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 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. 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.

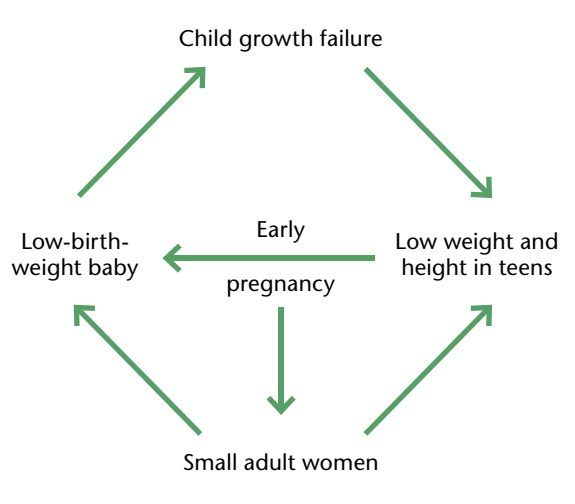
Preventing too early pregnancies is of the highest priority. This programmatic area should include sex education and family planning services for adolescents in order to reduce teenage pregnancy rates. This will be facilitated by a more enabling societal environment, where community norms and values 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?

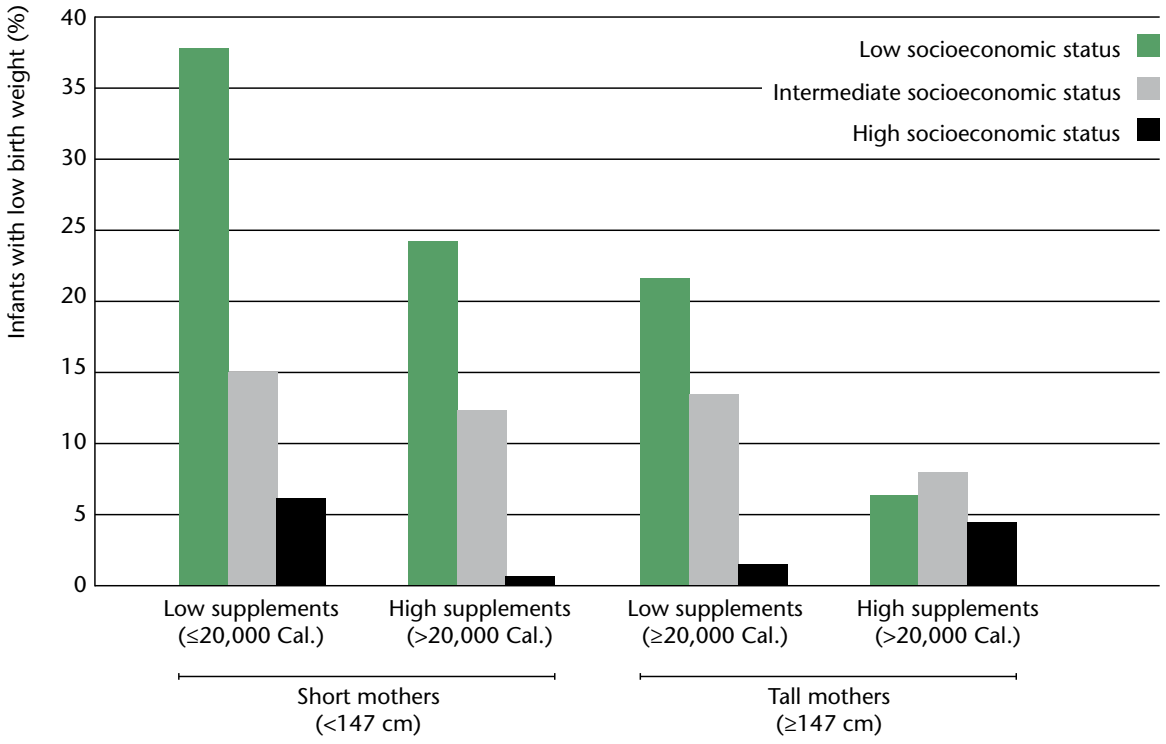
CAN BIRTH WEIGHT BE IMPROVED QUICKLY BY IMPROVING MATERNAL NUTRITION, EVEN IN SMALL ADULT WOMEN?

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?

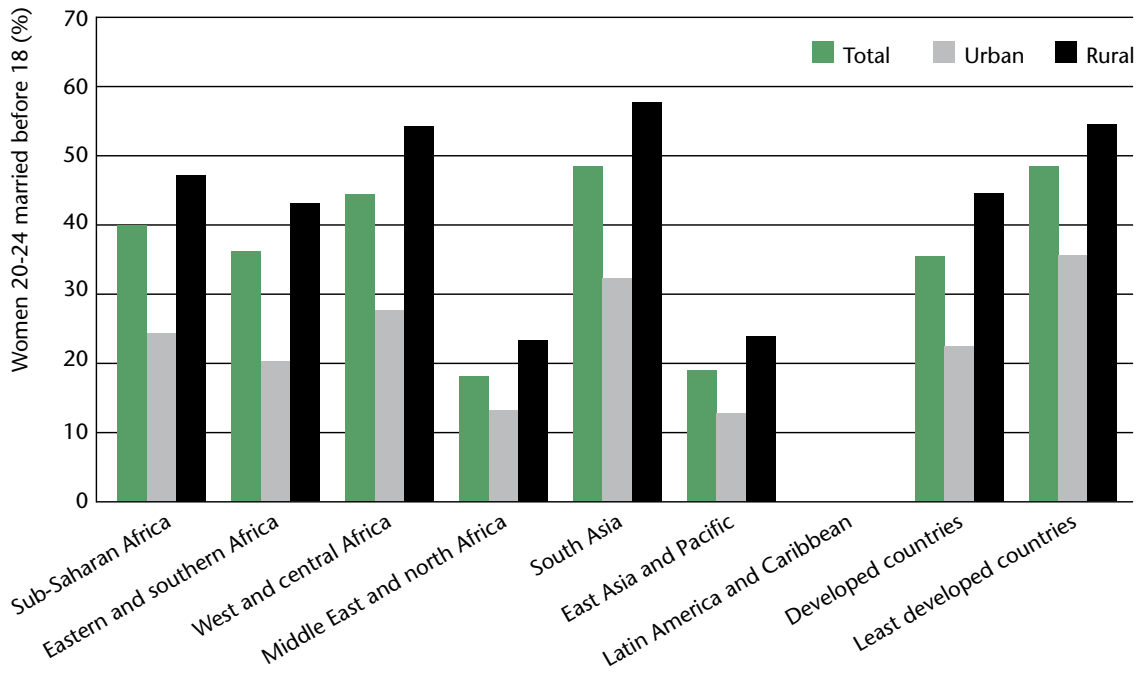
The major reason for low birth weight in babies of adolescent mothers is that pregnancy occurs before the woman is full grown. Small mothers have lower-birth-weight babies than taller mothers, and this is compounded in adolescents by an immature uterine and hormonal environment. Therefore, the best way 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.

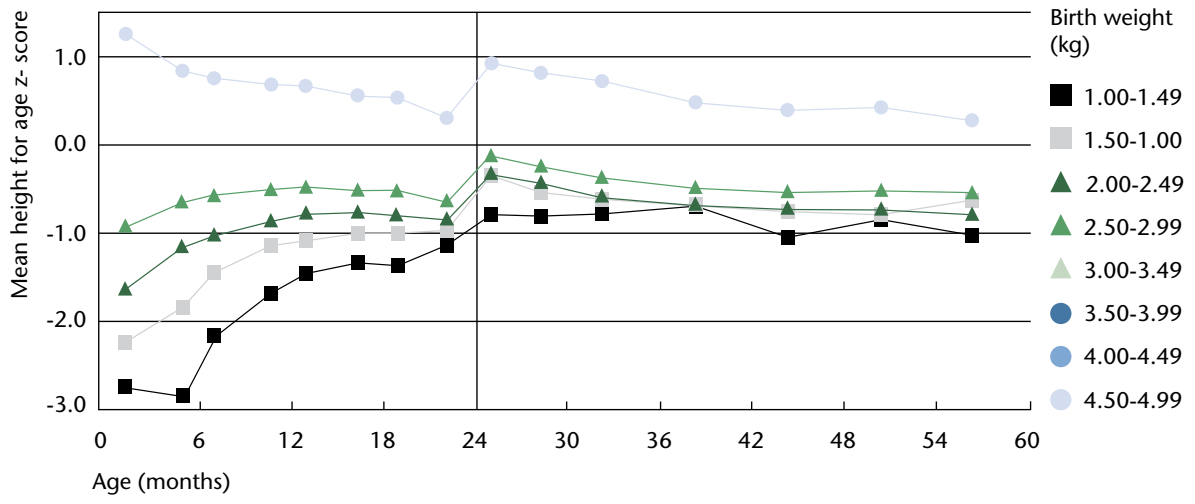
WHAT EFFECT DOES IMPROVED BIRTH WEIGHT HAVE ON CHILD GROWTH FALTERING, INTELLECTUAL DEVELOPMENT AND FINAL ADULT HEIGHT?

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.

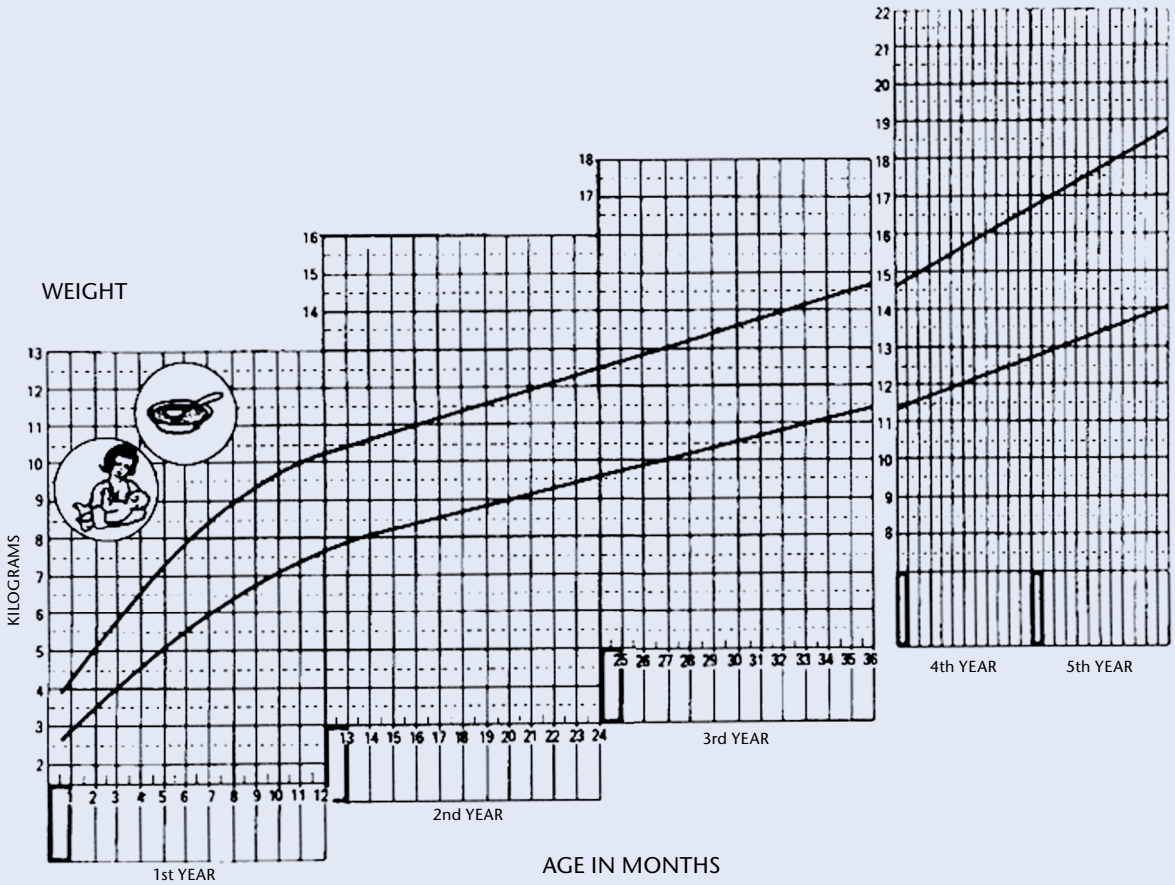
Part of the reason why there has been so little progress in maternal nutrition is because the priority focus has been placed on interventions that produce short-term gains in child survival. The central platform of the UNICEF child survival and development approach in the 1980s and 1990s was community-based 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



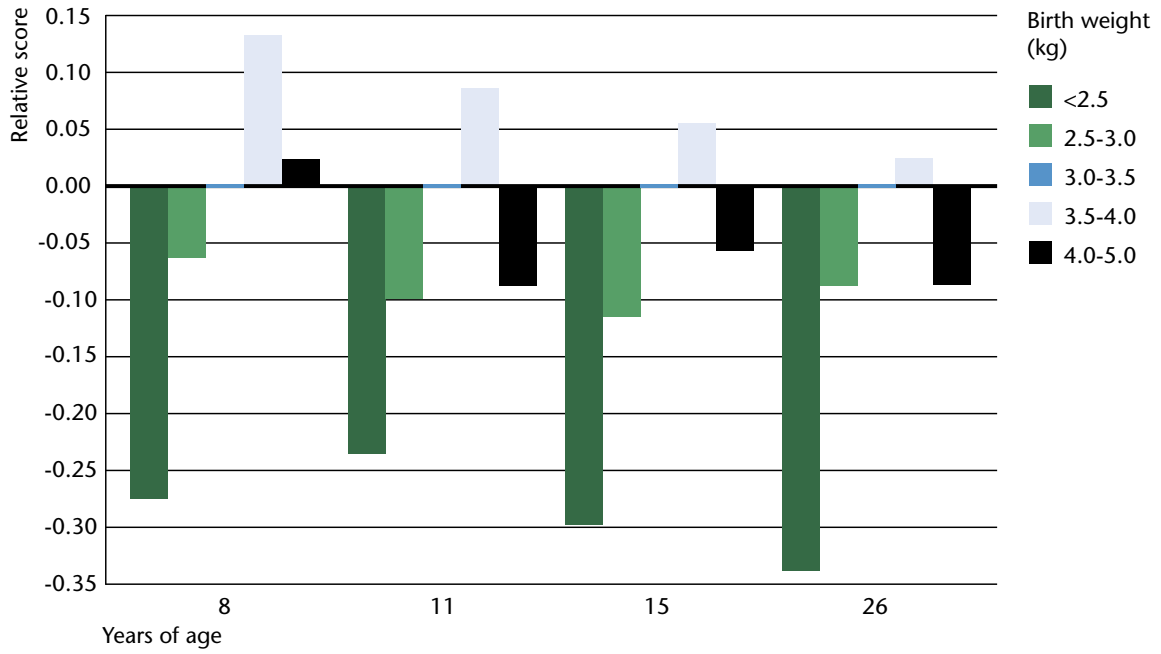
Source: Morley & Woodland (1979).

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.