, South Africa, and Viet Nam). An additional 24 BMI estimates were compiled from DHS surveys.[27]

Analytical methods

The data were plotted over time to examine regional trends in low birth weight, underweight children and underweight women. The most problematic low BMI estimate is for south-east Asia in 2000, with only three country estimates available from the WHO database. To compensate for this lack of data, additional prevalences of chronic energy deficiency were also looked up from FAO's country profiles[28] and national publications (Philippines FNRI, 2001); the mean (often from sub-national surveys) was approximately 20%, similar to the mean derived from WHO data. The datapoint was plotted at 20%.

Median age at marriage and low birth weight

Data compilation

The analysis of the relationship between age at marriage and low birth weight uses the same SPSS database as for the other analyses. A total of 88 datapoints were available, with each case representing one national survey result for low birth weight and the associated independent variables for that year (GNI, BMI, and enrolment of girls in secondary education). Cases were included from Asia, Africa, and Latin America & Caribbean. Data on median age at marriage (medmarr) were collected from DHS data for women aged 20-49 years for the period 1992 to 2006 These were matched to the years for which low-birth-weight estimates were available (plus or minus 5 years, based on the assumption that median age at marriage changes slowly). Methods of compiling the other variables are as follows: GNI (ln_GNI08): logarithm of GNI per capita for the year of each survey data point, calculated using gross national income converted to current USD (2008) using the Atlas method and divided by midyear population for each country: World Bank (Accessed on 23 June 2010 from http://ddp-ext.worldbank.org/ext/DDPQQ/member.do?method=getMembers&userid=1&queryId=135). BMI (ln_BMI): logarithm of BMI, compiled as described above on page 60.

Gross secondary school enrolment ratio for females (femsecf): UNICEF (Table generated from http://www.unicef.org/statistics/index_step1.php).

Analytical methods

Bivariate associations of low birth weight with median age at marriage were examined by scatterplot and regression within regions, as shown in Figure 14. In controlling for potential confounders, not all cases with low birth weight and marriage age could be matched with the control variables (GNI, BMI and education), thus the number of cases dropped from a total of 111 to 90.

SOURCES FOR INDEPENDENT VARIABLES

The methods for identifying independent variables and including them in the regression and prediction models for vitamin A deficiency, iodine deficiency disorders, anaemia, and underweight and stunting, for 1990, 1995 and 2000, have been previously described (Mason, Rivers & Helwig, 2005, pp. 7-24), and in most cases these were updated with more recent data. New data for the 2005 and 2007 estimates were primarily obtained from the UN Population Division,[29] an online database that includes country-level data from population-based surveys such as the Multiple

26 http://apps.who.int/bmi/index.jsp (accessed 23 June 2010).
27 http://www.statcompiler.com/index.cfm (accessed 23 June 2010).
28 http://www.fao.org/ag/agn/nutrition/profiles_by_country_en.stm (accessed 23 June 2010).
29 http://data.un.org/Browse.aspx?d=PopDiv and http://data.un.org/Default.aspx

Indicator Cluster Survey (MICS) and Demographic and Health Surveys (DHS), as well as data collected by national governments and UN agencies. These data are compiled by the UN data system for domains of interest (i.e. education, health, etc.) as well as MDG indicators. Additional data were downloaded from the World Bank, UNICEF and FAO: more details on the specific independent variables used for each outcome are listed at the end of this Annex, with sources for each.

To develop the regression models, the independent variables used for each outcome were matched to each country-year for which there were prevalence data. In cases where values for these independent variables were unavailable, data were usually interpolated between two years. For example, a value of 18 for the infant mortality rate for Belize 2002 was interpolated from the available data of 15 in 2005 and 20 in 2000 (as 20 - ((20 - 15)/5)*2). In some cases, where no data were available for years before and after the required year for interpolation, data were estimated as a value from the closest year (usually within two years, unless indicated otherwise). For example, the underweight database contained a survey prevalence estimate for 1989 for Uganda, but no data were available on female secondary schooling for that year. However, there were such data for 1988, so the 1988 value was used.

Regional dummy variables were created to represent different country groups (or countries, in the cases of China and India), taking the value 1 if the country was in that region, otherwise 0. Interaction terms between independent variables (usually with the regional dummies) were created by multiplying the two interacting variables, for use in the regression analysis. These were investigated in developing the regression models, and were included where significant ($p<0.1$). It should be noted that the regional specifications did not always exactly match the UN regions for which results were finally calculated and presented. This was generally either when earlier models were built upon for the new estimates, or when dummy variables for China and India alone were needed. These models are included in the respective methods sections.

Following the same methods, independent variables were compiled for base years 2000, 2005 and 2007, and (using Excel) used to calculate outcome estimates from the algorithms from the regression models. As above, in cases where values for these independent variables were unavailable for the base year, a linear interpolation was made from the nearest years reported. The algorithms used in Excel were the same as the final regression models, inserting independent variable values for 2000, 2005 and 2007. The datasets are available to researchers (at: www.tulane.edu/~internut).

Further details on the sources used to derive the independent variables are given below. Unless otherwise stated, data were accessed in March 2009.

Vitamin A deficiency

- Infant (0-1 years of age) mortality per 1000 live births (imrf): UN Statistics Division.

- Female (women aged 15 years and older) literacy (femlitf): UN Statistics Division (Table entitled "Gender info 2007: adult literacy rate" generated from: http://data.un.org/Data.aspx?q=adult+literacy&d=GenderStat&f=inID%3a49%3btimeID%3a35%2c38%2c41%2c42&c=1,2,3,4,5,6&s=_crEngNameOrderBy:asc&v=1).

- Regional dummy variables: Africa (dafr), India (dindia), Newly Independent States (dother), and South-East Asia (dseasia) (see table A3 for country and subregions).

Iodine deficiency disorders

- Percentage of households consuming adequately iodized salt (hhiod): UNICEF global database on iodized salt consumption (Table generated on 6 February 2009 from: http://www.childinfo.org/idd_profiles.php).

- Endogenous total goitre rates and years since iodization started are given by Mason, Rivers & Helwig (2005, pp. 17-21 and 86-95), and reproduced here in Table A5 for ease of reference.

Anaemia (children less than 5 years of age)

- Logarithm of GNI per capita as described above but not lagged (floggni): World Bank.

- Female (women aged 15 years and older) literacy (mergefem): UN Statistics Division.

- Regional dummy variables for India (fdindia), China (fdchina), South America (fdsamer), and sub-Saharan Africa (fdssa) (see table A3 for country and subregions).

Anaemia (non-pregnant women)

- Average meat consumption (g/person per day) (mtcopy): FAO data on consumption (http://faostat.fao.org/site/610/DesktopDefault.aspx?PageID=610).
- GNI per capita as described above but not logged (final_GN): World Bank.
- Regional dummy variables for India (fdindia), south Asia (fdsasia), and sub-Saharan Africa (fdssa) (see table A3 for country and subregions).
- Interaction term for grams of meat in diet and GNI per capita (fimtgni) (see table A3 for country and subregions).

Anaemia (pregnant women)

- Average grams of meat in diet, as described above (mtcopy): FAO data on consumption.
- Logarithm of GNI per capita as described above (floggni): World Bank.
- Regional dummy variables for India (fdindia), and China (fdchina) (see table A3 for country and subregions).

Underweight and stunting

- Gross secondary school enrolment ratio for females (femsecf): UNICEF (Table generated from http://www.unicef.org/statistics/index_step1.php).
- Percentage of the population living in urban areas (urbpopf): UNICEF (Tables generated from http://www.unicef.org/statistics/index_step1.php and http://www.unicef.org/statistics/index_step1.php).
- Infant (0-1 years of age) mortality per 1000 live births (imrf): UN Statistics Division (Table generated from http://data.un.org/Data.aspx?q=infant+mortality&d=CDB&f=srID%3a1230).
- Logarithm of GNI per capita for the year prior to each survey data point (lnlaggni), calculated using gross national income converted to current USD (2008) using the Atlas method and divided by midyear population for each country: World Bank (Accessed from http://ddp-ext.worldbank.org/ext/DDPQQ/member.do?method=getMembers&userid=1&queryId=135).
- Regional dummy variables: south Asia (dsasia), south America (dsameri), south-east Asia (dseasia), Newly Independent States (dnewind) (Former Soviet Union, now included in south central and west Asia).
- Interaction term for south America and the lagged logarithm of GNI per capita (intsmgnf).

Table A2.
Comparison of anaemia prevalence according to WHO (2008) and UNSCN (2000)

Anaemia	Non-pregnant women		Pregnant women		Children	
	UNSCN 2000	WHO 1993-2005	UNSCN 2000	WHO 1993-2005	UNSCN 2000	WHO 1993-2005
Africa	43.6	44.4	50.3	55.8	64.6	64.6
Asia	42.1 (36*)	33.0	45.6	41.6	46.4	47.7
Latin America and the Caribbean South America/Caribbean	25.5	23.5	28.4	31.1	39.7	39.5

* Setting India = 52% and China = 20%
Source: WHO, 2008, table A2.2, p 18.

Table A3. Country regions and subregions

Region	Country	Region	Country	Region	Country
Africa		**Asia**		**South America & Caribbean**	
East Africa	Kenya	East Asia	China	Caribbean	Cuba
	Madagascar		Mongolia		Dominican Republic
	Malawi	South central Asia	Afghanistan		Haiti
	Mauritius		Bangladesh		Jamaica
	Mozambique		Bhutan		Trinidad and Tobago
	Rwanda		India	Central America	Belize
	Somalia		Iran (Islamic Rep. of)		Costa Rica
	Uganda		Kazakhstan		El Salvador
	United Rep. of Tanzania		Kyrgyzstan		Guatemala
	Zambia		Nepal		Honduras
	Zimbabwe		Pakistan		Mexico
Central Africa	Angola		Sri Lanka		Nicaragua
	Cameroon		Tajikistan		Panama
	Central African Republic		Turkmenistan	South America	Bolivia (Plurin. State of)
	Chad		Uzbekistan		Brazil
	Congo	Southeast Asia	Cambodia		Chile
	Dem. Rep. of the Congo		Indonesia		Colombia
	Gabon		Lao People's Dem. Rep.		Ecuador
North Africa	Algeria		Malaysia		Guyana
	Egypt		Myanmar		Paraguay
	Libyan Arab Jamahiriya		Papua New Guinea		Peru
	Morocco		Philippines		Uruguay
	Sudan		Thailand		Venezuela (Boliv. Rep. of)
	Tunisia		Viet Nam		
Southern Africa	Botswana	West Asia	Armenia		
	Lesotho		Azerbaijan		
	Namibia		Georgia		
	South Africa		Iraq		
	Swaziland		Jordan		
West Africa	Benin		Kuwait		
	Burkina Faso		Lebanon		
	Côte d'Ivoire		Saudi Arabia		
	Gambia		Syrian Arab Republic		
	Ghana		Turkey		
	Guinea		United Arab Emirates		
	Guinea-Bissau		Yemen		
	Liberia				
	Mali				
	Mauritania				
	Niger				
	Nigeria				
	Senegal				
	Sierra Leone				
	Togo				

Table A4.
Comparison between UNSCN and WHO estimates for vitamin A deficiency in preschool children

UNSCN 2000		WHO 1995–2005	
Africa	39.5	WHO African Region	44.4
Asia	33.8	WHO Region of the Americas	15.6
South America & Caribbean	13.5	WHO South-East Asia Region	49.9
		WHO Eastern Mediterranean Region	20.4
		WHO Western Pacific Region	12.9

Source: WHO (2009, Table 11).

Table A5. Endogenous goitre prevalence estimates, with predicted prevalences of goitre (total goitre rate) and low urinary iodine, by country[30]

Region	Country	Estimate of endogenous (pre-iodization) total goitre rate	Predicted prevalence of total goitre rate in 1998	Predicted prevalence of total goitre rate in 2004	Predicted prevalence of low urinary iodine in 2004	Predicted prevalence of low urinary iodine in 2007
East Africa	Burundi	42.3	15.9	12.1	34.0	24.1
	Eritrea	19.1	11.8	9.4	40.1	37.9
	Ethiopia	29.5	32.3	21.9	85.2	62.9
	Kenya	32.8	6.8	7.2	19.6	22.1
	Madagascar	17.2	12.0	8.0	42.8	35.2
	Malawi	36.7	17.0	16.0	43.1	42.7
	Mauritius	28.1	31.9	31.9	85.2	85.2
	Mozambique	34.1	16.2	14.9	42.5	41.7
	Rwanda	41.8	14.0	13.1	28.3	27.9
	Somalia	12.3	26.7	26.7	84.8	84.8
	Uganda	38.8	16.4	11.4	38.9	25.3
	United Republic of Tanzania	34.7	16.4	16.9	40.4	46.8
	Zambia	50.6	17.8	17.4	30.9	32.5
	Zimbabwe	49.1	19.6	15.8	36.7	28.1
North Africa	Algeria	39.5	13.3	15.2	28.8	37.8
	Egypt	35.9	12.7	11.9	31.2	31.0
	Libyan Arab Jamahiriya	41.5	14.1	12.6	29.5	26.8
	Morocco	34.0	22.2	19.2	60.6	55.2
	Sudan	36.4	25.3	22.2	68.5	62.8
	Tunisia	28.2	5.6	5.1	20.4	19.8

Table continued on next page.

30 Estimates done by Peter Horjus, MPH.

(table A5 continued from previous page). Endogenous goitre prevalence estimates, with predicted prevalences of goitre (total goitre rate) and low urinary iodine, by country

Region	Country	Estimate of endogenous (pre-iodization) total goitre rate	Predicted prevalence of total goitre rate in 1998	Predicted prevalence of total goitre rate in 2004	Predicted prevalence of low urinary iodine in 2004	Predicted prevalence of low urinary iodine in 2007
Central Africa	Angola	37.3	33.7	19.7	81.4	51.8
	Cameroon	32.1	12.3	14.4	32.8	42.7
	Central African Republic	54.2	19.3	20.2	32.1	38.2
	Chad	51.4	22.1	20.0	44.2	40.5
	Congo	37.2	24.6	25.6	51.0	54.0
	Democratic Rep. of the Congo	46.2	27.1	16.8	66.0	34.8
	Gabon	31.4	32.8	18.8	84.8	53.4
Southern Africa	Botswana	38.5	19.4	13.8	51.9	35.0
	Lesotho	52.8	20.0	16.3	36.6	26.8
	Namibia	38.6	18.6	15.6	44.7	38.7
	South Africa	29.5	10.1	9.5	34.0	33.1
	Swaziland	12.2	13.8	5.2	57.2	32.2
West Africa	Benin	21.4	9.3	10.3	34.4	40.5
	Burkina Faso	36.6	23.9	18.9	61.8	50.8
	Côte d'Ivoire	22.7	10.7	8.1	35.2	30.7
	Gambia	20.6	28.4	20.5	81.8	67.9
	Ghana	21.7	17.4	14.0	57.9	51.0
	Guinea	25.2	20.5	13.6	59.9	45.0
	Guinea-Bissau	17.0	28.2	18.2	84.8	66.7
	Liberia	17.6	22.3	18.4	73.9	66.7
	Mali	47.6	29.0	17.3	67.1	33.7
	Mauritania	20.9	29.2	19.3	84.0	66.4
	Niger	47.4	22.7	21.0	46.2	46.3
	Nigeria	38.6	12.0	10.7	25.9	23.8
	Senegal	30.8	23.6	16.2	67.1	48.2
	Sierra Leone	18.4	20.3	13.7	56.7	50.0
	Togo	22.2	12.5	14.9	40.8	53.7
East Asia	China	33.5	13.3	10.5	32.5	26.9
	Mongolia	29.4	16.5	11.0	44.7	32.2

Table continued on next page.

(table A5 continued from previous page). Endogenous goitre prevalence estimates, with predicted prevalences of goitre (total goitre rate) and low urinary iodine, by country

Region	Country	Estimate of endogenous (pre-iodization) total goitre rate	Predicted prevalence of total goitre rate in 1998	Predicted prevalence of total goitre rate in 2004	Predicted prevalence of low urinary iodine in 2004	Predicted prevalence of low urinary iodine in 2007
South central Asia	Afghanistan	49.4	38.6	35.6	84.8	74.5
	Bangladesh	40.9	20.6	14.3	47.6	31.2
	Bhutan	58.2	19.1	16.4	30.2	23.0
	India	47.2	17.1	18.1	35.1	40.4
	Iran (Islamic Republic of)	36.9	13.0	10.5	29.4	24.1
	Kazakhstan	24.9	24.9	10.4	65.0	32.2
	Kyrgyzstan	25.7	28.0	12.5	74.9	38.2
	Nepal	60.8	21.4	19.8	37.7	33.5
	Pakistan	47.5	27.8	24.3	63.3	57.3
	Sri Lanka	24.2	16.1	7.8	50.7	27.4
	Tajikistan	34.1	31.5	18.6	77.6	49.6
	Turkmenistan	20.6	29.5	11.5	85.2	37.5
	Uzbekistan	28.6	30.1	16.0	78.7	47.0
South east Asia	Cambodia	19.4	28.3	10.2	82.5	38.3
	Indonesia	16.2	7.6	5.5	37.0	31.8
	Lao People's Democratic Rep.	32.6	12.6	12.3	31.0	34.1
	Malaysia	21.4	12.2	10.6	44.7	42.0
	Myanmar	25.0	15.4	12.2	45.8	40.9
	Papua New Guinea	20.0	14.4	11.4	49.5	44.2
	Philippines	16.1	15.2	9.9	59.4	44.6
	Thailand	24.7	12.7	11.7	43.6	42.5
	Viet Nam	17.6	7.9	5.2	32.2	26.8
West Asia	Armenia	28.6	24.1	11.1	58.6	30.3
	Azerbaijan	17.9	22.5	12.5	64.7	46.6
	Georgia	21.6	20.0	9.9	52.1	34.1
	Iraq	37.1	23.6	19.1	63.3	52.0
	Jordan	30.9	13.9	10.9	34.4	30.3
	Kuwait	38.1	21.3	17.5	51.5	44.7
	Lebanon	27.8	10.3	8.4	30.2	26.8
	Saudi Arabia	32.1	18.3	15.3	49.5	44.2
	Syrian Arab Republic	42.1	22.6	15.2	53.3	33.1
	United Arab Emirates	19.9	23.6	13.6	66.2	48.1
	Yemen	20.4	16.9	14.1	55.7	52.3

Table continued on next page.

(table A5 continued from previous page). Endogenous goitre prevalence estimates, with predicted prevalences of goitre (total goitre rate) and low urinary iodine, by country

Region	Country	Estimate of endogenous (pre-iodization) total goitre rate	Predicted prevalence of total goitre rate in 1998	Predicted prevalence of total goitre rate in 2004	Predicted prevalence of low urinary iodine in 2004	Predicted prevalence of low urinary iodine in 2007
Caribbean	Cuba	7.9	25.4	5.4	74.0	22.5
	Dominican Republic	11.2	15.0	11.8	51.0	44.2
	Haiti	11.2	19.1	14.6	58.9	52.0
	Jamaica	11.2	-0.1	-0.7	8.4	7.4
	Trinidad and Tobago	11.2	23.3	13.3	63.3	45.3
Central America	Belize	24.6	20.6	10.6	39.8	21.7
	Costa Rica	20.6	3.2	3.2	9.5	10.5
	El Salvador	19.3	4.7	7.1	14.0	23.6
	Guatemala	22.7	13.1	12.4	34.5	34.9
	Honduras	24.5	6.5	5.9	16.2	15.2
	Mexico	28.0	11.7	9.3	20.4	17.4
	Nicaragua	19.4	5.0	3.0	15.3	9.9
	Panama	19.4	3.1	2.5	10.3	9.3
South America	Argentina	43.6	13.7	12.6	16.3	14.3
	Bolivia (Plurinational State of)	45.4	11.9	11.4	11.8	11.2
	Brazil	46.6	12.2	12.4	11.0	12.6
	Chile	25.9	19.9	9.2	36.0	16.8
	Colombia	30.7	11.2	9.3	19.0	15.6
	Ecuador	30.5	8.1	7.1	12.1	10.4
	Guyana	18.0	18.5	8.4	39.8	21.7
	Paraguay	46.1	17.2	14.0	22.4	14.8
	Peru	32.4	7.5	7.1	11.0	10.8
	Ursuguay	27.5	9.6	8.1	18.3	15.6
	Venezuela (Bolivarian Republic of)	30.2	12.4	9.9	21.7	17.2

References

CHAPTER 1

Shrimpton, R., Prudhon, C., & Engesveen, K. (2009). The impact of high food prices on maternal and child nutrition. *SCN News 37*: 60-68.

CHAPTER 2

ACC/SCN (1987). *First report on the world nutrition situation.* Geneva, UN Sub-Committee on Nutrition.

ACC/SCN (1988). *First report on the world nutrition situation. Supplement on methods and statistics.* Geneva, UN Sub-Committee on Nutrition.

ACC/SCN (1991). *Controlling iron deficiency.* Gillespie S, Kevany J, Mason J, eds. Geneva, UN Sub-Committee on Nutrition.

ACC/SCN (1992). *Second report on the world nutrition situation*. Geneva, UN Sub-Committee on Nutrition.

ACC/SCN (1993). *Second report on the world nutrition situation. Volume II*: Country trends, methods, and statistics. Washington, DC, UN Sub-Committee on Nutrition.

Allen LH et al. (1994). Maternal body mass index and pregnancy outcome in the Nutrition Collaborative Research Support Program. *European Journal of Clinical Nutrition,* 48 (suppl. 3): S68-S77.

Barker DJ (1995). Fetal origins of coronary heart disease. *British Medical Journal*, 311:171-174.

Barker DJ et al. (1993). Fetal nutrition and cardiovascular disease in adult life. *Lancet*, 342 (8850): 938-941.

Caulfield LE et al. (2006). Stunting, wasting, and micronutrient deficiency disorders. In: *Disease control priorities in developing countries,* Chapter 28: 551-567.

FAO (2002). *Measurement and assessment of food deprivation and undernutrition.* Rome, Food and Agriculture Organization of the United Nations.

Mason J, Rivers J, Helwig C (2005). Recent trends in malnutrition in developing regions: Vitamin A deficiency, anemia, iodine deficiency, and child underweight. *Food and Nutrition Bulletin*, 26 (1): 1-110.

Mason J et al. (2001). *The micronutrient report: current progress and trends in the control of vitamin A, iodine, and iron deficiencies.* Ottowa, International Development Research Center.

Mason JB et al. (2006). Community health and nutrition programs. In: *Disease Control Priorities in Developing Countries*, Chapter 56:1053- 074.

McIntire D et al. (1999). Birth weight in relation to morbidity and mortality among newborn infants. *New England Journal of Medicine*, 340: 1234-1238.

Mensch BS, Singh S, Casterline JB (2005). *Trends in the timing of first marriage among men and women in the developing world*. New York, Population Council.

Monteiro CA, Conde WL, Popkin BM (2004). The burden of disease from undernutrition and overnutrition in countries undergoing rapid nutrition transition: a view from Brazil. *American Journal of Public Health*, 94(3): 433-434.

Munoz C, Scrimshaw NS (1995). *The nutrition and health transition of democratic Costa Rica*. Boston, INFDC.

Pedro MRA et al. (2004). The national vitamin A supplementation program and subclinical vitamin A deficiency among pre-school children in the Philippines. *Food and Nutrition Bulletin*, 25: 319-329.

Ronnenberg AG et al. (2003). Low preconception body mass index is associated with birth outcome in a prospective cohort of Chinese women. *The American Society for Nutritional Sciences*, 133: 3449-3455. SCN. (1994).

Fifth report on the world nutrition situation (2004). Nutrition for improved development outcomes. Geneva: UN Standing Committee on Nutrition.

Shrimpton, R., Prudhon, C., & Engesveen, K. (2009). The Impact of High food prices on maternal and child nutrition. *SCN News 37*: 60-68.

Sommer A, Davidson FR (2002) Assessment and control of vitamin A deficiency: the Annecy Accords. *Journal of Nutrition*, 132 (Suppl. 9): 2845S-2850S.

UN (1990) *World summit for children: world declaration on the survival, protection and development of children*. New York, United Nations.

UNICEF/WHO (2004). *Low birthweight: country, regional and global estimates*. New York, United Nations Children's Fund and World Health Organization.

UNICEF (2007). *Progress for children: a world fit for children statistical review*. New York, United Nations Children's Fund.

UNICEF (2009a). *The state of the world's children: maternal and newborn health*. New York, United Nations Children's Fund.

UNICEF (2009b). *Tracking progress on child and maternal nutrition*. New York, United Nations Children's Fund.

Viteri FE (1998). Prevention of iron deficiency. In: Howson CP, Kennedy ET, Horwitz A, eds. *Prevention of micronutrient deficiencies: tools for policymakers and public health workers*. Washington DC, National Academy Press, pp. 45-102.

Westof CF (2003). *Trends in marriage and early childbearing in developing countries*. Maryland, Demographic and Health Surveys (Comparative Report No. 5).

WHO (1992). *Low birth weight: a tabulation of available information*. Geneva, World Health Organization (WHO/MCH/92.2).

WHO (2004). *Iodine status worldwide; WHO Global Database on Iodine Deficiency*. de Benoist B et al., eds. Geneva, World Health Organization.

WHO (2008). *The world health report – Primary health care: now more than ever*. Geneva, World Health Organization.

WHO (2009). *Global prevalence of vitamin A deficiency in populations at risk 1995-2005: WHO Global Database on Vitamin A Deficiency*. Geneva, World Health Organization.

Wang Y, Monteiro C, Popkin BM (2002). Trends of obesity and underweight in older children and adolescents in the United States, Brazil, China, and Russia. *American Journal of Clinical Nutrition* 75(6): 971-977.

Yang, H., & de Onis, M. (2008). Algorithms for converting estimates of child malnutrition based on the NCHS reference into estimates based on WHO Child Growth Standards. *BMC Pediatrics*, 8 (19), 6.

Data sources

UNICEF. ChildInfo: Monitoring the situation of children and women. Available at: http://www.childinfo.org/ (accessed 3 March 2009).

UNICEF. Low birthweight incidence by country (2000-2007). Available at: http://www.childinfo.org/low_birthweight_profiles.php (accessed 3 March 2009).

WHO. Global Database on Child Growth and Malnutrition. Department of Nutrition for Health and Development. Available at: http://www.who.int/nutgrowthdb/database/en/ (accessed 3 October 2009).

CHAPTER 3

ACC/SCN (1992). *Second report on the world nutrition situation. Geneva*, Administrative Committee on Coor-dination of the UN/Sub Committee on Nutrition.

Aguayo VM et al. (2005). Acceptability of multiple micronutrient supplements by pregnant and lactating women in Mali. *Public Health Nutrition*, 8:33-37.

Ahmed F et al. (2005). Efficacy of twice-weekly multiple micronutrient supplementation for improving the hemoglobin and micronutrient status of anemic adolescent schoolgirls in Bangladesh. *American Journal of Clinical Nutrition*, 82:829-835.

Ashworth A (1998). Effects of intrauterine growth retardation on mortality and morbidity in infants and young children. *European Journal of Clinical Nutrition*, 52 (Suppl. 1):S34-S41.

Barber SL, Gertler PJ (2008). The impact of Mexico's conditional cash transfer program, Oportunidades, on birthweight. *Tropical Medicine and International Health*, 13:1-10.

Beard JL et al. (2005). Maternal iron deficiency anemia affects postpartum emotions and cognition. *Journal of Nutrition*, 135:267-272.

Binkin NJ et al. (1988) Birth weight and childhood growth. *Pediatrics*, 82:828-834.

Black RE et al. (2008). Maternal and child undernutrition: global and regional exposures and health consequences. *Lancet*, 371:243-260.

Brabin L, Verhoeff F, Brabin BJ (2002). Maternal height, birthweight and cephalo pelvic disproportion in urban Nigeria and rural Malawi. *Acta Obstetricia et Gynecologica Scandinavica*, 81:502-507.

Bryce J et al. (2008). Maternal and child undernutrition: effective action at the national level. *Lancet*, 371:510-526.

Carlson SE (2009). Docoshexanoic acid supplementation in pregnancy and lactation. *American Journal of Clinical Nutrition*. 89 (Suppl.):678S-684S.

Casanueva E et al. (2006). Adolecents with adequate birth weight newborns diminish energy expenditure and cease growth. *Journal of Nutrition*, 136:2498-2501.

Ceesay SM et al. (1997). Effects on birth weight and perinatal mortality of maternal dietary supplements in rural Gambia: 5 year randomised control trial. *British Medical Journal*, 315:786-790.

Chorghade GP et al. (2006). Why are Indian women so thin? Findings from a village in Maharashtra. *Public Health Nutrition*, 9:9-18.

Christian P, Khatry SK, West KP Jr (2004). Antenatal anthelmintic treatment, birthweight, and infant survival in rural Nepal. *Lancet*, 364:981-983.

Cole T (2000). Secular trends in growth. *Proceedings of the Nutrition Society*, 59:317-324.

Darmstadt GL et al. (2008). Saving newborn lives in Asia and Africa: cost and impact of phased scale-up of interventions within the continuum of care. *Health Policy Plan*, 23:101-117.

Demerath EW et al. (2004). Fifty-year trends in serial body mass index during adolescence in girls: the Fels Longi-tudinal Study. *American Journal of Clinical Nutrition*, 80:441-446.

Dewey KG, Huffman SL (2009). Maternal, infant, and young child nutrition: combined efforts to maximize impacts on child growth and micronutrient status. *Food and Nutrition Bulletin*, 30(Suppl. 2):S187-S189.

Fall CHD et al. (2009). Multiple micronutrient supplementation during pregnancy in low-income countries: a meta-analysis of effects on birth size and length of gestation. *Food and Nutrition Bulletin* 30:S533-S546.

Garn SM et al. (1986 Maturational timing as a factor in female fatness and obesity. *American Journal of Clinical Nutrition*, 43:879-883.

Garner P, Kramer MS, Chalmers I (1992). Might efforts to increase birthweight in undernourished women do more harm than good? *Lancet*, 340:1021-1023.

Gigante DP, Rasmussen KM, Victora CG (2005). Pregnancy increases BMI in adolescents of a population-based birth cohort. *Journal of Nutrition*, 135:74-80.

Gillespie S, Kevany J, Mason J (1991). *Controlling iron deficiency*. Geneva, UN System Standing Committee on Nutrition (SCN State of the Art Paper, No. 9).

Gopalan C (1987). General consideration in women and nutrition in India. In: Gopalan C, Suminder K eds. *Women and nutrition in India*. New Dehli, Nutrition Foundation of India, pp. 1-14.

Gupta P et al. (2007). Multimicronutrient supplementation for undernourished pregnant women and the birth size of their offspring: a double-blind, randomized, placebo-controlled trial. *Archives of Pediatrics and Adolescent Medicine*, 161:58-64.

Heikens GT et al. (2008). Nutrition interventions need improved operational capacity. *Lancet*, 371:181-182.

Helland IB et al. (2003). Maternal supplementation with very-long-chain n-3 fatty acids during pregnancy and lactation augments children's IQ at 4 years of age. *Pediatrics*, 111 (1):39-44.

Hininger I et al. (2004). Effects of a combined micronutrient supplementation on maternal biological status and newborn anthropometrics measurements: a randomized double-blind, placebo-controlled trial in apparently healthy pregnant women. *European Journal of Clinical Nutrition*, 58:52-59.

Huy ND et al. (2009). An effectiveness trial of multiple micronutrient supplementation during pregnancy in Vietnam: impact on birth weight and stunting in children at around two years of age. F*ood and Nutrition Bulletin*, 30 (Suppl. 4):S506-S516.

Huybregts L et al. (2009). Prenatal food supplementation fortified with multiple micronutrients increases birth length: a randomized controlled trial in rural Burkina Faso. *American Journal of Clinical Nutrition*, 90:1593-1600.

Jefferis BJ, Power C, Hertzman C (2002). Birth weight, childhood socioeconomic environment, and cognitive development in the 1958 British birth cohort study. *British Medical Journal*, 325:305.

Karlberg J (1989). A biologically oriented mathematical model (ICP) for human growth. *Acta Paediatrica Scandinavica*, 350 (Suppl.):70-94.

Kerber KJ et al. (2007). Continuum of care for maternal, newborn, and child health: from slogan to service delivery. *Lancet*, 370:1358-1369.

King J (2003). The risk of maternal nutritional depletion and poor outcomes increases in early or closely spaced pregnancies. *Journal of Nutrition*, 133:1732S-1736S.

Kost K, Henshaw S, Carlin L (2010). *Teenage pregnancies, births and abortions: national and state trends and trends by race and ethnicity*. Washington, Guttmacher Institute (http://www.guttmacher.org/pubs/USTPtrends.pdf www.guttmacher.org/pubs/USTPtrends.pdf, accessed 11 February 2010).

Kramer MS, Kakuma R (2003). Energy and protein intake in pregnancy. *Cochrane Database of Systematic Reviews*, (3):CD000032.

Kuklina EV et al. (2004). Growth and diet quality are associated with the attainment of walking in rural Guatemalan infants. *Journal of Nutrition*, 134:3296-3300.

Kurz K (1994). Adolescent growth. *SCN News*, 11:6-11.

Kurz KM, Galloway R (2000). Improving adolescent iron status before childbearing. *Journal of Nutrition*, 130:437S-439S.

Kusin JA et al. (1992). Energy supplementation during pregnancy and postnatal growth. *Lancet*, 340:623-626.

Lechtig A et al. (2009). Decreasing stunting, anemia and vitamin A deficiency in Peru: results of the Good Start to Life Program. *Food and Nutrition Bulletin*, 30:37-48.

Lechtig A, Shrimpton R (1987). Maternal nutrition: what relevance for child survival and development? In: Kretchmer N, Quilligan EJ, Johnson JD, eds. *Prenatal and perinatal biology and medicine. Vol. 1. Physiology and growth*. Chur, Harwood Academic Publishers, pp. 93-160.

Li H et al. (2003). Associations between prenatal and postnatal growth and adult body size and composition. *American Journal of Clinical Nutrition*, 77:1498-1505.

Lozoff B et al. (2006). Long-lasting neural and behavioral effects of iron deficiency in infancy. *Nutrition Reviews*, 64 (Suppl. 5):S34-S91.

Manandhar DS et al. (2004). Effect of a participatory intervention with women's groups on birth outcomes in Nepal: cluster-randomised controlled trial. *Lancet*, 364:970-979.

March of Dimes (2002). *Nutrition today matters tomorrow: report from the Task Force on Nutrition and Optimal Human Development* (http://www.marchofdimes.com/professionals/1926.asp, http://www.marchofdimes.com/professionals/1926.asp, accessed 22 July 2009).

Mardones F et al. (2008). Effects of a dairy product fortified with multiple micronutrients and omega-3 fatty acids on birth weight and gestation duration in pregnant Chilean women. *Public Health Nutrition*, 11:30-40.

Martorell R et al. (1998). Intrauterine growth retardation, body size, body composition and physical performance in adolescence. *European Journal of Clinical Nutrition* 52 (Suppl. 1):S43-S52.

Martorell R et al. (2010). Weight gain in the first two years of life is an important predictor of schooling outcomes in pooled analyses from five birth cohorts from low- and middle-income countries. *Journal of Nutrition*, 140:348-354.

Mason JB et al. (2002). Iodine fortification is related to increased weight-for-age and birthweight in children in Asia. *Food and Nutrition Bulletin*, 23:292-308.

Mendez MA, Monterio CA, Popkin BM (2005). Overweight exceeds underweight among women in most developing countries. *American Journal of Clinical Nutrition*, 81:714-721.

Moore AM et al. (2009). Adolescent marriage and childbearing in India: current situation and recent trends. New York, Guttmacher Institute (http://www.guttmacher.org, www.guttmacher.org, accessed 11 August 2009).

Mora JO et al. (1981). The effects of nutritional supplementation on physical growth of children at risk of malnutrition. American Journal of *Clinical Nutrition*, 34:1885-1892.

Morley D, Woodland M (1979). *See how they grow: monitoring child growth for appropriate health care in developing countries*. London, Macmillan Press (Macmillan Tropical Community Health Books).

Nahar S, Mascie-Taylor CG, Begum HA (2009). Impact of targeted food supplementation on pregnancy weight gain and birth weight in rural Bangladesh: an assessment of the Bangladesh Integrated Nutrition Program (BINP). *Public Health Nutrition*, 12:1205-1212.

Neufeld LM et al. (2004). Changes in maternal weight from the first to second trimester of pregnancy are associated with fetal growth and infant length at birth. *American Journal of Clinical Nutrition*, 79:646-652.

Newcombe R et al. (2007). Birthweight predicts IQ: fact or artefact? Twin Research and Human Genetics, 10:581-586.

Nishida C, Shrimpton R, Darnton-Hill I (2009). Landscape analysis on countries readiness to accelerate action in nutrition. *SCN News*, 37:4-9.

Ortolano SE et al. (2003). Effect of targeted food supplementation and services in the Bangladesh Integrated Nutrition Project on women and their pregnancy outcomes. *Journal of Health, Population and Nutrition*, 21:83-89.

Perez EM et al. (2005). Mother-infant interactions and infant development are altered by maternal iron deficiency anemia. *Journal of Nutrition*, 135:850-855.

Pojda J, Kelley L, eds (2000). *Low birthweight: report of a meeting in Dhaka, Bangladesh on 14-17 June 1999*. Geneva, Administrative Committee on Coordination of the UN/Sub Committee on Nutrition. and International Centre for Diarrhoeal Disease Research, Bangladesh (Nutrition Policy Paper No. 18).

Pollitt E et al. (1995). Nutrition in early life and the fulfillment of intellectual potential. *Journal of Nutrition*, 125 (Suppl. 4):1111S-1118S.

PRB (2010). World Population Highlights: Key findings from PRB's 2010 world population data sheet. *Population Bulleti*n, *65*: no. 2 (July 2010)

Priyosusilo A (1988). Health in the balance: the under-fives weighing program. *Indian Journal of Pediatrics*, 55 (Suppl.):S88-S99.

Pyle D et al. (1993). *We will never go back: social mobilization in the child survival and development programme in the United Republic of Tanzania*. New York, United Nations Children's Fund.

Rah JH et al. (2008). Pregnancy and lactation hinder growth and nutritional status of adolescent girls in rural Bangladesh. *Journal of Nutrition*, 138:1505-1511.

Raj A et al. (2009). Prevalence of child marriage and its effects on fertility and fertility-control outcomes of young women in India: a cross-sectional, observational study. *Lancet*, 373 (9678):1883-9. Epub 2009 Mar 9

Raj A et al. (2010). The effect of maternal child marriage on morbidity and mortality of children under 5 in India: cross sectional study of a nationally representative sample. *British Medical Journal*, 340:b4258. doi:10.1136/bmj.b4258.

Rao S et al. (2001). Intake of micronutrient-rich foods in rural Indian mothers is associated with the size of their babies at birth: Pune Maternal Nutrition Study. *Journal of Nutrition*, 131:1217-1224.

Rasmussen KM, Stoltzfus RJ (2003). New evidence that iron supplementation during pregnancy improves birth weight: new scientific questions. *American Journal of Clinical Nutrition*, 78:773-781.

Rees AM et al. (2009). Omega-3 deficiency associated with perinatal depression: case control study. *Psychiatry Research*, 30:166(2-3):254-259.

Richards, M et al. (2001). Birth weight and cognitive function in the British 1946 birth cohort: longitudinal population based study. *British Medical Journal*, 322:199-203.

Riley AP, Huffman SL, Chowdhury AK (1989). Age at menarche and postmenarcheal growth in rural Bangladeshi females. *Annals of Human Biology*, 16:347-359.

Ruowei L, Haas JD, Habicht J-P (1998). Timing of the influence of maternal nutritional status during pregnancy on fetal growth. *American Journal of Human Biology*, 10:529-539.

Schieve LA et al. (2000). Prepregnancy body mass index and pregnancy weight gain: associations with preterm delivery. The NMIHS Collaborative Study Group. *Obstetrics and Gynecology*, 96:194-200.

Scholl TO et al. (1994). Maternal growth during adolescent pregnancy. *Journal of the American Medical Association*, 274:26-27.

Scholl TO et al. (1997). Use of multivitamin/mineral prenatal supplements: Influence on the outcome of pregnancy. A*merican Journal of Epidemiology*, 146:134-141.

Scholl, TO et al. (2000). Leptin and maternal growth during adolescent pregnancy. *American Journal of Clinical Nutrition*, 72:1542-1547.

SCN (2000). *Fourth report on the world nutrition situation: nutrition throughout the life cycle*. Geneva, United Nations System Standing Committee on Nutrition.

SCN (2008). E*stablishing stunting as an additional indicator of endemic poverty to monitor progress made towards the achievement of MDG 1. Draft Statement from the Task Force on Assessment, Monitoring & Evaluation*. Geneva, United Nations System Standing Committee on Nutrition.

Semba R et al. (2008). Child malnutrition and mortality among families not utilizing adequately iodized salt in Indonesia. *American Journal of Clinical Nutrition*, 87:438-444.

Shenkin SD, Starr JM, Deary IJ (2004). Birth weight and cognitive ability in childhood: a systematic review. *Psychological Bulletin*, 130:989-1013.

Shrimpton R et al. (2001). Worldwide timing of growth faltering: implications for nutritional interventions. *Pediatrics*, May 107:e75.

Shrimpton R et al. (2009). Trends in low birthweight among the Bhutanese refugee population in Nepal. *Food and Nutrition Bulletin*, 30:Supp 2:S197-S206.

Siegel EH et al. (2005). Growth indices, anemia, and diet independently predict motor milestone acquisition of infants in south central Nepal. *Journal of Nutrition*, 135:2840-2844.

Smith GCS et al. (2002). Early-pregnancy origins of low birth weight. *Nature*, 417:916.

Soekarjo DD et al. (2004). Effectiveness of weekly vitamin A (10,000 IU) and iron (60 mg) supplementation for adolescent boys and girls through schools in rural and urban East Java, Indonesia. *European Journal of Clinical Nutrition*, 58:927-937.

Stoltzfus RJ et al. (2004). Low dose daily iron supplementation improves iron status and appetite but not anemia, whereas quarterly anthelminthic treatment improves growth, appetite and anemia in Zanzibari preschool children. *Journal of Nutrition*, 134:348-356.

Subramanian SV, Kawachi I, Smith GD (2009). Income inequality and the double burden of under and overnutriton in India. *Journal of Epidemiology and Community Health*, 61:802-809.

Tofail F et al. (2008). Effects of prenatal food and micronutrient supplementation on infant development: a randomized trial from the Maternal and Infant Nutrition Interventions, Matlab (MINIMat) study. *American Journal of Clinical Nutrition*, 87:704-711.

Torlesse H, Hodges M (2000). Anthelminthic treatment and haemoglobin concentrations during pregnancy. L*ancet*, 356:1083.

UNICEF (1990). *The nutrition strategy*. Document approved by the UNICEF Executive Board. New York, United Nations Children's Fund.

UNICEF (2001). *Early marriage: child spouses*. Florence, Innocenti Research Centre (Innocenti Digest, No 7).

UNICEF (2008). *The state of the world's children 2009.* New York, United Nations Children's Fund (Table 9, Child protection).

UNICEF/WHO (2004). *Low birthweight: country, regional and global estimates.* New York, United Nations Children's Fund.

Vaidya A et al. (2008). Effects of antenatal multiple micronutrient supplementation on children's weight and size at 2 years of age in Nepal: follow-up of a double-blind randomised controlled trial. *Lancet*, 371:492-499.

Victora CG et al. (2008). Maternal and child undernutrition: consequences for adult health and human capital. *Lancet*, 37:340-357.

Vir SC et al. (2008). Weekly iron and folic acid supplementation with counseling reduces anemia in adolescent girls: a large-scale effectiveness study in Uttar Pradesh, India. *Food and Nutrition Bulletin*, 29:186-194.

Vir V (1990). Editorial: adolescent growth in girls – the Indian perspective. *Indian Pediatrics*, 27:1249–1255.

Westhoff CF (2003). *Trends in marriage and early childbearing in developing countries.* Calverton, Maryland, ORC Macro (DHS Comparative Report, No. 5).

WHO (1995). *Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee*. Geneva, World Health Organization (WHO Technical Report Series, No. 854).

WHO (2004). *Reproductive health strategy.* Geneva, World Health Organization

WHO (2006a). *Promoting optimal fetal development. Report of a technical consultation*, Geneva, 25-27 November 2003. Geneva, World Health Organization.

WHO (2006b). Assessment of differences in linear growth among populations in the OWH Multicentre Growth Reference Study. *Acta Paediatrica*, 450 (Suppl.):56-65.

WHO (2009). *Landscape analysis on countries' readiness to accelerate action in nutrition.* Geneva, World Health Organization.

WHO/UNICEF (2004). F*ocusing on anemia: towards an integrated approach for effective anemia control.* Geneva, World health Organization.

Winkvist A, Habicht JP, Rasmussen KM (1998). Linking maternal and infant benefits of a nutritional supplement during pregnancy and lactation. American Journal of Clinical Nutrition 68:656-661. Erratum in: *American Journal of Clinical Nutrition*, 1999, 69:160.

Yip R, Scanlon K, Trowbridge F (1992). Improving growth status of Asian refugee children in the United States. J*ournal of the American Medical Association*, 267:937-940.

Zulfiqar AB et al. (2010). Countdown to 2015 decade report (2000-10): taking stock of maternal, newborn, and child survival. *Lancet*, 375:2032-2044.

CHAPTER 4

Adato M, Hoddinott J (2007). *Conditional cash transfer programs: a "magic bullet" for reducing poverty?* Washington, DC, International Food Policy Research Institute (2020 Focus Brief on the World's Poor and Hungry People). http://conferences.ifpri.org/2020Chinaconference/pdf/beijingbrief_adato.pdf

Alston JM et al. (2000). Research returns redux: a meta-analysis of the returns to agricultural R&D. *Australian Journal of Agricultural and Resource Economics*, 44:185-215.

Arimond M, Ruel MT (2004). Dietary diversity is associated with child nutritional status: evidence from 11 demographic and health surveys. *Journal of Nutrition*, 134:2579-2585.

Bolling C, Somwaru A (2001). US food companies access foreign markets through direct investment. *Food Review*, 24:23-28.

Checkley W et al. (2000). Effects of El Nino and ambient temperature on hospital admissions for diarrhoeal diseases in Peruvian children. *Lancet*, 355:442-450.

Cohen MJ et al. (2008). *Impact of climate change and bioenergy on nutrition*. Washington, DC, and Rome, International Food Policy Research Institute and Food and Agriculture Organization of the United Nations.

Commodity Online. India's green revolution that bypassed pulses (www.commodityonline.com, accessed 18 March 2010).

Confalonieri U et al. (2007). Human health. In: Parry ML et al. (eds) *Climate change 2007: impacts, adaptation, and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge and New York, Cambridge University Press, pp. 391-431.

Doak CM et al. (2005). The dual burden household and the nutrition transition paradox. *International Journal of Obesity*, 29:129 (136).

Easterling WE et al. (2007). Food, fibre and forest products. In: Parry ML et al. (eds) Climate change 2007: impacts, adaptation, and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge and New York, Cambridge University Press, pp. 273-314.

FAO (1972). *Food composition table for use in east Asia*. Rome, Food and Agriculture Organization of the United Nations.

FAO (1998). *Domestication and commercialization of non-timber forest products in agroforestry systems*. Rome, Food and Agriculture Organization of the United Nations.

FAO (2003). *Future climate change and regional fisheries: a collaborative analysis*. Rome, Food and Agriculture Organization of the United Nations (FAO Fisheries Technical Paper, No. 452).

FAO (2004a). *The state of food insecurity in the world 2004*. Rome, Food and Agriculture Organization of the United Nations.

FAO (2004b). *The state of food and agriculture in the world 2004*. Rome, Food and Agriculture Organization of the United Nations.

FAO (2006a). *The double burden of malnutrition: case studies from six developing countries*. Rome, Food and Agriculture Organization of the United Nations.

FAO (2006b). *Livestock's long shadow*. Rome, Food and Agriculture Organization of the United Nations.

FAO (2008a). *The state of food and agriculture in the world, 2008*. Rome, Food and Agriculture Organization of the United Nations.

FAO (2008b). *Wheat killer detected in Iran*. Rome, Food and Agriculture Organization of the United Nations (Press Release, 5 March).

FAO (2008c). *The state of food insecurity in the world 2008*. Rome, Food and Agriculture Organization of the United Nations.

FAO (2009a). *Imagine: achieving food security in times of crisis*. Rome, Food and Agriculture Organization of the United Nations.

FAO (2009b). *State of food insecurity in the world, 2009*. Rome, Food and Agriculture Organization of the United Nations.

FAO (2009c). *Hunger in the face of crisis: global economic slowdown underscores urgency of addressing long-term challenges*. Rome, Food and Agriculture Organization of the United Nations (Economic and Social Perspectives Policy Brief, No. 6).

FAO (2009d). *Crop prospects and food situation, No. 3, July 2009*. Rome, Food and Agriculture Organization of the United Nations.

FAO (2009e). *Food outlook preview: global market analysis, June 2009*. Rome, Food and Agriculture Organization of the United Nations.

FAO (2009f). *The investment imperative. Issue brief for the World Summit on Food Security*. Rome, Food and Agriculture Organization of the United Nations.

FAO (2009g). *Food outlook: global market analysis for cassava, November 2008*. Rome, Food and Agriculture Organization of the United Nations.

FAO (2009h). *Food outlook preview: market indicators and food import bills, June 2009*. Rome, Food and Agriculture Organization of the United Nations.

FAO (2009i). *Global information and early warning system on food and agriculture: countries in crisis requiring external assistance*. Rome, Food and Agriculture Organization of the United Nations.

FAO (2009j). *Pesa Centroamerica: Programma Especial Para la Seguridad Alimentaria – Special Food Security Program*. Rome, Food and Agriculture Organization of the United Nations.

FAO (2010a). *State of food insecurity in the world*, 2009. Rome, Food and Agriculture Organization of the United Nations.

FAO (2010b). *The state of food and agriculture 2009: livestock in the balance*. Rome, Food and Agriculture Organization of the United Nations.

FAO-ILSI (1997). *Preventing micronutrient malnutrition: a guide to food-based approaches*. Washington, DC, International Life Sciences Institute.

Hawkes C (2002). Marketing activities of global soft drink and fast food companies in emerging markets. In: *Globalization, diets and noncommunicable diseases*. Geneva, World Health Organization.

Hawkes C (2005). The role of foreign direct investment in the nutrition transition. *Public Health Nutrition*, 8:357-365.

Horton S et al. (2010). *Scaling up nutrition: what will it cost?* Washington, DC, World Bank.

Horton S, Ross J (2003). The economics of iron deficiency. *Food Policy*, 28:51-75.

IAASTD (2009). *Agriculture at a crossroads: global report*. Washington, DC, International Assessment of Agricultural Knowledge, Science and Technology for Development.

IASC (2009). *Climate change, food insecurity and hunger: key messages submitted for UNFCCC negotiators*. Geneva, Inter-Agency Standing Committee (Technical Paper of the IASC Task Force on Climate Change).

IFPRI (2006). *Understanding the links between agriculture and health: urban agriculture and health – 2020 vision for food, agriculture and the environment*. Washington, DC, International Food Policy Research Institute (IFPRI Brief, No. 13).

IFPRI (2009). *Climate change: impact on agriculture and costs of adaptation*. Washington, DC, International Food Policy Research Institute.

IMF (2009). *World economic outlook: crisis and recovery*. Washington, DC, International Monetary Fund.

Kuhnlein H, Johns T (2003). Northwest African and Middle Eastern food and dietary change of indigenous peoples. *Asia Pacific Journal of Clinical Nutrition*, 12:344-349.

Low JW et al. (2007). A food-based approach introducing orange-fleshed sweet potatoes increased vitamin A intake and serum retinol concentrations in young children in rural Mozambique. *Journal of Nutrition*, 137:1320-1327.

Mattson J, Koo WW (2002). *US processed food exports and foreign direct investment in the western hemisphere*. North Dakota, North Dakota State University.

McMichael A et al. (2004). Global climate change. In: Ezzati M et al. (eds) *Comparative quantification of health risks: global and regional burden of disease due to selected major risk factors. Vol. 2*. Geneva, World Health Organization, pp. 1543-1649.

Mendez M, Monteiro C, Popkin BM (2005). Overweight exceeds underweight among women in most developing countries. *American Journal of Clinical Nutrition*, 81:714-721.

Mendez MA, Popkin BM (2004). Globalization, urbanization and nutritional change in the developing world. *Journal of Agricultural and Development Economics*, 1:220-241.

Parry ML, et al. (2009). *Climate change and the risk of hunger: the scale of the challenge and required response*. Rome, World Food Programme.

Popkin BM, Gordon-Larsen P (2004). The nutrition transition: worldwide obesity dynamics and their determinants. *International Journal of Obesity*, 28:S2–S9.

Popkin BM, Horton S, Kim S (2001). *The nutritional transition and diet-related chronic disease in Asia: implications for prevention*. Washington, DC, International Food Policy Research Institute (Discussion Paper, No. 105).

Save the Children UK (2009a). *Snapshot of the SPSNP Programme in Sekota and Gubalafto Woredas, Amhara Region, Ethiopia*. Unpublished document.

Save the Children UK (2009b). *How cash transfers can improve the nutrition of the poorest children: evaluation of a pilot safety net project in southern Niger*. Unpublished document.

SCN (2006). *Double burden of malnutrition: a common agenda. 33rd Annual Session, Geneva, Switzerland, 13-17 March 2006*. Geneva, United Nations Standing Committee on Nutrition.

Shakir M (2006a). *Repositioning nutrition as central to development*. Washington, DC, World Bank.

Shakir M (2006b). *Better nutrition = less poverty*. Washington, DC, World Bank.

Shrimpton R, Prudhon C, Engesveen K (2009). The impact of high food prices on maternal and child nutrition. *SCN News*, 37:60-68.
Thompson B (2006). Community centred food-based strategies for alleviating and preventing malnutrition. Paris, United Nations Educational, Scientific and Cultural Organization. In: Impacts of Agriculture on Human Health and Nutrition, edited by Cakmak, I. and Welch, R.M., in Encyclopaedia of Life Support Systems (EOLSS), developed under the auspices of the UNESCO, Eolss Publishers, Oxford, UK, http://www.eolss.net

UNEP (2007). *Global environmental outlook: environment for development*. Nairobi, United Nations Environment Programme (GEO-4).

UNEP (2009). *The environmental food crisis: the environment's role in averting future food crises. A UNEP rapid response assessment*. Nairobi, United Nations Environment Programme.

UNICEF (2009). Tracking progress on child and maternal nutrition: a survival and development priority. New York, United Nations Children's Fund.

UN Economic and Social Council (1999). *Substantive issues arising in the implementation of the International Covenant on Economic, Social and Cultural Rights*. General Comment 12, Article 11: The right to adequate food. Geneva, United Nations.

UN Population Division (2009a). *World population prospects: the 2008 revision highlights*. New York, United Nations Department of Economic and Social Affairs.

UN Population Division (2009b). *What would it take to accelerate the fertility decline in the least developed countries?* New York, United Nations Department of Economic and Social Affairs (UN Population Division Policy Brief, No. 2009/1).

UN Population Division (2009c). *World urbanization prospects: the 2007 revision population database*. New York, United Nations Department of Economic and Social Affairs.

US International Trade Commission (2001). *Processed foods and beverages: a description of tariff and non-tariff barriers for major products and their impact on trade volume. Vol. 1*. Washington, DC, US Trade Commission.

Viatte G et al. (2009). *Responding to the food crisis: synthesis of medium term measures proposed in inter-agency assessments*. Rome, Food and Agriculture Organization of the United Nations.

Von Grebmer K et al. (2009). 2009 global hunger index: the challenge of hunger (focus on financial crisis and gender inequality. Washington, DC, International Food Policy Research Institute.

Wargiono N, Richana N, Hidajat A (2002). Contribution of cassava used as a vegetable to improve human nutrition in Indonesia. 7th Regional Cassava Workshop. ADD PLACE OF PUBLICATION, International Center for Tropical Agriculture.

Wei A, Cacho J (2001). Competition among foreign and Chinese agro-food enterprises in the process of globalization. *International Food and Agribusiness Management Review*, 2:437-451.

World Bank (2008). *World development report 2008: agriculture for development*. Washington, DC, World Bank.

World Bank/IFPRI (2007). *From agriculture to nutrition: pathways, synergies and outcomes*. Washington, DC, World Bank.

ANNEX

ACC/SCN (1992). *Second report on the world nutrition situation.* Geneva, United Nations Sub Committee on Nutrition.

ACC/SCN (1993). *Second report on the world nutrition situation: Volume II Country Trends, Methods, and Statistics.* Washington, DC, United Nations Sub Committee on Nutrition.

Blanc A, Wardlaw T (2005). Monitoring low birth weight: an evaluation of international estimates and an updated estimation procedure. *Bulletin of the World Health Organization,* 83: 178-185.

de Onis M, Blössner M (2003). The World Health Organization global database on child growth and malnutrition: methodology and applications. *International Journal of Epidemiology,* 32:518-526.

de Onis M et al. (2004a). Estimates of global prevalence of childhood underweight in 1990 and 2015. *Journal of the American Medical Association*, 291:2600-2606.

de Onis M et al. (2004b). Methodology for estimating regional and global trends of child malnutrition.

International Journal of Epidemiology, 33:1260-1270.
Mason J, Rivers J, Helwig C (2005). Recent trends in malnutrition in developing regions: vitamin A deficiency, anemia, iodine deficiency, and child underweight. *Food and Nutrition Bulletin*, 26 (1):1-110.

Mason J et al. (2001). *The micronutrient report: current progress and trends in the control of vitamin A, iodine, and iron deficiencies.* Ottawa, International Development Research Center.

Philippines FNRI (2001). *Philippine nutrition: facts and figures.* Taguig, Philippines, Food and Nutrition Research Institute.

SCN(2004) *Fifth report on the world nutrition situation: Nutrition for improved development outcomes.* Geneva: UN System Standing Committee on Nutrition

UNICEF (2007). *Progress for children: a world fit for children statistical review.* New York, United Nations Children's Fund.

WHO (1992). *Low birth weight: a tabulation of available information.* Geneva, World Health Organization (WHO/MCH/92.2).

WHO (2001). *Assessment of the iodine deficiency disorders and monitoring their elimination.* Geneva, World Health Organization (WHO/NHD/01.1).

WHO (2004). *Iodine status worldwide: WHO global database on iodine deficiency.* Geneva, World Health Organization.

WHO Multicentre Growth Reference Study Group. (2006). WHO Child Growth Standards: Length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: Methods and development. Geneva: World Health Organization; pp 312. Available at: http://www.who.int/childgrowth/publications/en/

WHO (2008). *Worldwide prevalence of anaemia 1993-2005: WHO global database on anaemia.* Geneva, World Health Organization.

WHO (2009). *Global prevalence of vitamin A deficiency in populations at risk 1995-2005: WHO global database on vitamin A deficiency.* Geneva, World Health Organization.

Yang H, de Onis M (2008). Algorithms for converting estimates of child malnutrition based on the NCHS reference into estimates based on the WHO child growth standards. *BMC Pediatrics,* 8:19 doi:10.1186/1471-2431-8-19.

Data sources

DHS STATCompiler (available at: http://www.statcompiler.com accessed 3 March 2009).

FAO country nutrition profiles (available at: http://www.fao.org/ag/agn/nutrition/profiles_by_country_en.stm accessed March 2009).

Most data come from this source, except where otherwise indicated. UN Statistics Division *World Development Indicators* (available at: http://data.un.org/Explorer.aspx, accessed 3 March 2009).

UN Statistics *Division World Population Prospects* (available at: http://data.un.org/Explorer.aspx accessed 3 March 2009).

UNICEF Low birth weight incidence by country (2000-2007). Available at: http://www.childinfo.org/low_birthweight_profiles.php accessed 3 March 2009.

UNICEF global database on iodized salt consumption (available at: http://www.childinfo.org/idd_profiles.php accessed 6 February 2009).

WHO global database on body mass index (BMI) (available at: http://apps.who.int/bmi/index.jsp accessed 3 March 2009).

WHO global database on child growth and malnutrition (available at: http://www.who.int/nutgrowthdb/en/ accessed 9 October 2009).

WHO global database on iodine deficiency (available at: http://www.who.int/vmnis/iodine/data/en/index.html accessed 6 February 2009).

WHO Anthro for personal computers: software for assessing growth and development of the world's children (version 3) (available at: http://www.who.int/childgrowth/software/en/ accessed 30 October 2009).

World Bank *World Development Indicators* (available at: http://ddp-ext.worldbank.org/ext/DDPQQ/member.do?method=getMembers&userid=1&queryId=135 accessed 3 March 2009).

Reports on the world nutrition situation

- 5th report on the world nutrition situation, March 2004
- 4th report on the world nutrition situation, January 2000
- 3rd report on the world nutrition situation, December 1997
- Update on nutrition situation, November 1996
- Update on nutrition situation, November 1994
- 2nd report on the world nutrition situation, volume II, country data, March 1993
- 2nd report on the world nutrition situation, volume I, global and regional results, October 1992
- Update on the world nutrition situation, January/February 1989
- Supplement on methodes and statistics to the first report on the world nutrition situation, December 1988
- 1st report on the world nutrition situation, November 1987

United Nations System

Standing Committee on Nutrition

This Sixth report on the world nutrition situation by the United Nations System Standing Committee on Nutrition (UNSCN) is part of a series of UNSCN publications reporting on trends in nutrition.

By analysing trends in vitamin A deficiency, iodine deficiency disorders, anaemia, underweight and stunting, as well as low birth weight, the report shows that progress is being made but, in some regions, not fast enough to reach the targets set for the Millennium Development Goals.

Lack of gender equality puts women at risk when food supplies are inadequate. This is especially serious in regard to maternal nutrition, because the health of infants and children is strongly linked to the quality and quantity of the food their mothers consumed before and during pregnancy.

Neglecting maternal nutrition will perpetuate the intergenerational cycle of growth failure.

This report calls for renewed attention to maternal nutrition, not only to turn the intergenerational cycle of growth failure into a virtuous one, but also for the mothers' own health and development.

The report suggests ways to realize the human right to adequate food, focusing on local food production and maintaining agricultural diversity. At a time when human achievements are being threatened by economic and climatic crises, ensuring adequate food and nutrition is more important than ever.

The information provided in this report will help policy-makers, public health officials, nutritionists and others act effectively and collectively to speed progress towards the achievement of the Millennium Development Goals.

Previous reports on the world nutrition situation, as well as Nutrition Policy Papers, can be obtained from:

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