THE DOUBLE BURDEN OF MALNUTRITION

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**EXECUTIVE SUMMARY**

The Double Burden of Malnutrition (DBM) is a recent concept recognizing the coexistence of both undernutrition and overnutrition in the same population across the life course. Indeed most governments have populations that are subject to both “excesses” and “deficiencies” of nutrients and therefore need programmes to be able to deal with both. The DBM concept also recognizes that undernutrition early in the life course contributes to an increased propensity for overnutrition in adulthood. The DBM affects all countries, rich and poor. At the individual level the most common form of DBM seems to be energy overnutrition and iron deficiency, which is found even in the USA. At the population level women are most affected by DBM, with most countries having more overweight than underweight women. The prevalence of DBM at the household level, with stunted children coexisting with overweight/obese women, is generally below 10% and is mostly commonly found in Latin American countries. Definitions of overweight and obesity are defined based on the relationship with risk of diseases, and the risk of mortality and morbidity increases considerably above a BMI of 25. This varies by region however, and may be as low as 21 among Asians. Visceral obesity, best measured by waist circumference, is of particular concern with regard to the development of insulin resistance or type 2 diabetes.

The consequences of the DBM are enormous. Early life undernutrition is an underlying cause associated with about a third of young child deaths. Among the survivors that become stunted in the first two years of life, their capacity to resist disease, to carry out physical work, to study and progress in school, are all impaired across the life course. Later in the life course, diet and nutrition, and especially obesity, are important underlying causes of many non-communicable diseases (NCDs) including hypertension, diabetes, cancer, stroke, and ischemic heart disease. NCDs are responsible for the majority of deaths worldwide and are disproportionately high in LMICs where nearly 80% of NCD deaths occur. Nearly half of NCD deaths in 2008 were caused by cardiovascular disease (CVD). The metabolic syndrome, in which abdominal obesity and type 2 diabetes play a central role, is associated with a doubling of cardiovascular disease risk. The costs of treating the metabolic syndrome are considerable and growing, consuming increasingly larger proportions of health budgets in both LMICs, and higher income countries.

The causes of the DBM are related to a series of changes going on in the world called the *nutrition transition*, which includes the *demographic transition* and the *epidemiological transition* of countries. A similar transition, called the “secular trend” has occurred at a more leisurely pace during the last two centuries in the rich or “developed” countries, causing *inter-generational* increases in height of about 1cm a decade. In the last two decades, and especially in the more prosperous LMICs, this process of change seems to have speeded up due to the global obesity epidemic, and is now occurring in most LMICs as *intra-generational* changes. The variables associated
with the nutrition transition and obesity epidemic can be grouped into four cross cutting themes, which include:

1) The Health/Biological Environment has seen the global population triple in the last five decades, suffering a demographic transition with falling fertility and populations getting older, associated with an epidemiological transition as NCDs replace infectious diseases as the main cause of death. Increasing proportions of those that survive constrained foetal and young child growth have increased potential for adiposity later in the life course, with a greater risk of CVD. This so called “metabolic programming” or “thrifty phenotype” phenomenon seems especially common in Asians, and seems to be of greater importance than any possible “thrifty genotype”. The food transition described below also means that people with constrained early child growth are more likely to lay down fat later in the life course, especially if they find themselves in a more “obesogenic” environment.

2) The Economic/Food Environment has seen incredible increases in both individual wealth as well as food production. Global economic activity grew fifty times and individual wealth ten times in the last century. Food production grew 20% more than population growth, largely due to the “green revolution” together with the industrialization and globalization of the food chain. With global trade in food now amounting to 10% of all global trade, consumption patterns are becoming increasingly “westernized” across the globe. A third of the total cereal production is now used to feed livestock, with meat and milk consumption doubling in LMICS in the three decades to 2000. The vast majority (around 80%) of the global population is reliant on just four staple foods, namely wheat, rice, maize and potatoes, which are transformed into thousands of processed foods, the majority of which can be eaten directly or with little preparation. The saturated fat and refined sugar content of processed foods makes them considerably more “obesogenic” than unprocessed foods. This food transition, whereby an increasing proportion of the diet comes from animal and/or “ultra-processed” foods, is being accelerated by a radical change in the global food marketing and distribution system, led by supermarket chains penetrating into LMICs. Trade liberalization through WTO has facilitated these changes, while allowing subsidies in the EU and USA to keep processed food prices low. LMICs, and especially the food dependent ones, are most affected by the recent hikes in food prices however, and the consumption of processed foods more likely to increase in consequence. In the industrialized countries obesity is a disease of poverty, in part because “healthy diets” are the most expensive ones. Many now question the efficiency of the current global food system, which is not only harmful in terms of its health effects, but also negatively impacts on global warming and the sustainability of development.

3) The Physical/Built Environment includes factors influencing individual activity behaviour, as well as the type, frequency and intensity of activity.
Already a half of the global population is urban. With urbanization people expend less energy at work and in the home. They are also increasingly away from their home and dependent on purchasing their food either in the street or a restaurant, which is likely to be ultra-processed and easy to prepare/consume. Space to exercise in, be it through walking, biking or playing games, may be difficult to find, especially in the poorer urban districts.

4) The Socio/Cultural Environment includes the influence of media, education, peer pressure or culture and how these affect a person’s individual drive for particular foods and consumption patterns, or physical activity patterns or preferences. The food industry spends US$40 billion a year on advertising, and most of which promotes the consumption of ultra-processed foods. Transnational soft drink and fast food companies market their products extensively worldwide, especially to children and youths.

The solutions for the DBM problems are reasonably well recognized in each of its parts, but not pulled together in any way into an overarching policy and programme framework. The principal body which provides policy guidance is the World Health Assembly (WHA) of the World Health Organization (WHO). Normative policy guidance in food safety is provided jointly by WHO and FAO through the Codex Alimentarius Commission. There are many policy recommendations from WHO for maternal and child undernutrition, albeit split up by nutrient and/or intervention focus, with recommendations on breastfeeding, complementary feeding, and anaemia control for example. There are also policy recommendations on nutrient intake and physical activity, with agreed goals for nations to pursue with regard to overnutrition. There are agreed action plans for tackling NCDs, but that include obesity as a risk factor not as an NCD. Most recently the WHA has urged all member states to scale up programmes to control malnutrition in all of its forms.

While many countries, perhaps a half, have policies for undernutrition as well and overnutrition as well as diet related non-communicable diseases, the existence of programmes for these conditions that are adequately funded and being implemented at scale is far less common. The provision of programme guidance for the DBM is again extremely fragmented, with no overarching framework guiding implementation. There is a growing global movement called SUN, which aims to help LMICs scale up nutrition programmes in order to tackle maternal and child undernutrition. This movement should be built upon and strengthened over time to include the other elements of programmes of tackling the DBM across the life course. Tackling MCU is the first step in preventing the DBM. A framework is proposed which describes the evidence for direct and indirect programme interventions for both over and undernutrition at different stages of the life course. The interventions include those to be delivered directly through the health service, through the education system, as well as in the workplace, as well as indirectly by fiscal policies and financial incentives.
The capacity to deliver the wide variety of interventions for tackling the DBM and the governance mechanisms for ensuring that the multi-sectoral programme are limited in most countries however. The capacity to act in nutrition is recognized to be very limited in most LMICs, and what little there is, is restricted to undernutrition and limited to the health service. Both the SUN movement and the programmes needed to tackle the DBM require a multisectoral approach, which will be difficult to implement successfully unless high level coordination mechanisms are in place with capacity to allocate budgets to participating sectors. Nutrition governance mechanisms may exists in some LMICs, but few if any of them approve budgets and have any real authority. No country seems to have governance mechanisms for nutrition that cover the DBM, and include all aspects including, food security, food safety as well as nutrition and diet related communicable diseases. The SUN Framework, which calls for a coordinated, multi-stakeholder approach, with true country ownership with one policy framework, and one national coordinating body, need consolidating over time to embrace the DBM in LMICs. A nutrition policy framework for the DBM is described, even though it is realized that no country yet seems to have achieved this level of organizational complexity.
1. INTRODUCTION

The aim of this document is to assess the global evidence for the Double Burden of Malnutrition (DBM). The DBM concept, first presented as a “new paradigm” just over a decade ago, is the coexistence of under-nutrition and over-nutrition in the same population. Separating the treatment and/or prevention of “deficiencies” and “excesses” was no longer considered to be sensible, as it was realized that most countries now had to deal with both problems. In addition to which, new evidence suggested that linkages across the life course meant that maternal and foetal undernutrition increases a population’s susceptibility to overnutrition and diet related non communicable diseases in adulthood. Because the DBM is linked to the burgeoning noncommunicable diseases (NCD) problem threatening all Low and Middle Income Countries (LMICs), there has been a call for countries to tackle the DBM as “one agenda”. Furthermore because of links with global warming and the achievement of sustainable development, the DBM is incredibly topical and of relevance in most countries.

But after a decade, what more do we know about the DBM? What exactly is it and how do you measure it? Who is most affected and what are its consequences? What are its causes and what experience is there about how to prevent it and mitigate its consequences across the life course? Furthermore what capacity do countries need to have to try to deal with the DBM problem? These are some of the questions that this paper tries to answer.

2. WHAT IS THE DOUBLE BURDEN OF MALNUTRITION?

Malnutrition refers to nutritional excesses as well as deficiencies, with undernutrition the result of insufficient intake, poor absorption and/or poor biological use of the nutrients, which can result in impaired body functions, impaired growth and underweight. Overnutrition is the result of excess or imbalanced nutrient intakes, which can also result in impaired body functions as well as overweight and/or obesity.

Although the DBM terminology is commonly used to mean just underweight and overweight (deficiency and excess of energy derived from macronutrients), it also includes deficiencies and excesses of micronutrients. The DBM problem is the coexistence of over and undernutrition, be it in the individual, the family or household, or at the national population level.

For many decades the term “malnutrition” has commonly but wrongly been used to mean under-nutrition. This misnomer derives from the early focus of nutrition research efforts on determining the causes of protein calorie malnutrition (PCM), as child undernutrition was then called. Indeed the term malnutrition is still commonly used by many agencies such as UNICEF, WHO and FAO to mean undernutrition, as that is what many agencies are focused on for a multitude of reasons, not least of which being
funding. While most donors are able to find funds for undernutrition, funding for overnutrition is often more difficult. The common understanding of the problem of overnutrition, or more specifically overweight and obesity, is that this is seen as an issue of personal choice and not an area that requires much state intervention.

The life-cycle dimension of the DBM is an important one since it is increasingly recognized that nutritional insults during the critical periods of foetal and young child development produce lifelong consequences. Adult height is largely determined by height at two years of age, with average child height growth after the second year of age being the same in all populations. Furthermore differences in child growth seen across populations are primarily due to environmental differences not genetic ones, and constrained growth early in the life seems to favour increased adiposity later in life in an environment where energy availability is not constrained.

In most developed countries a secular trend has been observed over the last century or more, in which final adult height has increased by around 1cm a decade as living conditions improved, especially in upper income groups. However the secular trend has now ceased in the USA with adult height decreasing and the population going from being the tallest in the world to being among the most overweight. The obesity epidemic has developed only recently in industrialized countries, as obesity rates were generally well below 10% prior to 1980. Since then, rates have doubled or tripled in many countries, and in almost half of OECD countries 50% or more of the population is overweight.

In most LMICs the DBM is associated with an increasingly faster transition in the factors that affect growth across the life course. The factors causing these effects are doing so within the same generation, or are intra-generational, i.e. being compressed within the same generation, with final adult height and overweight/obesity both increasing simultaneously, although the latter is increasing faster.

3. Who does the Double Burden of Malnutrition affect most?

The DBM affects all countries, not just Low and Middle Income Countries (LMICS). While 25% of the global population are overweight, 33% still suffer from iodine deficiency, 40% of women of reproductive age have anaemia, and 17% of pre-school children are underweight. These nutritional problems are not simply divided between rich and poor countries however, with over-nutrition and under-nutrition coexisting in most countries, and especially in Asia. Furthermore over-weight seems to be increasing faster than under-weight decreases in most LMICS, such that while obesity has doubled globally in the last three decades, it has tripled in LMICs in just two decades.

At the population level the DBM is most commonly found among women. The proportion of overweight women exceeds the proportion of underweight women in most
developing countries, both in urban and rural populations\textsuperscript{20}. Furthermore, as national income increases, the burden of obesity tends to shift towards lower socio-economic groups, with this shift occurring at a lower level of income for women than men\textsuperscript{21}. The cross over to higher rates of obesity than of underweight among women of low SES groups is found at a GNP per capita of about US$2500, the mid-point value for LMICs. In high income countries obesity is more common in the lower socioeconomic strata of society. A decade ago obesity in women was considered to be a serious problem in all regions of the world except sub-Saharan Africa, China and South Asia\textsuperscript{22}. Although the prevalence of underweight among women has remained high in Bangladesh, Nepal and India, the prevalence of overweight and obesity in women of reproductive age in these countries rose from 1996 to 2006\textsuperscript{23}. Despite rapid economic growth in India, underweight and overweight don’t yet coexist in the low-SES groups of women\textsuperscript{24} and the DBM among women is still greatest in the states with the highest degrees of income inequality\textsuperscript{25}. Indeed across 54 LMICs higher BMI and overweight in women remains concentrated in higher socioeconomic groups\textsuperscript{26}.

Figure 1. Who is most affected by the DBM?
As shown in Figure 1 underweight and obese women coexist in the 36 countries that have high rates of child stunting (>20%) and make up 90% of the global burden of child stunting. Furthermore it seems that the DBM is frequently found among mothers and children in the same household. The coexistence of maternal over-nutrition and child under-nutrition in the same household was observed in Latin America three decades ago, before the DBM concept was established. Studies during the seventies in Manaus in the Brazilian Amazon found 60% stunting in preschool children, as well as 60% maternal anaemia together with 30% percent maternal obesity. A national food and nutrition survey in Guiana in 1976 found 60% of preschool children to be underweight while 60% of mothers were obese.

More recently adult overweight and child underweight have been shown to coexist in the same households in of Brazil (11%), China (8%) and even Russia (6%). An in-depth analysis of the stunted child-overweight mother (SCOWT) phenomenon using 42 national survey data sets from Africa (27) Asia(7) and Latin America(8) found SCOWT be more common in Latin America than Africa, and that the prevalence was generally below 10% except in four countries, three of them in Latin America. The coexistence of child stunting and maternal overweight in the same household has more recently been described in Guatemala, Malaysia, Benin and Indonesia. These analyses largely concluded that the phenomenon seems to be more associated with economic development than urbanization per se.

At the individual level the commonest form of DBM seems to be energy overnutrition and iron deficiency. In the USA iron deficiency has been shown to be more common in obese children than normal weight children and in obese women than normal weight women. The iron deficiency found together with obesity and overweight in the US is not associated with anaemia however, and so the reduced circulating iron in serum may just be a consequence of the chronic systemic inflammation state found in these obese and overweight people. However several other studies have shown that...
increased adiposity is associated with increased risk of postpartum anaemia among women taking iron supplements during pregnancy in the US\textsuperscript{40}, and a reduced response to iron fortification in women and children from transition countries\textsuperscript{41}. The decrease in child undernutrition in Brazil during the nineties, which was accompanied by increase in adult obesity\textsuperscript{42}, paradoxically saw an increase in anaemia\textsuperscript{43}.

Definitions of overweight and obesity are defined based on the relationship with risk of diseases, and these have more recently been seen to vary by region. The WHO recommended classifications of bodyweight include degrees of underweight and gradations of excess weight or overweight that are associated with increased risk of some non-communicable diseases\textsuperscript{44}. These classifications developed two decades ago are based on body-mass index (BMI), calculated as weight in kilograms divided by height in metres squared (kg/m\textsuperscript{2}). The proposed BMI cut-off points were: 25·0–29·9 kg/m\textsuperscript{2} for overweight grade 1; 30·0–39·9 kg/m\textsuperscript{2} for overweight grade 2; and >40·0 kg/m\textsuperscript{2} for overweight grade 3. Although these are still the most widely used categories of overweight and obesity, there have been some modifications in recent years. In 1997, a WHO expert consultation proposed an additional subdivision at a BMI of 35·0–39·9 kg/m\textsuperscript{2} recognising that management options for dealing with obesity differ above a BMI of 35 kg/m\textsuperscript{2}. More recently it has also been recognized that Asians have a higher percentage of body fat than Caucasians with the same BMI and that the health risks associated with these BMIs are also greater in Asians than in Caucasians. In consequence a lower limit of overweight set at 23 kg/m\textsuperscript{2} is recommended for use in Asian populations\textsuperscript{45}. Furthermore more recent work suggests the BMI cut-off for overweight in the Asia Pacific region should be $\geq 21$\textsuperscript{46}.

Indeed it seems that the indicators and cut-offs used for defining overweight/obesity and predicting the risk of cardiovascular disease in LMIC populations undergoing the nutrition transition may need to be further revised. The waist-to-hip ratio (WHR) was found to be better than BMI for predicting the risk of type-2-diabetes in the Taiwanese population\textsuperscript{47}. Studies in Kerala India have revealed that while only a third were overweight at least a half had dyslipidaemia, and that anthropometric measures like BMI and waist circumference were only modest in predicting biochemical risk factors of NCDs\textsuperscript{48}. A review of the literature concerning the appropriateness of indicators for defining excess body weight found that measures of central obesity were more strongly associated with diabetes compared to BMI, but this was not the case for hypertension and dyslipidaemia, which were similar for BMI, WC and WHR\textsuperscript{49}. It has been suggested that in LMIC countries in rapid transition, because of the foetal origins of the NCD risks, that calf anthropometry may be a better predictor of cardiovascular risk\textsuperscript{50}.
4. What are the Consequences of the Double Burden of Malnutrition?

The problems associated with the double burden of malnutrition are considerable, and many are manifest across the life course. Although there doesn’t seem to have been any attempt to fully compute all of the consequences of the DBM, there are various piecemeal descriptions of the consequences and even costs estimates of the different parts of the double burden problem.

The effects of undernutrition during the foetal/infant period are certainly of major proportions, and among those that survive the consequence are seen across the life course. Estimates are that maternal and child undernutrition is associated with between a half\(^51\) and a third\(^52\) of global child deaths. These differences in the proportions of child mortality attributable to undernutrition probably reflect changes in the occurrence of different diseases with time. The contribution of undernutrition to child mortality varies by disease, being highest for diarrhoeal diseases (73%) and close to half for pneumonia, measles and severe neonatal infections\(^53\). As countries develop and progress is made in improving the household environment through improved water and sanitation, as well as reducing indoor household smoke exposure, together with increased vaccine coverage, more and more foetuses survive beyond infancy, despite having suffered from maternal and child undernutrition. These are the epidemiological and demographic transitions that are occurring simultaneously in most LMICs today.

For those foetuses that survive beyond infancy, the damage done by undernutrition during this early period can be seen across the life course. Final adult height, which is largely determined by two years of age, is a reflection of how good nutrition was during this early period in life\(^54\). Height at two years of age is considered the best indicator of the quality of a nation’s human capital, with maternal and child undernutrition associated with less schooling, and reduced economic activity later in the life of the child\(^55\). There is also evidence that constrained foetal growth produces measureable differences in immunity, as well as a greater propensity for diet related non-communicable diseases such as type 2 diabetes and cardiovascular diseases later in the life course. Based on conservative assumptions related only to lost productivity, the costs of child undernutrition in the Asia region were estimated to be at least 2 or 3 per cent of GDP\(^56\). Earlier work suggesting that half of the economic growth of the UK between 1800 and 1980 is attributable to the improved nutrition of the workforce could be a conservative estimate, as the author claimed\(^57\).

Later in the life course, diet and nutrition, and especially obesity, are important underlying causes of many non-communicable diseases (NCDs) including hypertension, diabetes, cancer, stroke, and ischemic heart disease\(^58\). NCDs are responsible for 63% of 57 million deaths worldwide and they are disproportionately high in LMICs where nearly 80% of NCD deaths occur\(^59\). The leading causes of NCD deaths in 2008 were cardiovascular disease (48%), cancers (21%), respiratory diseases (12%) and diabetes (4%). Furthermore 44% of all NCD deaths occur before the age of 70, and in LMICS
this ratio is higher (48%) than high income countries (26%). Among people before the age of 70 in 2008, cardiovascular diseases were responsible for the highest proportion of NCD deaths (39%) followed by cancers (27%). Chronic respiratory disease, digestive diseases and other NCDs were together responsible for approximately 30% of deaths and diabetes was responsible for 4%. As populations in LMICS age and longevity increases, NCD deaths are projected to increase and will become the most dominant cause of mortality in most countries by 2030.

The metabolic syndrome comprises a group of risk factors including abdominal obesity, dyslipidaemia, elevated blood pressure, and impaired glucose tolerance\textsuperscript{60}. Indeed the real problem with obesity seems to be the extent to which it is related to excess visceral fat. The underlying patho-physiology of the metabolic syndrome is thought to be related to abdominal obesity and insulin resistance, however the exact combination of medical disorders and the cut-offs used to define them varies according to expert source and geographic region. Although the original World Health Organization definition emphasized insulin resistance\textsuperscript{61}, more recent definitions from the National Cholesterol Education Program Adult Treatment Panel III (ATP III)\textsuperscript{62} and the International Diabetes Federation (IDF)\textsuperscript{63} have treated the individual components equally. For the clinical identification of the metabolic syndrome, Adult Treatment Panel III lists five characteristics: abdominal obesity, elevated triglycerides, low levels of high-density lipoprotein cholesterol (HDL-C), hypertension, and elevated levels of fasting glucose. When three of five of these criteria are present, the diagnosis of metabolic syndrome can be made\textsuperscript{64}.

The costs of treating the metabolic syndrome are considerable and growing, even in LMICS. Among the few LMICS with information, the costs of treating CVD in South Africa was already eating up to 25% of all health care spending (2-3% of GDP) a decade ago\textsuperscript{65}. There is more information available on the costs of the various components of the metabolic syndrome in the rich countries such as the USA for example, where the metabolic syndrome was present in almost a half of a population based study of the elderly\textsuperscript{66}, and the total costs to Medicare were 20% higher among participants with the metabolic syndrome. The metabolic syndrome per se was not an important predictor of long-term costs over and above its constituent parts however, with abdominal obesity, low HDL cholesterol, and elevated blood pressure associated with 15%, 16%, and 20% higher costs, respectively. Across the whole US population, overweight and obesity costs were recently estimated to be $147 billion or 9.1% of health care expenditures\textsuperscript{67}, and hypertension cost were US $109 billion a decade ago\textsuperscript{68}. The total cost of diabetes in the United States in 2007 after factoring in the additional costs of undiagnosed diabetes, pre-diabetes, and gestational diabetes was estimated at $218 billion\textsuperscript{69}. The direct and indirect costs of CVD in the USA were estimated at US$368 billion in 2004\textsuperscript{70}, with 1 in 3 adults having CVD and 36.3% of all deaths having CVD as the leading cause of death among men and women in 2008\textsuperscript{71}. The World Economic Forum suggests that NCDs will cost more than US$ 30 trillion globally over the next 20 years.
representing 48% of global GDP in 2010, and pushing millions of people below the poverty line.

5 WHAT ARE THE CAUSES OF THE DOUBBLE BURDEN OF MALNUTRITION?

The causes of the DBM are related to a series of changes affecting societies, which have been called the “nutrition transition”. The nutrition transition encompasses changes in the demographic, economic, behavioural and epidemiological situations of countries and their populations. This transition, which occurred at a more leisurely pace as the “secular trend” during the last two centuries in the rich or “developed” countries causing inter-generational changes, has accelerated in the last two decades especially in the more prosperous LMICs, and is now occurring in most LMICs as intra-generational changes. Furthermore since the sixties obesity has started to escalate even in industrialized countries, and a global obesity epidemic is unfolding. These transitions are of growing importance because of the rapidity with which they are happening and the massive consequences they are likely to bring for human health, wealth and development in all LMICs.

In the two centuries since the industrial revolution began the global population has skyrocketed. The population of the world was below one billion for most of the last ten thousand years, since man first came to rely on farming to gain food. Only in the last two hundred years with the industrial revolution did the global population begin to increase rapidly and pass one billion. Since the end of the last world war not only has the global population more than tripled, it has also become proportionally more located in developing countries in the southern hemisphere. From 2 billion in 1950 the world population catapulted to 7 billion in 2011, and the projections are that it will reach 9 billion before plateauing in 2050. The majority of the global population is located in Asia and Africa and this is where all of the projected population growth will occur over the next four decades, with Africa going from 1 billion to 2 billion, and Asia going from 4 billion to 5 billion. During this time Europe, Latin America and the Caribbean, Northern America, and Oceania will remain pretty static at just under 2 billion people.

Understanding the risks associated with of the DBM is not an easy task, not only because of the complexity of the issue, but also because of the rapidly evolving situation in most LMICs. The conceptual framework proposed by UNICEF for analysing the causality of child undernutrition is widely accepted and used globally. It is not easily adapted to analyzing the causality of both forms of malnutrition across the life course however; especially considering that early life course undernutrition can facilitate overnutrition later in the life course. The life course approach to understanding chronic disease epidemiology is recognized to be methodologically challenging. The difficulty is separating out the joint neighbourhood effects of exposure to parent and offspring, as well as the sensitive periods later in the life course when changes are more plastic and some degree of mitigation may be possible.

Various models have been proposed for trying to understand the causality of obesity, looking at how both human biology and the environments which populations inhabit
can affect behavioural patterns and body composition\textsuperscript{77,78}, with individual level factors as well as the socio-political, socio-cultural, socio-economic and socio-environmental contexts. A system map of obesity developed by the Foresight project in the UK has over 100 variables with either direct or indirect influence on energy balance\textsuperscript{79}. These variables can be grouped into four cross cutting themes, which include: 1) The Biological/Health Environment: an individual’s starting point - the influence of genetics and ill health; 2) The Economic/Food Environment, including factors which influence availability and quality of food near to home as well as economic access to food which influences consumption; 3) The Physical/Built Environment, including factors influencing individual activity behaviour, as well as the type, frequency and intensity of activity; 4) The Socio Cultural Environment, including the influence of media, education, peer pressure or culture and how these impact on person’s individual drive for particular foods and consumption patterns, or physical activity patterns or preferences.

In this paper we analyse the evidence available in the literature for each of these four groups of causes to look at both undernutrition and overnutrition across the life course in the same populations. It is realised that while each of these themes has influence on the DBM they are not necessarily dependent on another, especially because they may be influencing at different times across the life course. This also implies that interventions will need to be considered for each of these four groupings.

5.1 The Health/Biological Environment

The Health/Biological Environment is an individual’s starting point, and includes the influence the health services and the burden of diseases, as well as the individual metabolic and genetic influences.

5.1.1 The health system and the disease burden

Together with the massive increase of the global population there has also been an important change in its composition, called the demographic transition. As counties develop from a pre-industrial to an industrialized economic system, together with improved hygiene and sanitation and increased antenatal care and family planning, there is a shift from high birth and death rates to low birth and death rates. Due to this transition the average global family size has declined by half since 1950, and the proportion of older persons relative to the rest of the population has increased considerably. At the global level, 1 in every 12 (8.3%) of individuals was at least 60 years of age in 1950, and by the year 2000, 10% of the population was aged 60 years or older. Projections are that by the year 2050, 25% of the global population will be aged 60 or over.

Although there has been great progress in reducing fertility rates globally, the Least Developed Countries (LDC) are still lagging behind in the transition to low fertility and
have rapidly growing populations. Although fertility rates in the developing countries as a whole were reduced from 5 in the seventies to less than 3 today, it was still 4.8 in the LDCs in 2005, and in the LDCs of Sub-Saharan Africa it was 5.8. Adolescent pregnancies are also high in the LDCs, with 117 births per 1000 women aged 15-19y as compared with 37 per 1000 in the developing countries as a whole.

The demographic transition is associated with an epidemiological transition, such that the infectious diseases are replaced by the non-communicable diseases as the most important causes of disability and mortality. In the poorest of LMICs infectious diseases are still likely to be the most important cause morbidity and mortality. These diseases include diarrhoeal and acute respiratory infections for example, that mostly affect young children. With improvements in hygiene and sanitation as well as immunization coverage these diseases are becoming less important as causes of death, such that people tend to live longer. With the consequent aging of the population the non-communicable diseases, including cancer and cardiovascular diseases become the more common causes of morbidity and mortality, occurring later in the life course. In OECD countries there has been a reduction in mortality due to NCDs such as hypertension, diabetes, and dyslipidaemia through life style changes as well as medication by those with the disease.

There is considerable debate over whether or not obesity is a disease. It has been described by some as the disease of the twenty first century, but others have questioned the scientific basis for this, claiming that it lacks symptoms and impairments of function that characterizes it appropriately as a disease. Opponents argue that obesity is not a disease because it results from a person's chosen lifestyle, eating habits, and environment (i.e. residential location, social circle, economic status). Proponents stress that obesity is a disease because it is caused by genetics, biological factors or illnesses that cause weight gain, and by obesogenic environments.

The obese state is associated with many impaired functions that classify it as a disease. These are related to alterations in the metabolism of steroid hormones, metabolic alterations including lipid and glucose levels, and increases in the turnover of free fatty acids that lead to insulin resistance syndrome. In addition, excess adiposity has been linked to impaired immune function due to the increased cortisol secretion, possibly influencing the adverse pathophysiological effects of environmental and psychological stress.

Several international and US government entities have stated obesity is a disease. The World Health Organization (WHO) has classified obesity as diseases since its foundation in 1948, and in the report of the 1997 expert consultation entitled "Obesity: Preventing and Managing the Global Epidemic" called obesity a "chronic disease." The US Food and Drug Administration in its Jan. 6, 1999 "Regulations on Statements Made for Dietary Supplements Concerning the Effect of the Product on the Structure or Function of the Body; Final Rule, stated that the FDA "agrees... that obesity is a disease." The US Internal Revenue Service (IRS) announced a policy in 2002 stating...
that "obesity is medically accepted to be a disease in its own right." This policy allows Americans to claim tax deductions for doctor prescribed treatments, "special food," and weight loss programs for those who are medically diagnosed as obese.

Other entities have taken a less clear stance on whether or not obesity is a disease. Even WHO is not consistent, as its recent global status report on NCDs included overweight and obesity as metabolic/physiological risk factor. In the US the Centres for Medicare and Medicaid Services (CMS) has not classified obesity as a disease. Similarly, the American Academy of Family Physicians (AAFP), American Academy of Paediatrics (AAP), American College of Physicians (ACP), and American Nurses Association (ANA) did not have policy statements stating whether or not obesity is a disease as of year’s end 2009. In the health care bill approved by the US House of Representatives on Oct. 29, 2009, "being overweight or obese" is not classified as a disease but as a "behavioural risk factor" along with alcohol and drug use, tobacco, poor nutrition, physical inactivity, and risky sex.

It would seem important for LMICs to be very clear that they are treating obesity not just as a risk factor for CVD, but also as a disease in its own right. With a lack of clear consensus among international and national government entities and medical associations on whether or not obesity is a disease, advocate groups continue to lobby for and against classifying obesity as a disease. Proponents stress that declaring obesity is a disease would remove the social stigma associated with obesity, afford it the same legal protections as other illnesses and force medical professionals, insurers, and employers to treat it with the same degree of concern given other diseases. Perhaps for these very reasons opponents continue to resist such a classification.

5.1.2 Biological aspects

It has been suggested that the effects of the nutrition transition and the emergence of the DBM problems may also be influenced by genetic disposition of the populations concerned. The possibility has been raised that genetic factors could endow individuals that were able to efficiently collect and process food to deposit fat during periods of food abundance, which has been called the “thrifty genotype” hypothesis. Genetic traits not only affect metabolic capacity to store energy, but also affect people’s perceptions of hunger and satiety. Multiple studies of families, adoptees, twins and, most powerfully, adopted twins have all confirmed that heritable factors are likely to be responsible for 45–75% of the inter-individual variation in BMI.

However there is currently little evidence that the ancestral genomes of native Asian or African populations carry particular risk alleles for obesity. Although in certain populations obesity may be related to one gene locus, the vast majority of obesity is related to more than one gene locus, reflecting the many different environmental situations that humans have adapted to in the last ten thousand years. One useful way to think about the relation of genes with obesity was expressed by George Bray when he said, “the genetic background loads the gun, but the environment pulls the trigger.” The sudden rise of obesity prevalence during the past few decades clearly cannot be
accounted for by population genetic changes. Epigenetic contributions to obesity will need to be addressed through minimisation of the environmental triggers, rather than manipulation of the genetic guns\textsuperscript{99}.

The “\textit{thrifty phenotype}” hypothesis says that constrained foetal growth is strongly associated with a number of chronic conditions later in life\textsuperscript{100}. The influences of today’s “\textit{modern diet}” are likely to be greatest during the critical period of foetal and infant growth, when plasticity is greatest and epigenetic changes most likely to be determining the many NCD risks\textsuperscript{101}. We know that impaired embryonic, foetal and infant environment can lead to greater risk of visceral obesity and metabolic compromise in later life\textsuperscript{102}. Indeed relative visceral fat is already present from birth in small for gestational age children\textsuperscript{103}. This developmental plasticity, which is designed to permit the foetus to better adapt to the expected environment outside the womb\textsuperscript{104}, is of course dangerous if an environmental mismatch occurs. Also known as the \textit{foetal origins of adult disease} (FOAD) theory, it suggests that part of the DBM problem is due to a mismatch between the environment of the womb and that of the world outside when the child is born\textsuperscript{105}. The theory is confirmed by food supplementation trials during pregnancy and early childhood in undernourished populations of Guatemala, which led to improved risk factors for cardiovascular disease (blood pressure, glucose clearance and dyslipidaemia) during adulthood\textsuperscript{106}.

Humans today live in a nutritional environment that differs considerably from that for which our genetic constitution was selected. Furthermore in the case of Asia in particular and especially among its very stunted populations that are migrating from rural to urban areas, the risks of such a mismatch are greatly increased. Because of the rapidity of economic development and urbanization in most LMICS, stunted children that were subjected to constrained growth during the foetal and infant period are likely to be faced with accelerated growth during the rest of their childhoods. This accelerated weight growth during childhood is recognized to increase the risks of obesity and NCDs later in the life course\textsuperscript{107}. These risks are even greater in Asia, since Asian populations especially can have twice the level of body fat as that found in Caucasians with the same level of BMI\textsuperscript{108, 109}.

Fat deposits are glands that are involved in regulating energy balance. Obesity is fundamentally a problem of energy balance, and as such, it can only develop when energy (food) intake is in excess of total energy expenditure. Differences between intake and expenditure are primarily buffered by changes in the amount of lipid deposited in the specialized fuel storage organ, white adipose tissue (or white fat). These fat deposits are the source of key hormones which play an important role in the regulation of energy balance – particularly leptin – and a diverse range of protein factors and signals termed ‘adipokines’, which are involved in overall metabolic regulation. A number of inflammation-related proteins are also released by white adipocytes, as well as adiponectin, and these include cytokines, chemokines and acute phase proteins. The current view is that the inflammatory state of obesity plays a key causal role in the development of type 2 diabetes and the metabolic syndrome associated with obesity\textsuperscript{110}.
Vitamin D insufficiency has also been found to be associated with the metabolic syndrome in a variety of different populations\textsuperscript{111, 112}, but whether there is any causality in the relationships and which direction causality goes is as yet unclear.

There is an emerging consensus for the importance of obesity related inflammation as an underlying cause for all of the metabolic syndrome components\textsuperscript{113, 114}. The development of atherosclerotic lesions leading to myocardial infarction or stroke encompasses a cascade of cellular and molecular events that can be characterized as a chronic immune mediated inflammation\textsuperscript{115, 116}. Adipose inflammation has also been linked to insulin resistance\textsuperscript{117}, and the inflammation response to excess adiposity has also been proposed as a possible mechanism for controlling body fat distribution between subcutaneous and visceral fat\textsuperscript{118}. It seems that the inflammation of obesity may somehow be part of a mechanism for controlling energy metabolism\textsuperscript{119} during situations of energy imbalance.

There is also evidence that the appetite mechanisms that evolved in our ancestral forefathers on a mixed diet mostly made up of fruits, nuts, vegetables and game gathered in the forest are not suited to dealing with the high energy density “convenience foods” common in the modern western diet, especially when they are eaten as “snacks” between meals\textsuperscript{120, 121}. A small extra amount of energy, as little as 100 kcal if consumed every day, can lead to the gradual accumulation of fat, which eventually becomes overweight and then obesity\textsuperscript{122}. Once obese however, the difficulty is not just losing that weight, but keeping it off, as shown in some six hundred European subjects that lost 12kgs during six months of dieting put back 10kgs over the next eighteen months unless they took an appetite suppressant\textsuperscript{123}. It seem that the body becomes used to having those extra fat reserves and continues to try to maintain them\textsuperscript{124}.

5.2 The Economic/Food Environment

There are two parts of the food system in a country that are important to understand in order to be able to make policy and programme interventions to change them and reduce the double burden of malnutrition problems. The first part concerns the sorts of foods being produced either locally or being imported and being made available to the household, as well as the factors which influence this such as international trade agreements, food processing and distribution systems, food subsidies and prices, as well as availability of income to purchase food as appropriate. The second part concerns the actual amounts and sorts of food being acquired either through home production, exchange or purchase, how they are prepared and consumed.

5.2.1 Food availability and Access

During the last century the world has experienced economic growth of a kind not seen before in the history of mankind. While the global population has increased six fold
since the industrial revolution began in Europe just over a hundred years ago, per capita income has increased nine fold\textsuperscript{125}. Although the total economic activity in the world rose an astounding forty-nine times in this period, economic growth has been highly uneven, such that today there is a twenty fold gap between the richest economy the USA and the poorest region Africa, compared to a fourfold difference a century ago. Per capita income in the USA and Europe is six to ten times greater than in other regions of the world and getting bigger\textsuperscript{126}.

Coupled with the increasing wealth there has also been a relative per capita increase in global food availability. The supply of calories for human consumption rose by just over 20\% from the early sixties to the late nineties, despite the population almost doubling\textsuperscript{127}. Global food production has outpaced rising demand during the last four decades based on calculations made by FAO using food balance sheet data. Whereas average food consumption was calculated at 2360 kcal per person per day in the mid-1960s it rose to 2800 in the late nineties. Furthermore it is predicted that the world population will be increasingly well-fed with 3050 kcal available by 2030, with this change reflecting above all the rising availability in many developing countries whose average will be close to 3000 kcal in 2030, thus closing the gap on the industrialized countries with an average availability of 3500 kcal.

This remarkable increase in global food production in the last fifty years especially has been made possible mainly due to the “Green Revolution”—adoption of crop rotation, the mass production and use of petroleum-based fertilizers and chemical pesticides, the use of petroleum driven machinery, expanded irrigation, and the introduction of genetically superior, disease-resistant cultivars (cultivated crops). However after nearly tripling from 1950 to 1996, global grain production seemed to reach a plateau during the early part of this last decade. Production fell short of consumption most years during the nineties, and world grain production in 2006 had remained flat at about 2 billion tons - 2.4\% less than in 2005. But world grain production continued to climb in 2007 and has continued to climb since, with FAO’s forecast for world grain production in 2011 a new record high\textsuperscript{128}. Food stocks also recovered in 2008 climbing back over 500 million tons for the first time since 2001, although they are still considered insufficient. Looking further ahead, slower population growth and the levelling off of food consumption in many countries will continue to dampen demand, the growth of which is expected to slow to 1.2 percent a year over the period 2015 to 2030.

With increasing large scale global trade in food of the last two few decades, it is not surprising that food availability patterns have become more similar throughout the world. Information obtained from food balance sheets and presented in the Sixth World Food Survey\textsuperscript{129} indicated that the share of dietary energy supplies coming from vegetable sources in 1990-92 was 71\% in developed countries and 90\% in developing countries. Cereals alone provided 60\% of dietary energy in developing countries, as compared to just 30\% in developed. Meat and fish provided 14\% in developed against just 6\% in developing countries. FAO further reported in 2002 that meat consumption in developing countries had risen from only 10 kg per person annually in 1964-66 to 26 kg
in 1997-99, and was projected rise to 37 kg per person per year in 2030\textsuperscript{130}. Milk and dairy products have also seen rapid growth, from 28 kg per person per year in 1964-66, to 45 kg in 1997-99, and could rise to 66 kg in 2030. Globally, some 660 million tonnes of cereals are used as livestock feed each year, representing just over a third of total world cereal use.

Today only eighteen plants are used as staple foods globally, and over 80\% of the global population relies on just fours staple foods, namely wheat, rice, maize and potatoes\textsuperscript{131}. This is compared with the thousands of foods which made up the hunter-gather diet we evolved eating. The four staples are now transformed into a vast array of different processed food products, with more than 1500 different ones produced from wheat alone, the majority of which can be eaten directly. Many chemicals are added in order to make these few staple foods into the vast array of processed foods available in the market\textsuperscript{132}. These chemical additives include colourings, preservatives, antioxidants, emulsifiers, stabilizers, anti-caking agents and flavour enhancers. They help to make processed foods look, smell and taste better, as well as to improve their shelf life, and in 2000 the food industry spent $20 billion on such additives, and the average consumption was 7kg per person a year in the industrialized countries. In addition there are 4500 different flavouring agents, with an annual market worth $3.6 billion and 13 different sweetening agents besides sugar, with an estimated market of $2.5 billion globally. The number of new food additives being approved has grown considerably in the USA since the mid-nineties, when the Food and Drug Administration (FDA) moved from promulgating rules and posting the results of reviews for its decisions for food contact and generally regulated as safe (GRAS) substances, to reviewing manufacturer safety decisions and posting the results of the review on the agency website. Furthermore this new procedure is considered to have limited public opportunity to provide input\textsuperscript{133}.

The acceleration in the nutrition transition is being affected by a radical change in the global food marketing and distribution system. The emergence of supermarkets in developing countries is at the heart of this development with Latin America taking the lead\textsuperscript{134}. In 2000 they had roughly 60\% on average of the national retail sectors in South America and Mexico, up from 15\% in 1990. This means that the structural changes in the food distribution system that took 50 years in the United States have taken place in little more than a decade in Latin America. This rapid expansion was only possible as supermarkets moved far beyond their original niches, expanded from large to small and poor countries, from metropolitan areas to rural towns and expanded the customer base from the upper/middle to the poorer working classes. This expansion of supermarkets now extends well beyond Latin America and is only about 5–7 years behind in East and South-East Asia\textsuperscript{135}. Different perhaps to the situation in higher income countries, where supermarkets are often the principal if not only sources of fruits and vegetables\textsuperscript{136}, in LMICs supermarkets are often distribution channels for cheaper, unhealthy snacks and provide the platforms for fast food chains and ‘junk’ food. Since the 1950s, the spread of bread, together with expanding sales of a large variety of other baked goods, has been
a key ingredient to the adaptation of a “Western” diet. This trend is expected to continue, it may even accelerate, driven by a growing internationalization of food distribution systems, as the spread of supermarkets and rapid urbanization are major factors behind that diffusion. Indeed the export of US processed foods is growing fastest in countries where modern grocery retailing is growing the fastest, suggesting that modern grocery formats in developing countries are an important outlet to promote US agriculture products

Since early seventies and the development of the “Washington Consensus” around the conditionality for Structural Adjustment Programmes (SAPs) from the International Monetary Fund (IMF), LMICs have been increasingly forced to open up to free trade and to privatize national industries, as well as reduce state support to local agricultural production. The conditionality for structural adjustment was the precursors to the conditions of free trade agreements including the General Agreement on Tariffs and Trade (GATT) and the North America Freed Trade Agreement (NAFTA) through to the World Trade Organization (WTO). Agreement on the basis for agricultural sector trading has been a blocking point on successive DOHA rounds of the WTO.

Free trade has meant an increase in food imports by most LMICs, and foods imported are cheap because of continued state support to the industrial agriculture sector in the rich countries, allowing the dumping of cheaper food commodities onto the world market. In 2010, while the European Union paid out €39 billion on direct agriculture subsidies, the United States government spent $21.3 billion to subsidize mainly large-scale farmers. In the last fifteen years $16.9 billion went into subsidizing just four common food additives—corn syrup, high fructose corn syrup, corn starch, and soy oils, helping make processed foods cheaper. Most of these subsidies contribute to making wheat and maize products cheaper, such that Americans’ tax dollars are directly subsidizing junk food ingredients. Outside of commodity crops, other agricultural products receive very little in federal subsidies, with only $262 million spent since 1995 subsidizing apples, which is the only significant federal subsidy of fresh fruits or vegetables.

Trade liberalization can also affect the availability of certain foods by removal of barriers to foreign investment in food distribution. It can also enable foreign investment in other types of food retail; multinational fast-food outlets have made substantial investments in middle-income countries. Availability of processed food has risen in developing countries after foreign direct investment by multinational food companies. Transnational food corporations (TFCs) (franchises and manufacturers) such as KFC, McDonalds, Kraft and Nestle are all drivers of the fast-food market, processed foods and Western lifestyle that have become so widespread in developing countries.

Policies of trade liberalization, which have facilitated the rising availability and consumption of meat, dairy products and processed foods, are therefore contributing to the ‘nutrition transition’ that is associated with rising rates of obesity and chronic diseases such as cardiovascular disease and cancer.
Many consider that globalization of the food chain is no longer serving the common interest. The inclusion of food amongst commodities that have been subject to free trade agreements has been considered by grass roots farmer’s movements to be against the interests of most LMICs, threatening the future of their farming communities as well as their public health and nutrition situations. The “western diet” being promoted globally with support from the US and EU through their domestic agricultural subsidies especially, is not only considered to be unhealthy, it is also environmentally damaging. Agriculture production systems contribute around 13.5% of global greenhouse gas emissions and about half of this comes from meat and dairy production, such that many consider that promoting the consuming a more “Mediterranean” type diet would provide benefits to population health as well as to the environment.

The era of cheap food seems to be over however. Since 2000 the world food situation is being rapidly redefined by new driving forces, including income growth, climate change, and perhaps most importantly the increased production of bio-fuels motivated by higher oil prices. The major driver of food prices is the price of oil, and although the Food Price Index (FPI) of FAO fell progressively after the 1974 oil crisis, facilitating two decades of cheaper food, in 2007 it jumped 26% followed by another 24% increase in 2008 all linked to increases in oil prices. The cost of food reached an all time high early in 2011, and the food price index of FAO is twice the level it was a decade ago. Oil continues to cost over US$100 a barrel and with so much uncertainty in the Middle East region it is unlikely to fall below that level again in the near future. The perspective is that global food prices will continue to increase by at least 10% a year over the next few decades.

Indeed food is now a major item of international trade with the aggregate value of agricultural exports at the world level expected to reach a record USD 1.29 trillion in 2011, surpassing the trillion dollar mark for the third time in the past four years, and is around 10 percent of all global trade. The high food prices affect the LMICS more than any others however, as they are expected to pay 30 percent more than last year as compared with the rich nations whose food import bills are likely to rise by only 20 percent from 2010. Putting this in a broader perspective, expenditures on imported foodstuffs for LMICs could account for roughly 18 percent of all their expenditures on imports, compared to a world average of around 7 percent. The household level consequences of increases in food prices are most acutely felt in Low Income Food Deficit Countries (LIFDCs) where a 50% rise in staple food prices causes a 21% increase in total food expenditure, increasing these from 50 to 60% of income. In a high income country this rise in prices causes a 6% rise in retail food expenditure with income expenditure on food rising from 10 to 11%.

Many of the recent distortions in global food prices have been caused by speculative trading in the commodities markets. There is strong evidence that the Commodity Index Traders (CIT) “Roll Cycle”, which is a set period from the 5th to 9th business day of each month, during which funds tracking the most popular commodity index, the Standard & Poor’s Goldman Sachs Commodity Index (GSCI) must roll forward their
expiring futures contracts, systematically distorts forward commodities futures price curves towards a “contango” state. This state occurs when a commodity's futures price is higher than its current spot price. In this scenario, even if the spot price of a commodity is rising, it's possible to lose money in a fund that tracks the futures price of the commodity. This is likely to contribute to speculative “boom/bust” cycles by changing the incentives of producers and consumers of storable commodities, and also by sending misleading and non-fundamental price signals to the market. Investor speculation on the agricultural futures market followed on from the deregulation of commodity markets by Congress’s Commodity Futures Modernization Act of 2000. This together with the conversion of US corn crops to ethanol has been identified as the two critical factors driving higher food prices, and the perspective for 2013 and beyond is that it will get worse. Although corn only provides the U.S. with less than 1 percent of its energy, it has a much larger effect on global food availability. Although subsidies for converting corn to ethanol were stopped in December 2011, the federal government still guarantees demand for 37 percent of the national corn crop for conversion to ethanol, as compared to about 40 percent before that.

Not only is the era of “cheap” food over, but the sustainability of the global agricultural system as it is currently organized seems to be in great peril. Many consider that meeting development and sustainability goals will require a fundamental shift in agricultural knowledge science and technology in order to recognize and give increased importance to the multi-functionality of agriculture, accounting for the complexity of agricultural systems within diverse social and ecological contexts. This shift may call for changing the incentive systems for all actors along the value chain to internalize as many externalities as possible, and to recognize farming communities, farm households, and farmers as producers and managers of ecosystems. The Ministerial Declaration adopted at the start of the Doha Development Round of trade negotiations, on 14 November 2001, was a promising response to the anti-globalisation riots of the 1990s. However in the 10 years since the WTO pledged to deliver pro-development changes in the way it works, developing countries seem to have been completely sidelined by the global powers in their WTO deliberations.

5.2.2 Food consumption

The industrialization of the food chain has seen many remarkable changes in the way we eat and what we eat, many of which will have contributed to the rising tide of non-communicable diseases. One important change that is still in trend across the globe is the erosion of breastfeeding. In the period 2005-2009 it was estimated that just 38% of infants in developing countries were exclusively breastfed until six months of age. By region this ranged from just 23% in West and Central Africa, to 47% in East and Southern Africa.

Among the changes associated with the food transition has been an increase in the consumption of processed foods, which has caused changes in the composition of the diet. The type of carbohydrate in the diet has changed, with decreases in complex
carbohydrates such as starches and an increase in refined sugar, such that sugar consumption has typically increased fifty fold in industrialized countries, with upwards of 15% of energy intake now coming from refined sugar. The majority of this sugar is “hidden” in processed foods and drinks, rather than added to food by the consumer. But perhaps the most important change in the composition of the diet is related to its fat content. Over the last century this has increased from 20% to 40% of dietary energy. But it is not just the amount of fat, but the type of fat that is of importance.

Dietary changes associated with the “western diet” have affected both the type and amount of essential fatty acids as well the anti oxidant content of food.\textsuperscript{163} The industrial hydrogenating of liquid unsaturated fats, such as soya and corn oil to make them into solid saturated fats for baking purposes has allowed the mass production of cheap snack foods. In consequence the unsaturated fats that figured in traditional diets have largely been replaced by saturated fats in modern dietaries. The hydrogenation process leads to the formation of harmful trans fatty acids however, which are very atherogenic. The type of unsaturated fat being consumed has also changed with increases in omega 6 fatty acids and decreases in omega 3 fatty acids, such that the ratio of 6 to 3 omega fatty acids has increased from 1:1 to greater than 15:1.\textsuperscript{164} This change is related to the increased consumption of meat of intensively reared animals fed on grain (rich in omega 6) instead of grass (rich in omega 3).\textsuperscript{165}

Defining foods in function of their degree of processing is a relatively new and important concept with regard to understanding the potential obesogenicity of diets.\textsuperscript{166} Nearly all food is necessarily processed in order to be eaten, even if only by washing it. But three food groups have been proposed based on the degree of processing, namely: Group 1 unprocessed or minimally processed foods; Group 2 processed culinary or food industry ingredients; Group 3 ultra-processed food products. Processing of Group 1 foods includes the removal of inedible fractions, grating, squeezing, drying, parboiling, fermentation (non-alcoholic), pasteurization, freezing, wrapping and bottling for example. The processing of Group 2 foods includes the extraction and purification of components of single whole foods for use as culinary or food industry ingredients, through pressing, crushing, milling, refining, hydrogenation, hydrolysation, extrusion and use of enzymes and additives. These foods include vegetable oils, margarine, butter, whey, cream, lard, sugar, sweeteners, salt, flours, raw pastas and noodles, high fructose corn syrup, and gums for example. The processing of Group 3 products includes the combination of Group 2 ingredients with Group 1 ingredients through baking, battering, frying, curing, smoking, and pickling, in order to create durable, accessible convenient and palatable drinks and/or ready to eat or heat food products.

The problem is not the ultra-processing of foods however; it is the balance between the consumption of each of these three food groups in the everyday diet of the population. The Group 3 “convenience foods” require little if any preparation before cooking, and can be eaten as purchased, and/or micro-waved and/or eaten after reheating. They are most suited to snacking, which when coupled with their higher energy densities and high glycaemic indexes, can become a problem. High glycaemic index foods are those
which cause a high and prolonged post-prandial glucose level in the blood stream. Numerous observational, experimental and epidemiological studies suggest that postprandial hyperglycaemia plays a pivotal role in the pathogenesis of CVD\textsuperscript{167}. Furthermore the metabolic cost of assimilating the energy in processed foods appears to be half that of whole foods\textsuperscript{168}.

All over the world the Group 1 and Group 2 foods are being displaced by Group 3 ultra-processed products. In Brazil ultra-processed foods were already contributing around a third of dietary energy in 2003\textsuperscript{169}. In the UK eight ultra-processed products: bread, cakes, pastries, confectionery, biscuits, processed meats, cheeses and soft drinks together supply almost half of total household purchased calories\textsuperscript{170}. In the USA the five most commonly consumed foods are “regular” sugared soft drinks, cakes and pastries, burgers, pizzas, and potato chips\textsuperscript{171}.

How increases in the price of food currently occurring globally will affect the dietary component of the nutrition transition in LMICs is difficult to predict, but it most likely means that consumption of cheaper ultra-processed foods (many of which benefit from subsidies to keep their price low) will increase even more than before. Group 1 especially are likely to become increasingly expensive, while the mass produced Group 3 foods, made from largely subsidized food supply chains, will become comparatively cheaper. Unless measures are taken to avoid this the Group 3 ultra processed foods will become even more attractive to the poorest segments of the LMICs population. Energy dense foods composed of refined grains, added sugars, or fats are well recognized to represent the lowest cost option to the consumer\textsuperscript{172}. That obesity is paradoxically more common in the poorer segments of the developed countries is most likely because high energy density “fast foods” are cheaper to buy and/or easier to prepare than the more healthy foods such as fruits and vegetables\textsuperscript{173}.

It must also be recognized that the sudden explosion of obesity that is now engulfing most countries in the world is a relatively recent phenomenon. Swinburn and colleagues\textsuperscript{174} postulate that an energy balance flipping point has occurred quite recently during the last century in most high-income countries. Furthermore there are two distinct phases with the so-called “move less, stay lean” phase (1910–60), characterised by decreasing physical activity levels and energy intake, and a population that remained lean; and the subsequent so-called “eat more, gain weight” phase from 1960 onwards, characterised by increasing energy intake and a concomitant rise in population weight. Food supply data from the US lends support to this flipping point hypothesis, as well a recent study which found that the dietary factors showing the strongest positive association with the average 1.5kg weight gain over a four year period in US adults included the intake of potato chips, potatoes, sugar sweetened beverages, and negatively with the intake of vegetables, whole grain, fruits and nuts\textsuperscript{175}.

A paradoxical situation has been reported in many LMICs of increasing food availability, increasing overweight and obesity, yet apparent decreasing energy consumption\textsuperscript{176 177}. But it seems likely that this is due to both energy expenditures
having decreased, and energy intakes based on 24h recall having been underestimated\textsuperscript{178}. It may also be that the LMICs have not yet fully gotten into the “eat more, gain weight” phase of population energy balance, or it is just the upper wealth quintiles that are doing so.

5.3 The Physical/Built Environment

The Physical/Built Environment includes factors that influence individual activity behaviour, including the type, frequency and intensity of physical activity, as well as access to “healthy” food.

Most of the future global population growth will occur in the urban areas of developing countries. The proportion of the global population living in urban areas surpassed those living in rural areas in 2009, and projections are that by 2050 the majority of the global population, or just over 5 billion people, will be living in the urban areas of countries that are currently considered as developing, and just less than a third of the global population will live in rural areas\textsuperscript{179}.

Energy balance depends on regulating intake and expenditure, and the key variable of energy output is the degree of physical activity. This can be seen by the following comparison: In sedentary adults the basal metabolic rate (BMR) is 60\% and the thermic effect of food (TEF) is 10\% and physical activity (PA) is 30\% of total energy expenditure; in very active adults BMR is 40\%, TEF is 10\% and PA is 50\% of total energy expenditure. BMR and TEF are constant and so modifying PA is an essential element of energy expenditure in terms of achieving energy balance, and or losing weight\textsuperscript{180}, especially in an environment where the food available is predominantly energy dense.

5.3.1 Activity environment

With urbanization there have been many changes in life style with people becoming increasingly sedentary and dependent on purchasing their food instead of growing it themselves\textsuperscript{181}. With people moving from rural to urban areas comes a shift of the work force away from agricultural towards manufacturing and service employment, and a reduction in energy expenditures of men at work. With industrialization came kitchen stoves and coal followed by kitchen tools and electricity, all of which have contributed to reducing women’s domestic workload.

In urban areas people increasingly have nowhere to easily get exercise. The availability, accessibility and convenience of destinations and facilities, as well as the general functionality of the neighbourhood (e.g., the presence of sidewalks, traffic conditions) and aesthetics have been shown to be positively associated with various levels of physical activity\textsuperscript{182}.

Constrained growth during the foetal and infant period can be caused by a multitude of non income and/or food security related factors, including environmental hazards and stresses. Environmental factors that can limit foetal and infant growth include smoke, be
it cigarette or indoor house smoke, as well as toxins such as pesticides either coming from the diet or through exposure in the fields. All of these hazards and stresses tend to become reduced through the construction of urban infrastructure and dwellings that have to comply with building regulations which determine the need for sanitation, clean water and smoke free households with chimneys.

5.3.2 Activity behaviour

Urbanization is also related to changes in time allocation and leisure activities. Leisure increasingly becomes passive, with people watching TV or playing computer games instead of having physical exertion by playing a ball game. Independent of exercise levels, sedentary behaviours, especially TV watching are associated with significantly elevated risk of obesity and type 2 diabetes.

WHO recently estimated that between a quarter and a half of adults globally doesn’t get enough exercise. Women tended to get less activity than men, with just 20% of men in lower income countries not getting this level of exercise as compared nearly fifty percent of women in higher income countries. Insufficient weekly physical activity was considered as less than 30 minutes moderate activity five times a week or less than 20 mins vigorous activity three times a week.

Increasing amounts of time are spent outside of the home sat in local transport systems as well as working away from home, leading to increased consumption of foods from outside the home be they “snack foods” from the food industry, “street foods” or meals in restaurants. Much can be done to try regulating the sorts of food being sold on the streets for ready consumption and improve their nutrition profiles.

5.4 The Socio-Cultural Environment

The Socio Cultural Environment includes the influence of media, education, peer pressure or culture and how these impact on person’s individual drive for particular foods and consumption patterns, or physical activity patterns or preferences.

5.4.1 Socio-cultural influences

Television is an increasingly pervasive media in most LMICs. A multi-country survey of the influence of television advertisements on children reported that advertising to children was widespread across the countries surveyed, and that while all six countries had common core food-based messages in national nutrition guidelines, the diet actively being promoted on television in all countries goes in the opposite direction. For Indonesia it reported that 16% of children watched over 8 hours of television a day, and that for each hour of children’s programming there was 15 minutes of advertising, of which food advertising was dominant. In all six countries piecemeal legislation exists alongside self regulating codes, and punitive measures could be taken against those that
violate such codes, but only in the Philippines was there provision for suspension/retraction of licences to advertise. Indonesian advertising control was said to be solely based on a “complaint feedback” mechanism. Two subsequent reviews carried under the remit of WHO largely confirmed that the findings of the Consumer International survey are largely applicable and relevant for most countries across the globe. A large number of national governments have developed policies with dietary recommendations for their populations. These recommendations are often depicted graphically, such as in the ‘the Food Guide Pyramid’ originated in the US in 1992 by the US Department of Agriculture (USDA) and now adopted or adapted in many countries. However, as revealed by a consumers union report in the USA the mere $9.55 million spent on communications for the Federal and California “5 A Day” programs to encourage eating 5 or more servings of fruit and vegetables each day was drowned out by the $11.26 billion spent on advertising by the food, beverage, and restaurant industries in 2004 that largely promoted energy dense type 3 processed foods. In consequence the majority of the American public still remains unaware that eating at least 5 servings of varied vegetable and fruits each day can improve health outcomes and help manage weight gain.

In many LMICs and in the rural areas especially, modern communication media still haven’t totally penetrated, and many traditional the socio-cultural practices still prevail, many of which still contribute to maternal and early child undernutrition. Gender related issues are especially relevant in rural areas where women often do a lot of the work but are not favoured in terms of food access. Hard labour and an excessive work load during pregnancy contribute to constrained foetal growth, as does the stress associated with marital violence during pregnancy. Small size and the lack of maturity of teenage mothers is also an important factor determining the adequacy of foetal growth. In many LMICs cultural practices dictate that perhaps 40% of first pregnancies occur whilst the mother herself is still a child (<18y) Furthermore many such teenage mothers will not have finished growing, in which case their own growth takes preference over that of the foetus which ends up smaller. In consequence the mother gains more weight than she would if she was mature, and maternal height growth is cut short. The development of maternal obesity in mothers over twenty years of age seems to be related to teenage pregnancy and parity, which are largely determined by what is accepted as the cultural “norm”. Increased completion of schooling by girls, especially at the secondary level, greatly contributes to the reduction of child marriages and of teenage pregnancies.

5.4.2 Individual psychology (community dynamics and practices)

Together with the increase in global “wealth” during the last century, there has been a steady increase in individual “disposable income”. This income can be used to purchase goods such as newspapers, magazines, radios and television that in turn exercise great
influence over the “societal norms” or fashions. The same disposable income allows the purchase of food be it in stores or from vending machines in schools and/or street traders selling convenience snack foods. Schools also offer the opportunity to generate healthy life skills in addition to those relating to eating a healthy diet.

The food industry spends US$40 billion a year on advertising food, and most of which promotes the consumption of ultra-processed foods\textsuperscript{190}. Transnational soft drink and fast food companies market their products extensively worldwide, especially to children and youths\textsuperscript{191}. Multinational and domestic food companies, which promote energy-dense foods and drinks, use highly effective marketing techniques to encourage regular consumption, repeat purchases, and brand loyalty – especially among children. The majority of children in Indonesia love watching TV adverts (61%), which they thought informed them about product quality/features (75%) and updated them about new products (91%). While 75% of parents in Indonesia based their buying decisions on their own judgement, and only 33% said these were influenced by adverts, 58% said they were influenced by their children\textsuperscript{192}.

Global reviews carried out by WHO confirm that marketing of foods, principally through television, is being practiced in most countries, and the foods being marketed are predominantly high energy density type 3 processed foods\textsuperscript{193}. Many efforts exist globally for trying to regulate the marketing of food to children, mostly through self-regulation by industry, but regardless of these regulations the marketing seems to go on unchecked\textsuperscript{194}. The maturing brain goes from straight processing of facts before the age of 12 years, to a slow progression to abstract thinking starting between 12 and 14 years\textsuperscript{195}. Final maturity of the adolescent brain is only achieved by around 18 years of age. This is considered a good argument for limiting advertising of food especially before this age\textsuperscript{196}.

6 WHAT ARE THE SOLUTIONS FOR THE DOUBLE BURDEN OF MALNUTRITION?

Although it is recognized that the lifecycle consequences of the DBM will differ depending on location and population, and that it is difficult to predict with any certainty what the changing dietary patterns and conditions of life in LMICS will be, it seems highly likely that the burden of NCD risk in LMICs consequent to the DBM will be of far greater magnitude than that experienced to date in developed countries.

In that light it is sobering to consider that while there are many good examples of countries reversing some of the NCDs, such as CAD and CHD risk, there are very few examples (if any) of countries that have reduced or reversed the trend towards increasing overweight and obesity. This is not surprising considering that once excess weight is accumulated, i.e. a population is overweight and obese, then reversing the situation is extremely difficult.
Despite this lack of evidence of programme effectiveness there is a lot of policy and programme guidance as well as evidence of interventions that work. It also true that while many of these bits of policy and programme guidance exist, they are not really brought together into one “joined-up” DBM policy and programme guidance whole.

That this is the case is in many ways because of the newness of this phenomenon that has been created by the explosion of economic development and social advances that have happened largely in the last sixty years since the end of the Second World War. It may also be because of the relative newness of nutrition science and of the concept of the DBM. This is compounded by the lack of a professional cadre of workers in most countries suitable trained to develop, and manage and manage the implementation of programmes that deal with and recognize the realities of the DBM.

6.1 Policy recommendations for DBM

Global policy recommendations for DBM predominantly come from the main intergovernmental global body with authority for nutrition, which is the World Health Assembly (WHA). The WHA, made up of the Minsters of Health of all countries in the world, meets annually to make policy recommendations. To carry out this function the WHA has an Executive Board, which meets at least once a year prior to the WHA, and relies on technical and secretarial support from the World Health Organization (WHO) through its various technical departments. These technical departments typically produce technical reports produced by expert consultations, as well special reports such as the annual World Health Report. The main technical department for nutrition is the Department for Nutrition in Health and Development (NHD).

Global Policy with regard to food related policy issues are also produced the Committee on World Food Security of the Food and Agriculture Organization (FAO), that monitors the progress in the implementation of the World Food Summit Plan of Action, based on reports from national governments and international organizations. FAO provides technical support to the development of the realization of the right to food, and has excellent materials available on its website to support country led efforts in this area including a “Tool-box” on different aspects of the right to food\textsuperscript{197}. Normative policy guidance in food safety is provided jointly by WHO and FAO through the Codex Alimentarius Commission\textsuperscript{198}. The main purposes of Codex is to protect the health of the consumers and ensure fair trade practices in the international food trade, and promote coordination of all food standards work undertaken by international governmental and non-governmental organizations. Codex recommendations are not “endorsed” by either WHO and/or FAO, as they are best practice guidelines and whether they are followed is on a voluntary basis. Codex is recognized by the World Trade Organization however as an international reference point for the resolution of disputes concerning food safety and consumer protection.

The dramatic increase in diet-related chronic diseases across the globe in the last few decades has led to a series of global policy recommendations for changes in the way societies organize their affairs, especially in relation to diet and physical activity. The
World Health Report 2002 recognized that unhealthy diets and physical inactivity are among the leading causes of the major non-communicable diseases, namely cardiovascular disease, type 2 diabetes, and certain types of cancer. Four of the most important risk factors are high concentrations of cholesterol in the blood, inadequate intake of fruit and vegetables, overweight or obesity, and physical inactivity.

The Global Strategy on Diet, Physical Activity and Health (DPAS) was endorsed by the World Health Assembly in 2004. DPAS built on the findings and recommendations of the expert consultation on diet, nutrition and the prevention of chronic disease, which reviewed and summarized the ample evidence available for the importance of diet and physical activity for the prevention of chronic disease. The WHA resolution 57.17 urged member states to adopt the following recommendations for populations and individuals: 1) To achieve energy balance and a healthy weight; 2) To limit energy intake from total fats and shift fat consumption away from saturated fats to unsaturated fats and towards the elimination of trans-fatty acids; 3) To increase consumption of fruits and vegetables, and legumes, whole grains and nuts; 4) To limit the intake of free sugars; 5) To limit salt (sodium) consumption from all sources and ensure that all salt is iodized.

Furthermore WHA 57.15 urged member states to define a series of steps in order to realize these recommendations, consistent with national circumstances, including: a) establish national goals and objectives; b) develop a realistic timetable for their achievement; c) develop national dietary and physical activity guidelines; d) develop measurable process and output indicators that will permit accurate monitoring and evaluation of actions taken; e) take measures to preserve and promote traditional foods and physical activity.

The WHO expert consultation Report No 916 also provided guidance as to a range of population nutrient intake goals to be used to orient the development of national dietary guidelines. The nutrient intake goals are as shown in Table 1 below. The recommendations for total fat are formulated to include countries where usual fat intake is above 30% as well as those where it may be very low, but 20% is considered consistent with good health. Highly active populations groups with diets rich in vegetables, legumes, fruits and wholegrain cereal may sustain a high fat intake without risk of unhealthy weight gain but in populations with more sedentary situations the lower levels of intake are certainly more appropriate. The quality of the fat is also important, and should have little or no trans fatty acids, and a low saturated fat content. The unsaturated fats should include both n-6/n-3 polyunsaturated fats in a ratio no greater than 3, but it is not just the ratio but the amounts of both that are important.

It is recognized that higher intakes of free sugars threaten the nutrient quality of the diets by providing significant energy without specific nutrients. This is because free sugars promote a positive energy balance, and drinks rich in free sugars increase overall energy intake by reducing appetite control. Wholegrain cereals, fruits and vegetables are the preferred sources of non-starch polysaccharides (NSP), and the recommended intake...
of fruit and vegetables together with the consumption of wholegrain foods is likely to provide >20g/d of NSP (>25g/day of total dietary fibre).

Table 1 Recommended Population Nutrient Intake Goals

<table>
<thead>
<tr>
<th>Dietary Factor</th>
<th>Goal (% of total energy unless otherwise stated)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Fat</td>
<td></td>
</tr>
<tr>
<td>Saturated fatty acids</td>
<td>16-30%</td>
</tr>
<tr>
<td>Polyunsaturated fatty acids (PUFAs)</td>
<td>&lt;10%</td>
</tr>
<tr>
<td>n-6 Polyunsaturated fatty acids (PUFAs)</td>
<td>6-10%</td>
</tr>
<tr>
<td>n-3 Polyunsaturated fatty acids (PUFAs)</td>
<td>5-8%</td>
</tr>
<tr>
<td>Trans fatty acids</td>
<td>1-2%</td>
</tr>
<tr>
<td>Monounsaturated fatty acids (MUFAs)</td>
<td>&lt;1% By difference</td>
</tr>
<tr>
<td>Total Carbohydrate</td>
<td></td>
</tr>
<tr>
<td>Free sugars</td>
<td>55-75%</td>
</tr>
<tr>
<td>Protein</td>
<td>&lt;10%</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>10-15%</td>
</tr>
<tr>
<td>Sodium chloride</td>
<td>&lt;300mg/day</td>
</tr>
<tr>
<td>Fruit and vegetables</td>
<td>&lt;5g/day</td>
</tr>
<tr>
<td></td>
<td>&gt;400g/day</td>
</tr>
</tbody>
</table>

The sixty-third World Health Assembly in May 2010 endorsed resolution WHA63.14 which called for national and international action to reduce the impact on children of marketing of foods high in saturated fats, trans-fatty acids, free sugars, or salt.

Standards and guidelines related to texts for food products have been developed by Codex Alimentarius, but as described in the recent review of the global regulatory environment, there is considerable variation of approaches and regulations in countries across the world. WHO is working to provide guidance in developing or adapting nutrient profile models. The aim of this work is to harmonize nutrient profile model development to produce consistent and coherent public health nutrition messages for the consumer and ultimately improve nutrition and public health. Based on such nutrient profiles claims on food labels and in marketing for being “low fat” or “healthy choice” can be regulated by national food standards authorities. The food industry has also pledged to self regulate, but very stringent standards are needed if self regulation is to be effective. Besides which the voluntary nutrition-labelling adopted by the food industry in the USA is considered far from ideal in many ways.
The WHO Report 916 also recommended a goal for physical activity which focuses on maintaining healthy body weight. The recommendation is for a total of one hour per day of moderate-intensity activity, such as walking, on most days of the week. This is different from the widely recognized public health recommendation of half an hour a day of moderate physical activity, which while appropriate for the reduction of cardiovascular risk doesn’t reduce risk for all of the other NCDs. These recommendations are for people who are otherwise largely sedentary and don’t take into consideration the exercise provided by occupational activities such as cleaning for example. They are not intended for populations that are involved on a daily basis in heavy physical labour in order to gain a living, produce food and/or collect firewood for example.

At the World Health Assembly in 2010 resolution WHA63.23 was adopted calling on member states to increase political commitment in order to prevent and reduce malnutrition in all its forms, and to scale up interventions to improve infant and young child nutrition. The WHA also called on the Director General to provide support to member states in expanding their nutrition interventions and to develop a comprehensive implementation plan as a critical component of as global multi-sectoral nutrition framework. A summary report to the 64th World Health Assembly in 2011 provided a summary outline of a draft comprehensive implementation plan for maternal, infant and young child nutrition, which deals with double burden of undernutrition and overweight. Four background papers are being drafted to aid preparation of the draft plan.

The FAO Committee on World Food Security of as part of its reform, is also developing a Global Strategic Framework for Food Security and Nutrition, that will build upon existing frameworks such as the UN’s Comprehensive Framework for Action (CFA), the Comprehensive Africa Agriculture Development Programme (CAADP), and the Voluntary Guidelines to Support the Progressive Realization of the Right to Adequate Food in the Context of National Food Security.

The Global Strategy for the Prevention and Control of Non-communicable Diseases action plan concerns working in partnership to control 4 non-communicable diseases: cardiovascular diseases, diabetes, cancers, and chronic respiratory diseases, and is limited to just four shared risk factors: tobacco use, physical inactivity, unhealthy diets and harmful use of alcohol. Overweight and obesity control obviously need to be dovetailed into these, and this should be ensured at the country level. With the new evidence of the importance of the inflammatory state of obesity associated with spectrum of conditions linked to the metabolic syndrome, it makes even more sense to ensure that overnutrition aspects are adequately dealt with in the prevention and treatment of non-communicable diseases in LMICs. Treating obesity as a disease would seem to be an important if not essential element of any national plan to prevent and control cardiovascular diseases, diabetes and cancers.
Many if not most countries have national policies for both under and overnutrition but few are implemented at any sort of scale. The Lancet Nutrition Series Paper on effective action at the national level reported that most of the twenty countries with the highest burden of stunting had national level nutrition policies with programmes to tackle maternal and child undernutrition, but that few if any of these had nationwide coverage. The Global Status Report on non-communicable diseases 2010 included overweight and obesity as one of the main risk factors for NCD mortality together with tobacco use, insufficient physical activity, harmful alcohol use, unhealthy diet, raised blood pressure, raised cholesterol, and cancer-associated infections. Indeed most countries seem to organize the resolution of overweight and obesity problems as part of their NCD efforts, although not many seem to be very actively implementing any activities. Just 68% of countries are reported to have a written policy, plan or strategy for overweight/obesity control with only 48% of these said to be operational.

The action plan for food and nutrition policy agreed by the countries of the WHO European Region for the period 2000-2005 recommended developing integrated and comprehensive national food and nutrition policies that address three areas of nutrition security: public health nutrition; food safety; and sustainable food security. Most countries in Europe have such food and nutrition policies in place that could help to ensure that nutrition security is realized. But while legal provisions and entitlements exist for food security and food safety in most countries, public health nutrition still lags behind. While half of the countries have nutrition councils or bodies that provide scientific advice to politicians, less than a third have administrative structures to help ensure that such policies are implemented.

We can conclude that although there are many global policies for each of the bits of the DBM, there are very few if any of these which recognize each other or them all as part of a whole. Some of the policy guidance comes down through Ministries of Health and some through Ministries of Agriculture. That through the Ministry of Health is split between departments of nutrition and departments of noncommunicable diseases. How to bring all of this together into comprehensive DBM policy umbrella that spans the life course is a challenge that few countries have mastered, be it in LMICs or the richer ones.

6.2 Programmes for tackling the DBM.
Programmes for tackling the DBM obviously need to consider both preventive and curative approaches across the whole life course. It has been proposed that a series of such programmes need to cover five age groups: foetal life; infancy and childhood; adolescence; adult life; and old age. The argument being it is the so-called nutrition-infection complex which determines, in large part, how children grow and develop mentally. While in later life, the so-called diet-physical activity interactions greatly affect what diseases we will most likely suffer during our lifespan and, finally, how we will age and die. The factors operating in any stage of the life course have effects on both nutritional status and health at that stage of the life-course, but also cumulatively affect later phases. Indeed the protection of foetal and early childhood growth should be
seen as primary preventive interventions for both early life course undernutrition and later life course overnutrition.\textsuperscript{213}

A recent analysis of the international nutrition system published in the Lancet Nutrition Series\textsuperscript{214} considered the system to be fragmented and dysfunctional, and called for a more functional international nutrition system which is connected to and serves the needs of the national nutrition systems, which should be its building blocks.\textsuperscript{215} The LNS was unfortunately limited however in that it only considered maternal and child undernutrition. A national nutrition system obviously needs to be constructed which can deal with both under nutrition as well as overnutrition.

A framework which includes the interventions that can contribute to the preventions of the DBM across the life course is shown in Table 1. This builds on the table proposed Gillespie and Haddad\textsuperscript{216} in 2001 for reducing DBM in Asia, but drawing on the more recent Lancet Nutrition Series evidence base for interventions for tackling maternal and child undernutrition\textsuperscript{217} as well as recent reviews of evidence on interventions for tackling overweight and obesity\textsuperscript{218 219}. The table includes both direct and indirect nutrition interventions, and is organized by stages of the life course. Direct interventions are those targeted at the individual level, and have also been termed “nutrition specific” interventions in the SUN Framework. These include nutrient supplements, food supplements, nutrition education, and food fortification. Indirect interventions are those delivered at the level of the household or community, and include cash transfers, and fiscal policy instruments as well as codes of practice concerning marketing of foods. The SUN terminology for these is “nutrition sensitive”.

\newpage
The first priority in tackling the DBM, especially in LMICs, must be to tackle maternal and child undernutrition. In this respect, efforts to tackle the DBM must build on the efforts of SUN to scale up proven interventions for tackling maternal and child undernutrition, not detract from them. The SUN should also be constructed from the beginning with a view to basing all interventions on the human rights principles of accountability, participation, and non-discrimination, and fit them under broader national strategies for the realization of the right to food adopting a life-course approach in order to improve their effectiveness and their ability to contribute to sustainable,

Table 2 Life course interventions for tackling the double burden of malnutrition

<table>
<thead>
<tr>
<th>Stage of life course</th>
<th>Direct interventions</th>
<th>Indirect interventions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conception to birth</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Micronutrient (iron/folate) supplements</td>
<td>Prevent child marriage and teenage pregnancies</td>
</tr>
<tr>
<td></td>
<td>balanced protein energy supplements*</td>
<td>Conditional cash transfer programmes (with nutrition education)</td>
</tr>
<tr>
<td></td>
<td>deworming</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reduction of household/cigarette smoke</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Presumptive radical treatment for malaria*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Insecticide-treated bed nets*</td>
<td></td>
</tr>
<tr>
<td>Young Children (0-5 years)</td>
<td>exclusive breastfeeding promotion,</td>
<td>Code of marketing of breastmilk substitute</td>
</tr>
<tr>
<td></td>
<td>appropriate complementary feeding promotion</td>
<td>Conditional cash transfer programmes (with nutrition education)</td>
</tr>
<tr>
<td></td>
<td>Hand washing and hygiene interventions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>young child supplementation with vitamin A and zinc,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>management of severe acute malnutrition</td>
<td></td>
</tr>
<tr>
<td>Children (5-18 years)</td>
<td>School based</td>
<td>No vending machines or junk food sales in schools</td>
</tr>
<tr>
<td></td>
<td>o providing healthy meals</td>
<td>No advertising of food aimed at children</td>
</tr>
<tr>
<td></td>
<td>o promotion and provision of daily physical exercise</td>
<td></td>
</tr>
<tr>
<td></td>
<td>o Weekly iron supplements/deworming</td>
<td></td>
</tr>
<tr>
<td>Adulthood (18+yrs)</td>
<td>Medical service provider counselling on healthy diet</td>
<td>Food labelling</td>
</tr>
<tr>
<td></td>
<td>Worksite encouragement to exercise and eat healthy foods</td>
<td>o Nutrition signposting</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o Control food claims</td>
</tr>
</tbody>
</table>

* indicates interventions that might be required if not already included in programs that are already in place.
long-term solutions across the life course. Furthermore appropriate steps should be taken to ensure that such interventions strengthen local food systems and favour the switch to sustainable diets\(^{220}\).

For the foetal and early child stages of the life course, direct interventions are largely provided through the health services, and if this package of essential nutrition interventions for the period of conception to 2 years were taken to scale in LMICs at observed levels of programme effectiveness they could prevent about one-quarter of child deaths under 36 months of age and reduce the prevalence of stunting at 36 months by about one-third\(^{221}\). Such direct nutrition interventions programmes are not only more likely to be successful but also to be sustained if they include a community based component\(^{222} \, 223\). Adequate community outreach is essential in order to ensure a high coverage of the continuum of care with essential nutrition interventions across the three modalities of service delivery (health post based, periodic outreach, and community-based activities) from conception through to two years of age\(^{224}\).

In addition to the well recognized benefits of breastfeeding in reducing mortality in infants and young children, there is increasing recognition of its benefits for preventing overweight/obesity later in the life course. Suboptimal breastfeeding, especially non-exclusive breastfeeding in the first six months of life, results in 1.4 million deaths and 10% of the disease burden in children younger than five years\(^{225}\). Recent research also suggests that exclusive breastfeeding during early months is central to the mechanism by which breastfeeding protects against later obesity\(^{226}\). Future growth seems to be programmed during the first six months of life, when normal growth in exclusively breastfed babies is much slower than in bottle fed ones. Furthermore there is a ‘dose–response’ effect for the prevention of obesity, since a longer duration of breastfeeding is associated with lower tendency to later obesity. The risk of being overweight is 20% greater if exclusively bottle fed than exclusively breastmilk fed during the first six months of life.

There is great international interest in and enthusiasm for cash transfers (CTs) as a more sustainable way to provide social protection than giving food aid. There are two types of CT: Unconditional CTs are given to poor and vulnerable people with no restrictions on how the cash is spent, and no requirements beyond meeting the eligibility criteria. By contrast, conditional cash transfers (CCTs) are delivered only on condition that recipients meet certain requirements, such as that their children should be enrolled in and attending school, and/or must be immunized, etc. Effective implementation of CT programmes requires adequate and sustained financing, administrative and management capacity, and political commitment. Finely targeted CCTs may be more fiscally affordable than universal transfers, but delivering these transfers every month, in full and on time presents challenges, especially where physical infrastructure and logistical capacity are constrained. Where government capacity and budget allocations for monitoring and supervision are limited, these programmes can be vulnerable to ‘leakages’ and corruption\(^{227}\). Evidence of a nutritional impact of CTs is still very
limited, especially beyond Latin America\textsuperscript{228\textendash}229\textsuperscript{230}, where the Progressa programme does some show some impact and is the gold standard\textsuperscript{231\textendash}232.

Evidence for the efficacy of interventions for the prevention of obesity are more limited to the school age and adults, where direct interventions are carried out in a variety of setting including, schools, medical service and workplaces. Schools have been found to be the critical setting for preventing child obesity\textsuperscript{233}, as well as reducing other chronic disease risk factors and improving fitness\textsuperscript{234}. Most US states have adopted laws that regulate the availability of sugar sweetened beverages in school settings\textsuperscript{235}, and in France and the UK vending machines have either been banned in schools or are no longer filled with sugar sweetened beverages or Type 3 processed snack foods. These interventions being implemented based on the recognition that excessive consumption of sugar sweetened beverages is an important driver of the current obesity epidemic in the USA\textsuperscript{236}, and is associated with a significantly elevated risk of type 2 diabetes\textsuperscript{237}.

School based programmes should cover the role of both nutrition and physical activity in maintaining physical and mental health, with school food services providing healthy meals and the promotion and provision of daily physical exercise as part of the curriculum. An example is provided by the Nutrition Friendly Schools Initiative (NFSI)\textsuperscript{238} which aims to increase access and availability of healthy foods as well as opportunities to be physically active, and to decrease access and availability of unhealthy or "junk" foods as well as support healthy lifestyles. It has been tested in California with some success\textsuperscript{239}, and in LMICs should be expanded to include micronutrient and life-skill interventions aimed at adolescents especially in order to control anemia as achieved so successfully in Uttar Pradesh, India\textsuperscript{240}.

Worksite interventions, by offering education, screening for risk factors, offering incentives to walk or ride a bike to work and facilities for exercise during breaks, as well as healthy foods in cafeterias, can reduce staff sick days and health costs to the benefit of both employers and employees. An example is provided by Johnson & Johnson which introduced Live for Life in 1979 and by the end of the third year savings to the company were more than US$400 per year per employee\textsuperscript{241}. A recent systematic review of worksite nutrition interventions provides further support to these findings\textsuperscript{242}.

Interventions by health care providers can also be very effective, especially if they are trained to measure BMI and/or waist circumference, so that they can detect patients who are either overweight and/or gaining weight. Even brief messages about nutrition through diet counseling can influence behavior and the magnitude of the effect is related to the intensity of the intervention\textsuperscript{243}. A more recent meta analysis confirmed these findings\textsuperscript{244}.

Transport policy and environmental design have fundamental effects on the determinants of physical activity and therefore influence the risk of obesity and other chronic diseases. The availability, accessibility and convenience of destinations and facilities, as well as the general functionality of the neighbourhood (e.g., the presence of sidewalks, traffic conditions) and aesthetics have been shown to be positively associated
with various levels of physical activity. Urban planning can play an important role in increasing opportunities for exercise, and local governments have an important role to play, be it through creating parks and open spaces for exercise as well as bike lanes, and pavements to encourage pedestrians. Limiting the role of automobiles is one important area for interventions and this can be achieved by a variety of channels including making private car ownership and use more expensive. This can be achieved by raising taxes on cars as well as on fuel, introducing road tolls and congestion charges, as well as parking fees. The fees collected can be used to improve the provision of public transportation.

Improved food supply can be achieved by a variety of methods including better processing and manufacture, fortification, increasing access to healthy foods and curtailing marketing of ultra-processed foods. An example of improved processing is the elimination of trans fatty acid, which has been largely achieved by modifying the process of hydrogenation of vegetable oils. This has been achieved both through legislation and manufacturers complying with public health directives. In Mauritius the government required a change in the commonly used cooking oil from palm oil to soybean oil, changing people’s fatty acid intake and reducing their serum cholesterol levels. Fortification of foods also allows improved dietary intake, such as in salt iodization for example, which has allowed over a billion people globally to no longer suffer from iodine deficiency.

Policies regarding the production, importation, distribution and sale of specific foods can also influence their cost and availability. Food stamps can be linked to purchase of fruit and vegetables in local farmers markets for example as is done in the USA where the USDA Federal nutrition assistance programs provided about $10 billion in support of fruit and vegetable consumption in Fiscal Year 2005. These funds support the purchase and distribution of fruits and vegetables by USDA to schools, food banks, and other program providers; purchase and use by programs providers through the Child Nutrition Programs, and participants’ purchases in the marketplace through Food Stamps, WIC, and the farmer’s market nutrition programs. Consumers can also be protected from aggressive marketing of unhealthy foods, such as in Brazil for example which has banned television advertising of foods aimed at children. Most US states have adopted laws that regulate the availability of sugar sweetened beverages in school settings, and similar measures have been introduced in France and the UK where vending machines have been banned in schools.

Fiscal policies such as subsidies and taxes can either stimulate or reduce consumption of products including foods. Capitalist economics has been considered to have a central role in the global obesity epidemic, and economic policies arguably the optimal target for intervention. The heavy tax on cigarettes certainly helped reduce their consumption in many countries for example. Poland provides an example for food, where reduced subsidies on lard and butter soon after the transition to a democratic government, resulted in a rapid increase in the consumption of cheaper non-hydrogenated vegetable fat. In consequence the ratio of dietary polyunsaturated to
saturated fat increased from 0.33 in 1990 to 0.56 in 1999 and mortality from CAD dropped 28%\textsuperscript{252}. A tax on sugar sweetened beverages has many proponents, and if sufficiently large (20%) has great potential to reduce obesity as well as to raise revenues\textsuperscript{253}. The food industry has also pledged to self regulate, but it seems that very stringent standards are needed if self regulation is to be effective\textsuperscript{254}.

Public education campaigns to promote a “healthy diet” can be effective, especially if it is a direct intervention delivered through medical services or in schools. Healthy diets based on the food group and pyramid approach have been much criticized, not least because during the thirty years of the food pyramids obesity rates in the US have soared. In an effort to restructure US food nutrition guidelines, the USDA revised them in 2010\textsuperscript{255} and has now rolled out its new MyPlate program. My Plate is divided into four slightly different sized quadrants, with fruits and vegetables taking up half the space, and grains and protein making up the other half. The vegetables and grains portions are the largest of the four.

One of the problems with the food pyramid based dietary guidelines was that it was more about “what to eat” than “how much to eat”. The original food pyramid aimed at limiting fat intake, and in general seems to have had an effect, with low fat diets and special “light” foods becoming very popular. But with no differentiation between types of fats, the benefits of the “good” unsaturated fats were forgone\textsuperscript{256}. Also guidelines have recommended consumption of a lot more starchy foods, and in particular grains (cereals) and cereal products, with little or no consideration given to the benefits of eating reduced carbohydrate diets\textsuperscript{257}. The text of such recommendations often gives preference to ‘minimally processed’ or ‘high-fibre’ or ‘wholegrain’ versions. However the cereal part of the pyramid doesn’t differentiate between the types of processing that the cereal and/or starches have been subject to\textsuperscript{258}. An over emphasis on some of the food groups, such as meat, milk and bread for instance, is said to be the result of industry pressure\textsuperscript{259}, and this is not surprising since the guidelines are used to determine the content of school curricular, the content of school lunches, as well as the food distributed through welfare channels. As a result of lobbying, potatoes have been classified as vegetables\textsuperscript{260} and more recently even pizza was classified as such by the US Senate\textsuperscript{261}.

Labels which describe the nutrition content of foods can in theory permit the more discerning consumer to make more informed purchases. Evidence for the effectiveness of “front of pack” labelling is still weak however\textsuperscript{262}. Nutrition labels on pre-packaged foods, which are among the most prominent sources of nutrition information, are perceived as highly credible sources and many consumers use nutrition labels to guide their selection of food products. Evidence also shows a consistent link between the use of nutrition labels and healthier diets. However, the use of labels varies considerably across subgroups, with lower use among children, adolescents and older adults who are obese. Labels are most used by educated and richer segments of population.
Standards and guidelines related to texts for food products have been developed by Codex Alimentarius, but as described in the recent review of the global regulatory environment, there is considerable variation of approaches and regulations in countries across the world\textsuperscript{263}. Nutrient profiling permits the classification and/or ranking of foods according to their nutritional composition. Such classifications can be used for various applications, including marketing of foods to children, health and nutrition claims, product labelling logos or symbols, information and education, and the provision of food to public institutions. WHO is working to provide guidance in developing or adapting nutrient profile models\textsuperscript{264}. The aim of this work is to harmonize nutrient profile model development to produce consistent and coherent public health nutrition messages for the consumer and ultimately improve nutrition and public health. Based on such nutrient profiles claims on food labels and in marketing for being “low fat” or “healthy choice” can be regulated by national food standards authorities. The food industry has also pledged to self regulate, but very stringent standards are needed if self regulation is to be effective. Besides which the voluntary nutrition-labelling adopted by Industry in the USA is considered far from ideal in many ways\textsuperscript{265}.

All of the OECD has set themselves objectives and targets for tackling overweight and obesity, and are developing interventions\textsuperscript{266}. The large majority of these interventions are aimed at improving diets rather than increasing physical activity. The latter are most typically pursued at the local level particularly through community based efforts. The most common target group is children and a largest number of interventions are school based. Interventions aimed at tackling obesity by improving diets and increasing physical activity in at least three areas, including: health education and promotion; regulation and fiscal measures; and counseling in primary care, have favourable cost-effectiveness ratios. The health impacts of individual interventions are small, when interventions are assessed in isolation, but the use of multiple-intervention strategies may significantly enhance overall impacts while retaining a favourable cost-effectiveness profile. Interventions, especially those aimed at children, may take a long time to make an impact and reach favourable cost-effectiveness ratios. Impacts on health expenditure are relatively small (in the order of 1% of original expenditures for the relevant diseases), intervention costs exceed health care cost savings for most interventions. Interventions with the most favourable cost-effectiveness profiles are outside the health care sector. Counselling of individuals at risk in primary care has the largest health impact, but is also the most expensive intervention of those assessed in the analysis. The distributional impacts of interventions are mostly determined by differences in morbidity and mortality among socio-economic groups. Fiscal measures are the only intervention producing consistently larger health gains in the less well-off.

Evidence coming from Australia suggests that community based approaches can also effective in reducing and controlling overweight and obesity\textsuperscript{267}. Not surprisingly, effective involvement of the right stake holders is important for community based efforts to work\textsuperscript{268}. Different sectors of national and local government, local leaders, local councils, sport associations, parent-teacher associations, and clubs, NGOs,
academics, the media and the private sector need to be implicated and involved in different forms of dialogue and partnerships. The establishment of a good governance mechanism is central, as well as effective channels of communication stakeholders. Stakeholders can commit human and financial resources to the project, as well as establish or review their practices to comply with the project objectives. Community interventions are supported by public funds (national or local), as well as by charities and other private sources, including corporate sponsorships. Whenever this happens it is important to emphasize the need for transparency, public disclosure and strict ethical rules, especially when the funding is accepted from private sources that might have a conflict of interest with the project objectives.

6.3 Nutrition Capacity and Governance
When considering how to tackle the DBM problem in LMICS the renewed momentum to act in nutrition gathering pace across the globe could, should and must be built upon. A process of dialogue called SUN (Scaling up Nutrition)\textsuperscript{269} developed during the last two years has been widely endorsed by over 100 international development institutions which recognize that development funding for nutrition interventions to reduce maternal and child undernutrition has been far too small\textsuperscript{270}, especially considering the negative consequences it brings in terms of mortality and morbidity and for human capital development. The SUN movement recognizes that taking to scale a package of evidence based high impact nutrition interventions such as those proposed in the Lancet Nutrition Series\textsuperscript{271} will not only prove to be a very cost effective over the long run, but will also make a big contribution to achieving most of the Millennium Development Goals.

The SUN movement has a agreed a Framework\textsuperscript{272}, which calls on all partners to scale up efforts against maternal and child undernutrition by among other things: 1) developing a coordinated, multi-stakeholder approach; 2) using the Paris Accra Principles of Aid Effectiveness; 3) Mobilizing key stakeholders in an inclusive approach to country ownership, 4) Using the “Three Ones”, namely:- One agreed overarching policy framework that provides the basis for coordinating the work of all partners; -One national coordinating authority; -One agreed national monitoring and evaluation system; 5) Develop strong prioritized country nutrition strategies that while grounded in country specificity: -take particular account of the “window of opportunity” from conception to two years of age; -be multi-sectoral, linking agriculture and food security, social protection and public health; -and include elements of capacity development and monitoring and evaluation.
Table 3. The Four Overarching Pillars of DBM Nutrition Policy Framework

<table>
<thead>
<tr>
<th>Sector</th>
<th>Sustainable Food Security</th>
<th>Food Safety</th>
<th>Healthy Lifestyle</th>
<th>Nutrition</th>
</tr>
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<tbody>
<tr>
<td>Health</td>
<td></td>
<td>• Food safety and hygiene regulations</td>
<td>• Promotion of healthy eating</td>
<td>• Micronutrient supplementation</td>
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<td></td>
<td></td>
<td>• Food Inspections</td>
<td>• Promotion of exercise</td>
<td>• Nutrition education</td>
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<td></td>
<td></td>
<td>• Food standards</td>
<td>• Infection Control</td>
<td>• Dietary Guidelines</td>
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<td></td>
<td></td>
<td></td>
<td>• Family Planning</td>
<td>• Nutritional surveillance</td>
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<tr>
<td>Public Works/urban development</td>
<td>• Rural roads</td>
<td>• Water and Sanitation</td>
<td>• Urban bike lanes</td>
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<tr>
<td></td>
<td>• Irrigation</td>
<td></td>
<td>• Pedestrian walkways</td>
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<tr>
<td>Agriculture</td>
<td>• Food availability</td>
<td>• Food standards</td>
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<tr>
<td></td>
<td>(Food production)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td>• School gardens</td>
<td>• Hygiene education</td>
<td>• Physical exercise</td>
<td>• Nutrition education</td>
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<td></td>
<td>• School meals</td>
<td></td>
<td>• Life skills and sex education</td>
<td>• Anaemia control</td>
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<tr>
<td>Social Welfare/Security</td>
<td>• Food Access (cash transfers)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industry/Trade</td>
<td>• Food availability</td>
<td>• Food Standards</td>
<td>• Food fortification</td>
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<tr>
<td></td>
<td>(manufacture and marketing)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Public Information</td>
<td></td>
<td></td>
<td>• Marketing of food to children</td>
<td>• Code of marketing of breastmilk substitutes</td>
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<tr>
<td>Finance/economy</td>
<td>• Food Subsidies</td>
<td></td>
<td></td>
<td>• Food Taxes</td>
</tr>
<tr>
<td></td>
<td>• Import/export restrictions</td>
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Although the SUN movement is focussed on maternal and child undernutrition, it is important to recognise that this is one of the most important first steps LMICS should be taking to prevent the DBM in the future. All of these global nutrition initiatives propose the use of multi-sectoral approaches, which necessarily require some sort of mechanism to coordinate/articulate the various sectoral policies and programme efforts. The Commission on Nutritional Challenges of the 21st Century put improved coordination and functionality for nutrition at the centre of its recommendations, considering this essential for developing more coherent national nutrition policies and programmes for tackling the DBM problem.

Experience with trying to implement the National Plans of Action for Nutrition (NPAN) stemming from the International Conference on Nutrition (ICN) in early nineties also suggests that some central coordination mechanism was essential for successful implementation. The ICN efforts to implement national nutrition programmes, which were for both over and undernutrition, also showed that the strategies from the different sectors involved could be best grouped into the four pillars, as described in Table 3 above. This overarching DBM policy framework was found to facilitate the attribution of service delivery functions both within the Ministry of Health as well as across other sectors and the setting of broad responsibilities in terms of goals and strategies to achieve them, and is presented as an illustrative example of how such a high level coordinating body might be organized to help facilitate the full range of programmes involved in tackling the DBM across the life course.

There are few good examples of such high level coordination mechanisms and of implementation of nutrition programmes at scale, be it in one sector or many or for undernutrition let alone overnutrition. Perhaps the most advanced nation state in this regard is Brazil, where during the last few decades there has been a spectacular fall in child undernutrition, as measured by stunting in particular. Brazil has a high level coordinating body for oversight and broad policy setting, as well as a coordination mechanism for implementation (see Box1), Although still largely focused on “hunger” a plan for the prevention and control of obesity is apparently being developed.

Evidence from the WHO led Landscape Analysis Country Assessments (LACA) done in many low and middle income countries (LMIC) over the last few years, indicates that the capacity to act in nutrition is very often quite limited, both at national and district levels. Improving capacity at all levels of the health system through creating master’s graduates down to improving health professional in-service training is a common recommendation of LACA reports. Very few of these LMIC countries have academic centers that provide formal nutrition training however. So how to develop this capacity is obviously a challenge.
The capacity to act in nutrition has been signalled as a critical element limiting the large scale implementation of nutrition programmes for several decades. The need for a more balanced approach, not only looking at the “what to do” but also looking at the “how to do” has been a recurrent theme among nutritionists concerned with the application of nutrition science. While several reviews prior to the LNS interventions paper confirm that the “what” of undernutrition to be reasonably well established, and a considerable body of experience exists on working out the “how” in various developmental settings across the globe, the capacity to act, or to implement such activities at scale in the LMICs most affected, has consistently been found to be lacking. Indeed the LNS national level assessment confirmed yet again, the capacity to train in how to manage and implement nutrition programmes in such LMICs is virtually non-existent. The World Public Health Nutrition Association aims to promote the development of the nutrition workforce capacity, thus offering an opportunity to standardize such processes across countries, and eventually to allow a process of professional certification.

We shouldn’t be surprised that the capacity to act in nutrition is so little developed in LMICS. Until the SUN movement, the dominant development paradigm has been a trickle down one, with undernutrition expected to be fixed by economic development. This is because nutrition is a relatively young science, with most of what we know

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**Box 1: HIGH LEVEL NUTRITION COORDINATION AND GOVERNANCE IN BRAZIL**

Brazil’s Zero Hunger Strategy involves 11 ministries in partnership with civil society which makes up the National System for Food and Nutrition Security established by law in 2006, requiring the State to enforce the universal right to food and nutrition security as a public policy. Through this system, the Government agencies at national, state and municipal levels, together with civil society organizations, must act jointly in the formulation and implementation of policies and actions to combat hunger and promote food and nutrition security.

Monitoring of the implementation of the policy and approval of the budget is carried out by a National Council on Food and Nutrition Security (CONSEA) which brings together 18 State Ministers and 36 representatives of civil society and is directly linked to the Presidency of the Republic. In addition there is an inter-ministerial coordination mechanism for agreeing who does what and how in implementation at all levels especially between the ministries of Health, Education and Social Welfare.

Between 1996 and 2006/07, Brazil reduced child stunting from 13.5% to 6.8% nationally, and with spectacularly decline from 22.2% to 5.9% in the Northeast, the country’s poorest region. These achievements were largely due to the Zero Hunger Strategy, the cornerstone of which is a conditional cash transfer programme called “Bolsa Familia” benefiting 11 million poor families on the condition that they comply with an agenda for keeping children in school and for health monitoring.
being discovered in the last few decades\textsuperscript{291}. While the first recommended nutrient intakes in the USA in 1941 included just eight vitamins and minerals, some forty years later they covered 24 nutrients\textsuperscript{292}. Furthermore it is only in the last decade that the enormous society wide benefits that results from improving undernutrition have been properly understood\textsuperscript{293}, and it has become accepted that economic development alone only reduces the problem of maternal and child undernutrition very slowly\textsuperscript{294}, while the costs of tackling the problem rapidly are relatively small\textsuperscript{295}. Furthermore the obesity epidemic which is now affecting most nations, only really took off thirty years ago. In order to tackle the avalanche of nutrition related chronic diseases that seems set to overtake most LMICs in the next few decades, efforts to scale up the capacity to act will obviously need to be a major focus of attention.

We can conclude that the capacity to act in nutrition is very limited in most LMICs and what little there is, is restricted to undernutrition and limited to the health service. Both the SUN movement and any effort to tackle the DBM require a multi-sectoral approach, which will be difficult to implement successfully unless high level coordination mechanisms are in place with capacity to allocate budgets to those participating. Nutrition governance mechanisms may exists in many LMICs, but few if any of them approve budgets and have any real authority. Creating the capacity to act to deliver nutrition specific interventions through the health sector to tackle maternal and child undernutrition is the first priority both for reducing undernutrition now, as well as reducing the risk of diet related non-communicable diseases later in the life course. In the mean time the capacity to deliver multi-sectoral programme needs to be created.

7. Conclusions

In conclusion we can predict that most LMICs can expect rapidly increasing levels of overweight and obesity in adults that will produce an increased burden of insulin resistant diabetes and cardiovascular diseases as a result of their economic growth. These changes are summarized in Figure 2 below showing the multitude of factors which influence the development of the DBM across the life course, which is an “updated” version of the one in the SCN document entitled “Ending Malnutrition by 2020: An Agenda for Change in the Millennium”. It describes how the increasing numbers of young people migrating to urban areas are more likely to be stunted due to constrained foetal and young child growth and become exposed to increasingly obesogenic urban environments. Within just a few more decades two thirds of the global population will reside in urban areas of current LMICs. People in urban environments are becoming increasingly exposed across their life courses to relatively cheap energy dense processed foods that are artificially cheap due to US and EU subsidies. Furthermore most people in LMIC urban environments have decreased energy expenditures due to sedentary occupations and life styles, with little opportunity and/or space to get adequate exercise. Unless urgent measures are taken to prevent this chain of events, either by reducing the exposure to energy dense processed foods, and/or
increasing exercise levels across the life course the impact on future health expenditures will be crippling and unsustainable.
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