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Introduction

1.1 General background

The recent increases in communications, travel and trade among countries, partly due to globalization, have brought about major changes in food consumption patterns of populations. This is especially true of developed countries, where availability of different types of cuisines has led to a type of “convergence in tastes” of populations. However, diets may not be optimal from a health standpoint, partly because of sugar and fat content and also due to increasingly sedentary lifestyles. Moreover, even in middle-income and developing countries, the affluent are consuming a variety of cuisines that are contributing to the obesity epidemic and increasing the prevalence of chronic diseases such as hypertension, diabetes and cardiovascular disorders. At the same time, problems of hunger and poor diet quality are widely prevalent in developing countries. Inadequate food intakes by children hinder physical growth and can impair their mental development; poor quality of diet in terms of low intakes of micronutrients such as calcium, iron and vitamins can adversely affect children’s immune systems, thereby hampering school attendance and learning. Children’s cognitive development is critical for increasing the future supply of skilled labor and for economic growth (Bhargava, 2001a; Bhargava, Jamison *et al.*, 2001). From a food policy standpoint, policy-makers in developing countries are now faced with the complex tasks of combating diseases associated with under-nutrition as well as those due to over-consumption of food. It is therefore essential for researchers in the social and biomedical sciences to take a broad view of the consequences of sub-optimal diets for population health and well-being.

Historically, nutritionists working in developing countries tackled diseases due to hunger and poverty and were mainly concerned with deficiencies in dietary energy, protein and micronutrients (see e.g. Scrimshaw *et al.*,

1959; Waterlow, 1974). Nutritional epidemiologists in the latter half of the twentieth century turned their attention to the adverse effects of excessive intake of dietary fat and cholesterol on chronic conditions such as cardiovascular disease and cancers (Keys, 1980, 1984). As information from various studies continues to accumulate, research in food policy issues can incorporate the relevant knowledge to develop effective policies for disease prevention via dietary modifications. One of the earliest applications in food policy analysis was the influential work by Hutchinson (1969) that underscored the importance of food shortages (“energy deficiencies”), noting that “protein when divorced from carbohydrate in the diet is of no use in repairing the wear and tear of body protein”. Thus, policy-makers should address energy deficiencies before combating protein deficiencies. Knowledge from the nutritional sciences is useful for formulating food policies that can potentially affect the lives of millions of individuals in making healthful food choices. Moreover, economic analyses have a central role in policy formulation because food prices and household incomes affect food consumption decisions, especially in developing countries. Changes in diet and lifestyles are also important and analyses should incorporate behavioral (i.e. psychological) factors for enhancing the efficacy of educational programs encouraging healthful eating.

The material presented in this monograph can be divided into four broad themes. First, evidence from developing countries on the effects of household incomes and other variables on food consumption patterns is summarized in Chapter 2. Second, the effects of food intakes on child health outcomes such as height, weight and morbidity in developing countries are covered in Chapter 3; nutritional and other factors affecting children’s cognitive development are addressed in Chapter 4. Because high fertility (birth) rates affect surviving children’s health status, issues of child survival typically covered in demographic research are addressed in Chapter 5. Third, links between adults’ nutritional and health status and their economic (labor) productivity in developing countries are addressed in Chapter 6. Fourth, owing to excess food consumption, especially in developed countries, an obesity epidemic is increasing the prevalence of chronic diseases. Chapter 7 summarizes diverse approaches to obesity research in the fields of nutrition, psychology and economics. It should be emphasized that a major objective of this book is to provide an overview of quantitative analyses of issues surrounding food consumption and population health. Because researchers in disciplines such as economics, nutrition, psychology, demography, anthropology and public health emphasize somewhat different aspects, this presentation should be useful

for assessing the relative importance of the factors affecting population health. Readers less familiar with statistical methods can skip technical discussions in many places and focus on substantive issues relating to food consumption and population health; the glossary summarizes some of the terminology used in different disciplines.

An important aspect of analyzing the links between food intakes and health outcomes is that food consumption decisions are heavily influenced by customs, especially in traditional societies. Because such customs have evolved gradually over time, individuals are likely to change their food consumption patterns slowly. By contrast, rapid industrialization has led to dramatic changes in food intakes. From a health standpoint, however, it is not obvious that rapid changes in diets afforded by economic development are preferable to changes occurring gradually over time. Moreover, traditional diets do not necessarily imply poor understanding of nutritional issues even among populations with low literacy rates; diets have evolved by observing the health benefits of intakes of essential foods such as grains, milk and meat. Moreover, the practice of vegetarianism in India was partly based on religious philosophy and also on the expected workload of individual groups (“castes”). For example, the upper castes typically did not perform strenuous work and did not appear to require nutritious foods such as meat that were deemed essential for “warrior” castes. From a modern perspective, while vegetarian diets may supply inadequate quantities of vital nutrients such as iron that can be absorbed by the body, it is also the case that excessive fat and cholesterol intakes in industrialized societies are deleterious for health. Both situations, however, can be remedied by appropriate nutritional and/or educational interventions. For example, iron supplementation and increased consumption of dairy products can reduce anemia prevalence among vegetarians, while increasing consumption of whole grain products and fruits and vegetables can lower the fat and cholesterol content of Western diets.

In developing a framework for analyzing the effects of food intakes on health outcomes, two sets of issues need to be addressed. First, problems of energy and micronutrient deficiencies should be urgently tackled in developing countries. Combating these deficiencies requires elaborate policies, especially in areas of food shortages or where the price system may inhibit consumption of foods high in nutrients such as protein, iron and vitamins A and C. Moreover, even in developed countries such as the US, children from poor backgrounds can face hunger spells and poor households benefit from programs such as the Supplemental Food Program for Women, Infants, and Children, which supplies milk, cheese

and fruit juice to pregnant women and to children less than 5 years of age. The second point is that because of unhealthy eating patterns, high levels of economic development do not necessarily entail improved dietary intakes. In addition, sedentary lifestyles associated with affluence reduce physical activity, thereby throwing individuals into a positive energy balance, i.e. promoting weight gain. Because these problems are also prevalent in middle-income countries and are on the rise in developing countries, it is fruitful to analyse the effects of sub-optimal diets on individual health using a comprehensive modelling framework.

Further, there is a need to integrate the literatures in the nutritional and social sciences for understanding the effects of food intakes on health, though the task is a complex one. For example, there are debates in the nutritional sciences regarding the effects of dietary fat on obesity (e.g. Willett, 1998a; Bray and Popkin, 2000). If one adds to such controversies the different approaches to food consumption in disciplines such as anthropology, psychology and economics, then developing a common analytical framework seems an elusive task. However, certain processes are well understood in the biomedical sciences and it is important to incorporate that knowledge in empirical analyses of food intakes and health outcomes. For example, studies such as Spurr (1993) have demonstrated that oxygen uptake, reflecting physical work capacity, is reduced in under-nourished individuals with low body mass index (BMI). Similarly, anemic individuals with low hemoglobin concentration were found to take longer to perform agricultural tasks in Indonesia (Basta *et al.*, 1979), which is likely to be due to reduced oxygen transportation. Not surprisingly, therefore, an analysis of time allocation patterns among Rwandese adults showed that individuals with a low BMI participated in less strenuous activities and spent greater amount of time resting and sleeping (Chapter 6). While knowledge from scientific experiments is useful for specification of empirical models for health outcomes, the pathways are often complex. For example, the link between low micronutrient intakes and children's scores on cognitive tests in developing countries is complicated by the fact that the school environment plays an important role in child development. Such issues are addressed in Chapter 4 using data from developing countries. A multi-disciplinary approach incorporating knowledge from the biomedical and social sciences is useful for modeling the pathways through which nutritional and health status affect critical outcomes such as children's cognitive development and the labor productivity of adults.

Economists have been interested in issues of food, nutrition and health policies for a variety of reasons. In developing countries, food prices play a

fundamental role in ensuring adequate intakes; smooth functioning of agricultural markets is essential for the well-being of a large number of individuals. From a scientific standpoint, it is also critical to understand the effects of specific nutrient intakes for maintaining individual health and productivity. For example, Stigler (1945) estimated “minimum cost diets” by the linear programming method, though noting the importance of interactions between nutrients present in the meal for nutrient absorption. While nutrient interactions are complex processes studied in laboratory settings, insights from experiments can be valuable for formulation of food policies. A good example is the widely prevalent iron deficiencies in less developed countries due to low intakes of absorbable iron (UNICEF/WHO, 1999). Iron from meat, fish and poultry (“heme iron”) is more easily absorbed by the human body than non-heme iron derived from staple foods such as wheat and rice; the presence of meat and ascorbic acid in the meal increases the absorption of non-heme iron (Monsen *et al.*, 1978). Thus, an important issue for food policies is whether absorption of iron from staple foods can be enhanced by increasing the iron content of staple foods and/or by higher intakes of enhancers of iron absorption such as meat and ascorbic acid (Bhargava, Bouis *et al.*, 2001). Without an understanding of the nutritional issues, it would be difficult to formulate such a policy discussion. A multi-disciplinary approach to food policies is likely to suggest cost-effective ways of reducing deficiencies of iron and other vital nutrients in developing countries.

An important example linking knowledge of the biochemistry of food to economic policy is the work by Leibenstein (1957) arguing that higher wages for workers in developing countries would improve their nutritional status and hence productivity. This “wage efficiency hypothesis” has influenced work by economists such as Mirrlees (1975), Stiglitz (1976), Bliss and Stern (1978) and Dasgupta (1993). In practice, the relationship between energy intakes and wages is affected by factors such as the need of workers to spend part of their wages to support family members (Majumdar, 1959), demand conditions in the regional labor markets, micronutrient deficiencies such as iron deficiencies that can depress physical work capacity, and the time necessary for improving individuals’ health status. Furthermore, nutritionists such as Beaton (1984) have argued that lower food intakes can lead to reductions in energy expended on tasks, i.e. induce behavioral and economic changes. Thus, it is useful to analyze the effects of food shortages by investigating the effects of nutritional status on individuals’ time allocation patterns. Chapter 6 summarizes some of the literature on relationships between health and wages in

developing countries. By combining the literatures in nutrition, economics and health, one can enhance the substantive content of empirical models and arrive at policy conclusions that can benefit large numbers of individuals subsisting on agriculture.

Another example for the need for adopting a multi-disciplinary approach to formulating food policies is the obesity epidemic, affecting population health especially in developed countries. Food budgets are relatively small proportions of total household budget in developed countries because of low food prices and higher incomes. In addition, low wages in the service sector depress food prices, especially in fast-food restaurants. Such restaurants often increase the fat content of prepared food to appeal to customers' tastes and may promote over-eating by offering larger portion sizes. While nutritionists are interested in issues such as the effects of specific nutrients like saturated fat on body weight, it is likely that economic factors such as low food prices and profit margins are contributing to the obesity epidemic. Moreover, it is difficult for economists to devise interventions for promoting healthy eating without knowledge of nutritional issues underlying the relationships between diet and obesity. By the same token, nutritionists and epidemiologists spend considerable effort making links between fats, carbohydrate and protein intakes and adiposity (Bhargava and Guthrie, 2002), though in short time frames. Because such analyzes cannot address the underlying economic factors that contribute gradually to the obesity epidemic, a multi-disciplinary approach is essential for understanding the effects of food consumption and other variables on population health. The motivation for organizing the material in the ensuing chapters is outlined in sections 1.2–1.5.

1.2 Economic factors and energy and micronutrient deficiencies in developing countries

Historically, shortages of staple foods such as wheat and rice were prevalent in developing countries, leading to hunger and starvation (Dreze and Sen, 1990; Fogel, 1994). Thus, selling staple foods at subsidized prices through special shops has been a popular strategy of governments in developing countries for reducing under-nutrition. There is a literature in agricultural economics on the formulation of food policies for developing countries (e.g. Timmer *et al.*, 1983; Pinstруп-Andersen, 1988), in part because subsidies for staple foods can constitute a large proportion of national budgets. In cases of food shortages, food imports and the food

distribution system play a critical role in alleviating hunger; wars and civil strife can hamper food distribution. Although recent increases in food production have reduced food shortages, deficiencies of protein and micro-nutrients such as vitamins and minerals are widely prevalent in developing countries (IFPRI, 1990). For example, shortfalls in vitamin A and C intakes in Indonesia were found to contribute to nutritional blindness (Sommer, 1990). Because the productivity of the future labor force depends on children's learning (Bhargava, 2001a), and adult productivity is adversely affected by iron deficiencies (Basta *et al.*, 1979), it is perhaps somewhat narrow from a food policy standpoint to focus only on the adequacy of energy intakes. Instead, policy-makers should adopt the broader goal of improving "quality of diet" in developing countries.

The effects of household incomes on food intake are important for food policy analyzes. However, most researchers in the past analyzed data from household expenditure surveys on aggregate commodity groups such as food, clothing and housing. Because of the high degree of aggregation, one can over-estimate magnitudes of the effects of income on energy and nutrient intakes using these types of data. The effects of household incomes on diet quality are particularly informative when individuals' food intakes are directly measured over time, i.e. when longitudinal data on food intakes and socioeconomic variables are available for analysis. For example, a longitudinal study in three states in south India conducted by the International Crops Research Institute for Semi-Arid Tropics (ICRISAT; Ryan *et al.*, 1984), and a study in the Mindanao region of the Philippines (Bouis and Haddad, 1992) have provided valuable dietary, health and socioeconomic information. Because of the logistics of monitoring households over time, such studies are often confined to specific geographical regions. Thus, households face similar food prices, and issues such as the effects of household incomes on quality of diets in terms of micronutrient content can be analyzed in a more systematic manner than was previously feasible. When longitudinal data on food intakes are available, the likely effects of food subsidies on health outcomes, such as anthropometric indicators, discussed in the earlier food policy literature can also be analyzed using more complex formulations.

Chapter 2 covers issues surrounding the effects of household incomes on food consumption in developing countries. The discussion recognizes the importance of cultural factors affecting food consumption and postulates "dynamic" demand models that are consistent with "habit persistence" in diets (Gorman, 1968). Moreover, the nutrition literature is integrated into the presentation and it is underscored that social scientists need to

understand certain basic aspects of the nutrition literature. For example, most nutrients are present in most foods though in different proportions. Thus, while increases in food intake generally increases the intake of nutrients such as protein, iron, calcium and vitamins A and C, choices between different foods entail large changes in the distribution of nutrient intakes. Individuals desiring greater quantities of vitamins A and C, for example, are likely to consume more fruits and vegetables, though such foods also contain small quantities of protein and iron. This integrated approach to food consumption is in the spirit of Stigler (1945), though it differs from contributions in the economics literature in that simplifying assumptions which may be inconsistent with biomedical knowledge are not invoked. Policy-makers are more likely to incorporate research findings into food policy formulation if analyses are based on scientifically acceptable assumptions.

Another aspect of the material covered in Chapter 2 is that it is recognized that individuals' energy and nutrient requirements influence their food intakes. Thus, it is important to account for individuals' heights and weights in models for energy and nutrient intakes. The discussion can be viewed as extending the previous literature in food economics, since section 2.3 first presents models for demand for food at the household level. Moreover, previous estimates of the effects of household incomes on energy and nutrient intakes ("income elasticities") from food expenditure data at the household level are summarized. Subsequently, section 2.4 presents models for energy and nutrient intakes estimated by using data on individuals' intakes; it is argued that one would expect income elasticities based on food intakes to be lower than those estimated by using expenditure data at the household level. Moreover, small magnitudes of income elasticities of energy (~ 0.1) and nutrients estimated from individual-level data are consistent with biomedical evidence on individuals' requirements; it is perhaps unrealistic to expect income elasticities of energy to be very high (~ 0.8) unless there are severe food shortages and starvation. The empirical estimates of income elasticities for energy and nutrients from India, the Philippines, Bangladesh and Kenya are discussed in section 2.5. The econometric models employed are similar and hence the estimates provide interesting contrasts between these countries. For example, because income levels were low in Kenya, one would expect the income elasticity of energy to be higher in Kenya (0.29) than (say) in the Philippines, where it was 0.08. The analytical framework and empirical results in Chapter 2 should be useful for the formulation of food policies

that seek to ensure adequate energy and nutrient intakes in developing countries.

1.3 Food policies and children's physical and mental development in developing countries

A major goal for food policies is to facilitate children's physical and mental development in less developed countries. The formulation of food policies that improve the protein and micronutrient content of diets is important for enhancing children's anthropometric indicators. Moreover, the effects of micronutrient deficiencies such as those of iron on children's cognitive development have been emphasized by psychologists and nutritionists (e.g. Pollitt *et al.*, 1993; Scrimshaw, 1996). However, the literature in the biomedical sciences has mainly estimated simple correlations or associations between dietary intakes and cognitive test scores. At low levels of income, children's physical development and learning are intertwined; children's cognitive development depends on their nutritional and health status, household resources, and the educational infrastructure (Bhargava, 1998; Bhargava, Jukes *et al.*, 2005). It is therefore important for social scientists and policy-makers to investigate the proximate determinants of children's cognitive development, which is critical for the future supply of skilled labor and hence for economic development.

Chapter 3 begins by discussing nutritional and socioeconomic factors affecting children's physical development and morbidity in developing countries. Methodological issues such as the implications of the "health production functions" terminology used in the economics literature are spelled out; it is noted that "health functions" is a more general concept because of differences between production of commodities and the manner in which children achieve better health status. Econometric models for children's heights, weights and morbidity are developed in section 3.2 and graphically illustrated in Fig. 3.1. These models reflect knowledge in nutritional sciences, such as the beneficial effects of higher protein intakes on children's heights and weights. Moreover, the relationships between height and weight emphasized in the anthropometric assessment literature are incorporated into the models. It is also noted that these models for children's anthropometric indicators and morbidity are consistent with "stock/flow"-type formulations used in the economics literature.

Section 3.3 presents the results from models for heights and weights of children estimated using data from the Philippines and Kenya. The models

show beneficial effects of diet quality on children's anthropometric indicators. The models for child morbidity are presented in section 3.4 and the findings are likely to be useful for the formulation of food policies. For example, higher intakes of vitamin A were associated with lower child morbidity in the Philippines and Kenya. Moreover, for Kenyan children, data were available on the scores obtained by parents on cognitive tests. The results showed that while parental years of education were not significant predictors of lower child morbidity, parental test scores were significant predictors. Thus, education programs improving, in particular, maternal knowledge regarding children's diets and health are likely to lower morbidity in countries with low female education. Chapter 3 also discusses certain studies investigating the determinants of child morbidity in Bangladesh, Pakistan, the Philippines and Peru.

Chapter 4 is concerned with the effects of children's nutritional and health status on cognitive development and begins with analysis of the effects of maternal nutritional status on infant health. Some of the biomedical literature is briefly summarized and the results from modeling the effects of maternal nutritional status on Kenyan infants' length, head circumference and weight at birth are presented. Moreover, maternal health status plays an important role in infant growth between 1 and 6 months, as is shown by dynamic econometric models for length, head circumference and weight. For example, maternal hemoglobin concentration and BMI were important predictors of the dynamics of Kenyan infants' weights in the first six months of life.

Further, Chapter 4 addresses children's physical growth and cognitive development in developing countries. An important randomized controlled trial in Guatemala providing a nutritional supplement is described and the results are critically assessed. Section 4.4 discusses the implications of the theoretical contributions of Vygotsky (1987) to the developmental psychology literature for empirical models for child development. The analytical framework is useful for understanding potentially differential effects of children's nutritional status on their scores on verbal and analytical tests. Evidence is presented on Kenyan school children and the results were broadly in accordance with theoretical considerations. For example, while children's BMI and head circumference were important predictors of the scores on digit span, Raven's matrices and arithmetic, the anthropometric indicators were less important for explaining scores on verbal tasks. Furthermore, analyses of data from a randomized controlled trial in Tanzania treating school children against hookworm and schistosomiasis infections are presented in section 4.5. Methodological issues

such as the importance of modeling the pathways underlying children's cognitive development are discussed. These issues are important due to the current popularity of randomized trials in social sciences. For example, it is argued that data from the treatment group are important for assessing the benefits of removing hookworm and schistosomiasis for children's iron status, which is reflected in hemoglobin and ferritin concentrations. By contrast, children's scores on cognitive and educational achievement tests are likely to evolve gradually and are also influenced by the school infrastructure. Thus, modeling test scores using data from the control group can provide useful insights. For example, better-qualified teachers and greater numbers of work assignments in Tanzania were found to enhance children's scores on educational achievement tests.

Chapter 5 covers demographic, health and mortality issues in developing countries. While nutritional supplementation programs for pregnant women are likely to show beneficial effects on child growth, most studies cover only a small number of women. Large-scale interventions are expensive and often formulated using piecemeal approaches. More importantly, many pregnant women receive no ante-natal care and children are often not vaccinated due to poor access to health care. In the absence of family planning methods, large numbers of children born to women within short time intervals are detrimental for maternal and child health. As documented in Chapter 4, children with poor nutritional and health status are unlikely to reach their full potential. Thus, children's health status and cognitive development also depend on the health care and family planning services available. It is important for formulating cost-effective policies to recognize the synergisms between food and health care policies. Knowledge from disciplines such as nutrition, psychology, demography and economics can be combined for enhancing child health in developing countries.

Chapter 5 begins by discussing the possible discrimination against girls in south Asia emphasized in the demography and economics literatures (e.g. Chen *et al.*, 1981; Sen and Sengupta, 1983). Some methodological difficulties in making comparisons using children's heights and weights are illustrated, using the data from Pakistan and Vietnam. It is argued that child mortality is a more suitable indicator for assessing gender discrimination. Proximate determinants of child mortality are briefly discussed in section 5.2, using national averages for countries. Section 5.3 presents an analysis of infant mortality in Uttar Pradesh using household data from the National Family Health Survey-1 to investigate the possible reasons for higher mortality among girls. Methodological issues such as

the dynamic relationships between fertility (number of children) and child mortality, and certain econometric aspects, are discussed. The empirical results showed that the chances of female mortality were higher for “unwanted” girls born at high birth orders (e.g. the fifth child). In contrast, the mortality chances of girls born at low birth orders were *lower* than for boys. The results also showed the importance of health care infrastructure; for example, women vaccinated against tetanus experienced significantly lower infant mortality. These results underscore the importance of ante- and post-natal care for women and infants in enhancing children’s survival chances and for improving the health status of the surviving children, which is critical for learning.

Lastly, Section 5.4 analyses the data from another demographic survey from Uttar Pradesh (PERFORM), which compiled extensive information on the health care infrastructure. For example, there are numerous private and public health care providers in countries such as India and some may have very limited qualifications. Because the PERFORM survey compiled detailed information, the effects of health care utilization on fertility can be analyzed. Moreover, from a conceptual standpoint, the frameworks in the economics of supply and demand for children (Easterlin and Crimmins, 1985) and that of “endogenous placement” of health care facilities are reappraised. The empirical results for models for contraceptive use, such as female sterilization, the intrauterine device, birth control pills and condoms, indicate the importance of the health care infrastructure in public and private facilities. Overall, it is emphasized in Chapter 5 that tackling demographic issues such as high fertility and child mortality rates in developing countries is important for improving the well-being of women and children and for creating skilled labor, which is critical for economic growth.

1.4 Nutritional status and labor productivity in developing countries

The links between the nutritional and health status of adults and labor productivity are of fundamental importance to policy-makers, especially in developing countries. Moreover, unlike for children, the effects of improving adult health status are visible in a short time. For example, treatment of adults with full-blown AIDS can lead to dramatic improvements in their health and a return to employment. This is especially the case in developed countries, where HIV-positive individuals can remain

productive for years. By contrast, labor productivity may be hindered by co-morbidities and nutrient deficiencies, especially in developing countries. While adult health in developing countries is an important determinant of performance in physically demanding tasks, from a food policy viewpoint it is important to estimate the costs and benefits of improving diets.

The literatures in the biomedical sciences and economics on the effects of health status on labor productivity have emphasized somewhat different aspects. In the biomedical sciences, individuals' physical work capacity is assessed using tests of endurance that provide quantitative measures of performance (e.g. Spurr, 1983). Biomedical scientists are interested in the effects of variables such as adults' height, muscle mass and hemoglobin concentration on the performance of physical tasks. By contrast, the economics literature on the "wage efficiency hypothesis" has emphasized the effects of higher wages on labor productivity via the effects on improved nutritional intakes. At a conceptual level, biomedical studies are simpler to interpret since they are based on well-understood principles of human physiology. In contrast, social science phenomena are more complicated since wages depend on labor market conditions and the effects of higher wages on health and productivity are likely to operate with delays. Chapter 6 outlines the biomedical and economics approaches to analyzing relationships between adult health and productivity and points out difficulties in interpreting empirical results because many adults in developing countries do not receive monetary wages.

The background literature in the biomedical sciences on the effects of nutritional and health status is briefly summarized in section 6.1. A randomized controlled trial of iron supplementation for rubber plantation workers in Indonesia (Basta *et al.*, 1979) is discussed in detail. Moreover, interpretation of the findings from randomized trials is discussed. It is argued that when the scientific phenomena are well understood, it may not be necessary to conduct randomized trials to accumulate further evidence such as that on the benefits of iron supplementation on labor productivity. Instead, policy-makers can utilize the results from previous randomized trials to devise food policies for improving productivity. While the benefits of iron supplementation in different settings would depend on "habitual" dietary intakes and iron loss due to intestinal parasite infections, resources available for research can be used for assessing nutrient deficiencies in the populations and for designing cost-effective policies.

Section 6.2 discusses empirical models used in the economics literature for analyzing the relations between health and wages in developing coun-

tries. Moreover, Figure 6.1 summarizes the relationships between wages, food intakes, anthropometric measures, and physical work capacity together with underlying variables that can modify these relationships. The long-run effects of better nutritional and health status are emphasized in the discussion. Section 6.3 summarizes the results from a study of time allocation patterns in Rwanda which showed beneficial effects of adults' BMI and household intakes on time allocated to productive activities (Bhargava, 1997). Moreover, under-nourished adults were found to spend greater proportions of time resting and sleeping. While the effects of health on wages were also investigated in this study, the main advantage of analyzing time allocation patterns is that the relationships are not confounded by market forces affecting the demand and supply of labor. Overall, the results in Chapter 6 show the benefits of improving adults' nutritional and health status on labor productivity. The extent to which different foods that are good sources of energy, protein and micronutrients should be subsidized would depend on food prices and the budget for subsidies. It is noted in Chapter 2 that energy deficiencies are less common outside sub-Saharan Africa and policy-makers need to estimate the prevalence of protein and micronutrient deficiencies for designing cost-effective food policies.

1.5 Diet and obesity in developed countries

The final chapter in this book is concerned with issues of behavior, diet and obesity in developed countries such as the US. There is a stark contrast between food choices made by the poor in developing countries struggling to meet their energy and nutrient requirements, and excess food consumption in developed countries. Moreover, even in developed countries, low-income households may face food shortages, while the affluent in developing countries are beginning to suffer from chronic diseases such as diabetes and coronary heart disease due to excess weight. Thus, policy-makers need to address simultaneously issues of under- and over-nutrition, and the design of food policies is complicated by the dependence of food consumption patterns on behavioral (psychological) and economic factors. For example, subsidies for agriculture in developed countries lower food prices and can promote excess food consumption, while jeopardizing the livelihoods of small farmers in developing countries that cannot compete with large-scale mechanized agriculture.

Section 7.1 begins by summarizing the nutritional and epidemiological approaches to obesity. In these disciplines, hypotheses driving the investigations are well defined and randomized controlled trials are often conducted to test theories. For example, an important hypothesis is that intakes of dietary fat can promote obesity because fat is poorly oxidized, especially by sedentary adults. While this hypothesis has been supported in laboratory experiments, in practice, fat is energy-dense and contains 9 kilocalories (kcal) per gram. Thus, higher fat consumption is likely to increase the overall energy intake. But this is also true of the consumption of sugars, such as high-fructose corn syrup, which contains 4 kcal per gram and may not give the feeling of “satiety”, thereby leading to an increase in intake. The problems are compounded by the fact that dietary assessment in developed countries is complex; such issues are discussed in section 7.1. Further, measures of obesity such as waist and hip circumferences (“central obesity”) are important risk factors for coronary heart disease. Section 7.1 briefly summarizes the relevant anthropometric assessment literature for the general reader. Also, the results from an analysis of data from Women’s Health Trial: Feasibility Study in Minority Populations (WHTFSMP) for lowering fat intakes are summarized. The analysis showed that higher intakes of saturated, monounsaturated and polyunsaturated fats were not systematic predictors of anthropometric measures. Rather, women with “unhealthy” eating habits and low levels of physical exercise were heavier and had higher waist and hip circumferences. Implications of these findings for food policy are discussed.

Section 7.2 describes various approaches in the psychological literature to dietary modifications and obesity; alternative theories of human behavior influence strategies for promoting dietary changes in studies in developed countries. For example, the “health belief model” emphasizes the importance of individuals’ perceptions of risks of contracting diseases, and the perceived risks may facilitate dietary changes. This approach contrasts with the utility maximization assumption in the economics literature. Ways of integrating the approaches are discussed. Further, psychologists have designed interventions for reducing child obesity in schools and certain studies are described in section 7.2. Last, because the questionnaire in WHTFSMP was designed by nutritionists, epidemiologists and psychologists, one can quantify relative magnitudes of psychological variables on changes in dietary intakes. The results reported in section 7.2 show that women’s perception of health risks and “self-efficacy” were important predictors of dietary intakes, especially in the intervention group. Moreover, educated women made greater changes in the intervention group,

though this was generally not the case for the control group. Because low-income populations in the US have poor dietary habits, it would be desirable to provide nutrition education, as is done in the Supplemental Food Program for Women, Infants and Children. While the costs of such programs are high, healthy diets and lifestyles can result in major savings in medical expenditures. While the long-run sustainability of dietary changes needs to be further investigated, the efficacy of nutrition education programs is likely to be enhanced by incorporating psychological variables.

Section 7.3 describes the approaches to obesity in the economics literature. Low food prices in grocery stores and fast-food restaurants, higher household incomes, and sedentary lifestyles are potentially contributing to weight gain among populations. Moreover, large numbers of foods available in grocery stores can complicate the conventional modeling of demand for food. The “characteristics” models for demand for food, emphasizing the importance of invoking assumptions that are consistent with knowledge in the biomedical sciences, are discussed. Furthermore, a study emphasizing the role of food processing technologies in increasing intakes is discussed (Cutler *et al.*, 2003). Also, articles relating maternal hours of employment to childhood obesity and a study linking low food prices to obesity in the US are discussed. This section also discusses strategies for reducing the prevalence of obesity, taking into account nutritional, psychological and economic approaches. In view of the high costs of caring for chronic diseases, an integrated approach is essential for stemming the obesity epidemic. While several strategies for obesity prevention are outlined, it is unlikely that major progress can be made without substantial resources devoted to educating the public about the benefits of healthy diets and lifestyles. Moreover, subsidies to large farmers and agribusiness in developed countries need to be reappraised, since they may adversely affect population health in developed and developing countries. Finally, Chapter 8 summarizes the main implications of the material presented in Chapters 2–7 and suggests future research that can facilitate development of effective food and health policies for improving well-being.