

Diet-related conditions that increase the risk of chronic diseases

Fetal programming

There have been extensive reviews of the effects of fetal and infant insults on health. David Barker and colleagues at the University of Southampton [11–13] have brought into mainstream medical literature the notion of metabolic programming, i.e., that insults operating at a critical period in early life result in long-term changes in the structure or function of humans and also a range of animal models [50].

Fetal and perinatal insults are combinations of undernutrition of the mother and fetus or child, caused by diets that are low or deficient in key micro- and macronutrients. In the case of obesity in later life, the hypothesis is that fetal growth retardation results in metabolic changes that are adaptive to nutritionally stressful circumstances *in utero*. A similar argument can be made for postnatal growth retardation, manifested as stunting. As the child grows, the metabolic efficiencies that were necessary to cope with undernutrition become maladaptive to subsequent overnutrition, leading to the development of abnormal lipid profiles, altered glucose and insulin metabolism, and obesity. Such fetal programming does not by itself lead to increased morbidity and mortality. Rather, it shifts metabolism such that LBW infants become more susceptible to obesity, adult-onset diabetes, and CVD when faced with a richer, more energy-dense diet, reduced physical activity, and increased adiposity, as children or as adults.

Evidence that supports the fetal programming hypothesis is growing on two fronts. First, there is extensive literature on the effects of experimental manipulation of the pre- and early postnatal environment in animals [50]. Second, most of the limited studies on humans have been done in developed countries, although studies in developing countries are beginning to emerge [51]. Studies on humans are difficult because they require detailed information about status at birth, early postnatal growth, and health or anthropometric status in later childhood and adulthood. The few studies done have generally relied

on current status assessment of children or adults, with data for infancy obtained from medical records linking birth status with later hypertension, diabetes, and CVD [50].

There are two critical questions regarding the results and applicability of this work. First, although the epidemiology indicates a clear relationship between fetal programming and later life, is this the result of continuation of the same insults to the fetus and infant, or are there impacts during pregnancy and infancy that affect the biology of the individual in ways that subsequent environmental factors cannot? Second, the mechanisms for this relationship are not well understood and therefore interventions cannot be guided precisely [19, 20]. The most important studies on this in Asia are those that have measured not only the prenatal environment and pregnancy outcomes, but also environmental insults after infancy, (e.g., in the Philippines [22, 52, 53]).

Some of the best reviews are those of these early nutrition insults on hypertension, adult-onset diabetes, and CVD, e.g., a meta-analysis of studies linking birthweight with blood pressure [54]. The 27 best studies show a range of reductions in systolic blood pressure of 1.3 to 2.10 mm of Hg (average, 1.7) per one kg increase in birthweight, over birthweights ranging from 1 to 5 kg. However, these studies either excluded or neglected to consider the very high birthweights related to gestational diabetes. The research on diastolic blood pressure is weaker and less consistent, with reductions in the range –0.3 to –1.7 mm of Hg per kg increase in birthweight. It is clear that obesity potentiates this birthweight-hypertension relationship. Moreover, with every decade of age, the reduction in systolic blood pressure with birthweight increases by 0.35 mm of Hg per kg.

Fewer studies have examined the relationship between birthweight and adult-onset diabetes [13]. Insulin production and insulin resistance, both important in the etiology of adult-onset diabetes, appear to be affected by fetal development, but it is hard to select a specific risk ratio (RR). For CVD, although its

definitions have not always been consistent, a general result is clear. LBWs, in particular low PI births, appear to be strongly positively related to CVD [13, 50].

It has been suggested [11, 55] that long-term health risks are greater for disproportionately IUGR infants, i.e., those who are thinner (low PI). Recent research has shown that subsequent catch-up growth and obesity are needed for fetal programming to be expressed [50]. This would lessen the risk of CVD in Asians, compared to those born in high-income countries, because a much smaller proportion of babies born in Asia have low PIs [50]. A study in the Philippines [22], where 36.7% of a population of LBW babies had low PIs, is cited above. Further studies of this same birth cohort showed that girls who were relatively thin at birth, but who grew rapidly in the first six months, had earlier menarche.* Similarly, it has been shown that girls who were relatively thin at birth but relatively fat as adolescents had higher blood pressure and total cholesterol than those who stayed thin, or those who were relatively heavy at adolescence but not thin at birth [53].

As with adult-onset diabetes, the risk of CVD for LBW or LBW-low PI births seems to be compounded by subsequent adiposity. It has been suggested [19] that this relates to a different mechanism than that proposed by Barker [11–13]. It is clear, however, that individuals from LBW and LBW-low PI births are at a two- to four-fold greater risk of CVD in the environments studied to date. This means that the remarkable nutrition transition in Asia and the Pacific will lead to far worse CVD morbidity patterns than might be expected from current and recent high levels births and fetal programming effects.

Postnatal effects: stunting

Underweight during infancy and stunting in early childhood are risk factors for subsequent obesity. In some cases, infant and early childhood growth retardation result from the same underlying factors that cause IUGR, e.g., poverty, poor maternal nutrition, poor weaning diet, and consequent increased risk of infections [56, 57]. IUGR increases the risk of stunting in infancy and later childhood [58]. Independent of IUGR, many children in developing countries, and indeed impoverished and undernourished children in North America and other developed regions, become stunted during infancy as the result of inappropriate weaning practices, repeated infections, and poor diet: all in the context of poverty [58]. The highest incidence

of stunting occurs in the weaning period and soon after. Early childhood stunting is not readily reversible when children remain in the same poor environments. Improved diets and other environmental effects will, however, lead to catch-up growth [59].

The stunting-obesity relationship is supported by data from a number of studies [17, 60–64]. This limited literature suggests RRs of 2.0 to 8.0 for the stunting-obesity effect. A conservative RR of 3.0 was chosen for economic analysis in this review. The literature does not yet support any direct effects of stunting on hypertension, diabetes, or CVD. These possible effects of stunting have not been studied while controlling for birthweight effects. Moreover, the literature is too small for meta-analysis. In the few longitudinal studies of the role of LBW as a cause of stunting in Asia, for example [58], half or more of stunted children did not have LBWs.

Obesity: the effect of diet and physical activity on the risk of chronic diseases

There is a massive and growing literature on the causes of overweight and obesity [65]. Obesity increases the risk of other major chronic diseases, notably CVD and certain cancers. Approaches to correct obesity in adult life remain a matter for debate, but there is an established consensus, reflecting common sense and known biological mechanisms, that energy-dense diets and physical inactivity increase the risk of overweight and obesity. Therefore, the incidence of overweight and obesity in any country can be seen as a function of the energy density of diets and levels of physical inactivity [66]. A large literature shows that nutrient-dense diets, with relatively low energy density, and also regular physical activity, not only predict relatively low levels of obesity, but are also effective approaches for reducing obesity, as well as the risk of adult-onset diabetes, CVD, and certain cancers [67].

Obesity is now a major public health problem in Asia and the Pacific. A generation ago, it was identified as a major problem perhaps only in some western Pacific islands. National surveys from several Asian countries have since shown that the problem is more widespread. Overweight is a lesser condition than obesity and is usually defined by a body mass index (BMI) between 25 to 30. BMI is defined as weight in kg divided by height in meters squared (kg/m^2). Overweight is a precursor of obesity and can increase the risk of other diseases such as diabetes, hypertension, and CVD.

International standards used to delineate the overweight and obese are not appropriate for Asia. A BMI of 25 in an Asian adult appears to have a far greater adverse metabolic effect than it would in a Caucasian adult [68]. WHO and the International Obesity Task

* Adair LS. Fetal programming of age at menarche? Chapel Hill, NC: University of North Carolina-Chapel Hill, 2000 (Unpublished manuscript).

Force (IOTF) formed a group of scientists and agencies in Asia to review this. This group has proposed BMI lower limits of 23 for overweight and 25 for obesity for Asians [69]. The issue is complex, however, as there is extensive racial and ethnic heterogeneity in the Asia-Pacific region. For example, BMI-morbidity relationships for East or South Asians, might not be appropriate for Pacific islanders [69]. Patterns of metabolic disease vary across Asia and the Pacific. Asians tend to put on more abdominal fat, whereas Pacific islanders tend to suffer overweight- and obesity-related diseases at greater BMIs, but are more prone to diabetes [69].

Hence, approaches to obesity must be considered in a regional, subregional, and national context. This change would affect considerably definitions of overweight and obesity in different parts of Asia and the Pacific. For example, the 1997 China Health and Nutrition Survey (CHNS) [27] regarded only 2.6% of the sampled population as obese, according to the international BMI lower limit of 30. The survey sample included 8,378 adults from eight provinces. However, 19% would have been regarded as obese if the lower limit was 25. With the BMI upper limits of 23 for overweight and 25 for obesity, total overweight and obesity in PRC would rise from 19.1 to 36.6% for this sample. In this review, the widely accepted WHO BMI lower limits of 25 for overweight and 30 for obesity are retained. This could be changed in future because all the necessary data are available.

Data were obtained from highly reliable, nationally representative or nationwide surveys collected by the following: the present authors and their associates, for the Kyrgyz Republic and the PRC; the World Bank, for Vietnam; the Rand Corporation, for Indonesia; and three governments, Malaysia, the Philippines, and the Republic of Korea. In all cases, weight and height data

were measured using standard World Bank or other protocols [24, 25, 32, 70] and the 1993 CHNS [32]. The data available are representative of the middle-, upper-, and lower low-income country groups, and Pacific SIDS. The Kyrgyz Republic, currently the poorest of the Central Asian republics, had a much higher living standard when it was part of the former Soviet Union. Therefore, its higher intakes of meat, dairy products and fat up to 1992, as well as its concurrent occupational structure and activity pattern, are not representative of its current position as a lower income country [48].

In Asia and the Pacific, gender differences in obesity are usually smaller and less consistent than in Africa, the Americas, and Europe [71] (fig. 21; table 7). Except for Nauru and the Kyrgyz Republic, higher levels of economic development are linked with high obesity levels. Pacific SIDS, such as Samoa and Nauru have been the subject of many studies related to their high rates of obesity and related chronic diseases. Nearly half of the populations of the western Pacific have BMIs above 30.

Where data exist, obesity levels are higher in urban than rural areas (fig. 22; table 7). This relates to marked differences between urban and rural residents in patterns of diet and activity.

Obesity levels are not only associated with being wealthy. Income-obesity relationships in four Asian countries for which representative national data were available (the PRC, Indonesia, the Kyrgyz Republic, and Viet Nam) are shown in figure 23. These data are for adults aged 18 and older. In Indonesia, there is a pronounced difference in overweight and obesity patterns by income tertile. This pattern is not so clear-cut in the other three countries. In the Kyrgyz Republic, overweight is constant across income groups, though obesity increases slightly with income. In the

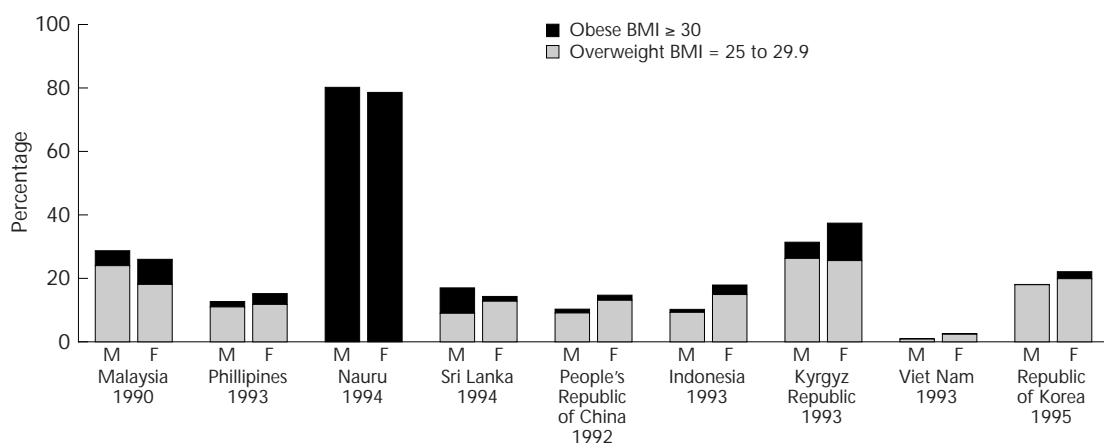


FIG. 21. The prevalence of obesity as a % of total adult population, by gender, in some Asian countries and in the Republic of Nauru. Source: [71]. Notes: BMI = body mass index; M = male; F = female

PRC, there is a small increase in obesity in the high income tertile. In Viet Nam, no pattern is apparent.

There is one further complex situation. In many households, underweight and overweight persons coexist. As Asian and Pacific populations shift toward more-energy dense and lower fiber diets and lower activity levels, it is predicted that there will be a major problem of coexistence of underweight and overweight persons in the same household. Figure 24 presents evidence from low-income countries for which large, nationwide surveys contain anthropometric weight and height data for all members of individual households. Households with both underweight and overweight members represent 3 to 15% of all households in these countries, levels that are far above chance [72]. An underweight child coexisting with an overweight, nonelderly adult was the predominant pair combination. In Figure 24, BMI limits were used for all age groups, rather than using stunting or other measures which would increase significantly the proportion of such households. Therefore, these assessments reflect the current nutrition status of their members.

Early analysis suggests that the speed of the nutrition transition is increasing the likelihood that both underweight and overweight problems will coexist in the same household [72]. As the overall prevalence of undernutrition declines, there appear to be shifts in diet and activity patterns that lead, in many households, to a greater coexistence of obesity with persistent undernutrition. Because dietary shifts toward energy-dense diets (linked with obesity) are occurring much

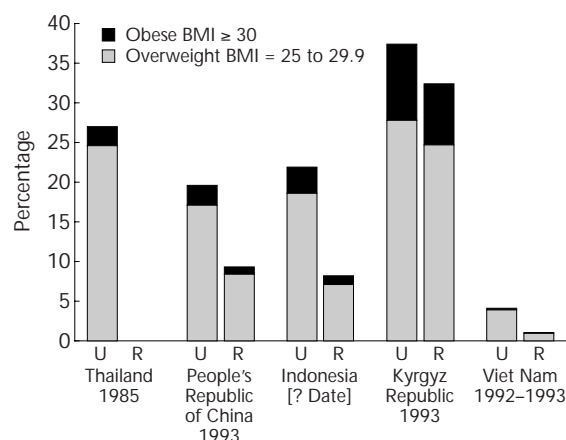


FIG. 22. The prevalence (%) of obesity in urban and rural areas of some Asian countries. Source: ref. 71. Notes: BMI = body mass index, R = rural, U = urban.

more rapidly among lower income households, it can be expected that increasing proportions of such households will have underweight and overweight members coexisting in the near future [30, 31]. Furthermore, among households noted in figure 24 with underweight members, 30% to 60% also had overweight members [72]. This research challenges the assumption that underweight and overweight are opposing public health concerns and illustrates the need for public health programs in Asia and the Pacific that address simultaneously both underweight and overweight.

TABLE 7. The prevalence of obesity (% of total adult population) by gender and by urban and rural residence in some Asian countries and in the Republic of Nauru

	BMI = 25.0 to 29.9		BMI ≥ 30		BMI < 25		Year
By gender							
	Male	Female	Male	Female	Male	Female	
Republic of Korea	18.0	19.9	0.8	2.2	18.8	22.1	1995
Malaysia	24.0	18.1	4.7	7.9	28.7	26.0	1990
Philippines	11.0	11.8	1.7	3.4	12.7	15.2	1993
Nauru			80.2	78.6			1994
People's Republic of China	9.1	13.1	1.2	1.6	10.3	14.7	1993
Indonesia	9.3	14.9	0.93	3.0	10.3	17.9	1993
Kyrgyz Republic	26.3	25.6	5.1	11.8	31.3	37.3	1993
Viet Nam	0.87	2.4	0.05	0.16	0.92	2.5	1992-3
By urban vs. rural residence							
	Urban	Rural	Urban	Rural	Urban	Rural	
Thailand	24.6		2.4		27.0		1985
People's Republic of China	17.1	8.4	2.5	0.92	20.4	9.8	1993
Indonesia	18.6	7.1	3.3	1.1	21.8	8.1	1993
Kyrgyz Republic	27.8	24.7	9.6	7.7	37.4	32.4	1993
Viet Nam	3.9	0.95	0.21	0.08	4.1	1.0	1992-3

Sources: ref. 10, 71.

BMI = body mass index.

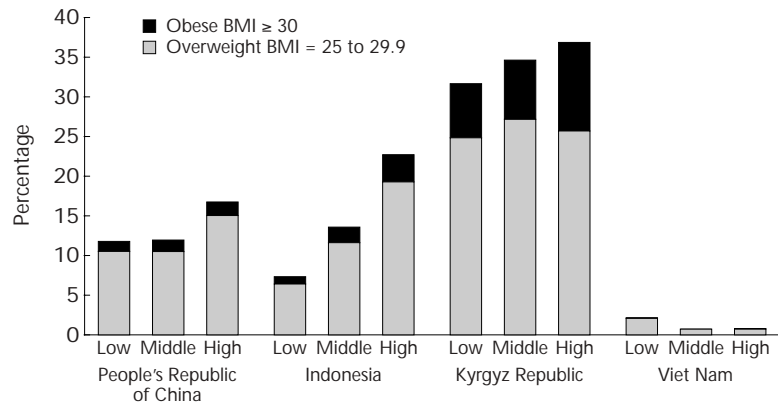


FIG. 23. The prevalence (%) of obesity by income tertile in the People's Republic of China, Indonesia, the Kyrgyz Republic, and Viet Nam. Sources: PRC, People's Republic of China Health and Nutrition Survey (1993), http://www.cpc.unc.edu/projects/china/china_home.html; Indonesia [24]; Kyrgyz Republic [70]; Viet Nam [25]. Notes: BMI = body mass index.

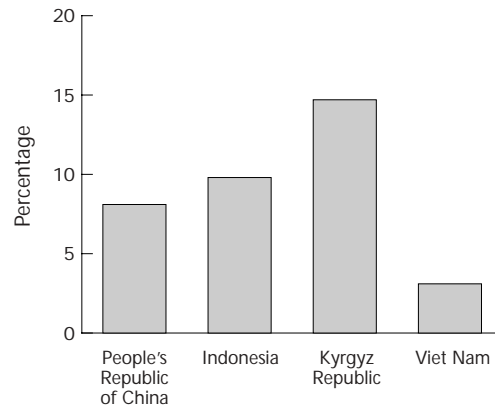


FIG. 24. Proportions (%) of all households with both underweight and overweight members in the same household, in the People's Republic of China, Indonesia, the Kyrgyz Republic, and Viet Nam. Sources: PRC, People's Republic of China Health and Nutrition Survey (1993), http://www.cpc.unc.edu/projects/china/china_home.html; Indonesia [24]; Kyrgyz Republic [70]; Viet Nam [25].