Nutrition and Aging in Developing Countries

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ABSTRACT  The number of individuals aged 60 y or older is projected to double as a proportion of the world’s population and to more than triple in number over the next 50 y. These changes will be most dramatic in the less developed countries, where the transition from a young to old age structure will be more compressed in time than it has been for developed countries. At the same time, there is evidence of a characteristic sequence of changes in diet and declines in physical activity associated with social and economic change. Diets are becoming higher in fats, animal products, and refined foods and lower in fiber, contributing to rapidly increasing prevalences of obesity and type 2 diabetes. The number of people with diabetes in developing countries is projected to almost triple by the year 2025. Hypertension and vascular disease are also rapidly becoming more prevalent. Evidence that lower birth weights are associated with greater likelihood of adult obesity and chronic disease underscores the magnitude of risk in these countries. Few programs or institutions currently exist to address the problems of the growing elderly population. The social changes that accompany urbanization will likely increase nutritional risk for this group. Despite lower energy intakes with age, elderly have higher requirements for several micronutrients, making them vulnerable to deficiencies that further aggravate chronic conditions. To reduce the impending burden of disease and disability worldwide, urgent action is needed to understand and to address the nutritional needs of the aging population. J. Nutr. 131: 2417S–2423S, 2001.

KEY WORDS: • nutrition • aging • developing countries • diet • chronic disease • nutrition transition

The number of individuals aged 60 y or older is escalating rapidly worldwide. The United Nations Population Division estimated that this age group represented ~10% of the world’s population, or ~600 million people, in 1999. They project that by the year 2050, this proportion will increase to 20% and will include >2 billion people. These changes will be most dramatic in the less developed countries, where the population age structure will change rapidly from one that is predominantly young, with few elderly, to one with more balanced numbers across age groups (1). Figure 1 (2) illustrates this dramatic shift, as predicted over the next 50 y. Currently, only Europe and Japan have populations with >20% of the population aged 60 y or older. By 2050, with the exception of most of Africa, almost all countries will have exceeded this proportion. Furthermore, the population 80 y or older is projected to more than triple, and the number of centenarians is expected to increase 15-fold from 1999 to 2050.

This transition from a young to old age structure will be more compressed in time for the less developed countries than it has been for the more developed countries. This rapid shift will have profound effects on their infrastructure, their economies, and their health care systems. Few of these countries currently have programs aimed at older individuals. The systems of nursing homes, geriatric specialists, home care nurses, senior nutrition programs and senior centers that have developed to meet these needs in developed countries do not exist in most of the developing world (3). The implications of these demographic changes need urgent attention if the difficulties inherent in this transition are to be minimized.

Nutritional status has a major impact on disease and disability and offers great promise for minimizing this oncoming burden. However, the current trend in developing countries is toward higher fat, more refined diets that contribute to increased risk of chronic disease, and the prevalence of chronic disease is already increasing rapidly. At the same time, social and demographic changes are placing elderly at even greater risk of food insecurity and malnutrition. This double burden of undernutrition and obesity in an aging population poses tremendous challenges for developing countries, whose policies and institutions are currently unprepared to handle the demands these changes will bring.

The nutrition transition

The leading cause of death among older people worldwide is vascular disease and associated chronic conditions (4). There is great potential for prevention of these diseases through healthy lifestyles that include physical activity, nutritious diets and avoidance of smoking or substance abuse.
Unfortunately, along with a dramatic change in age structure, there is evidence of a characteristic sequence of changes in dietary behavior and physical activity patterns that lead to increased risk of chronic disease. This has been called the “nutrition transition” by Popkin et al. (5) and appears to be occurring rapidly and predictably in countries throughout the world. We have summarized these changes in Figure 2, based on descriptions by Popkin et al. and Vorster et al. (6). Basically, with a change from traditional, rural communities to more population-dense, urban environments, there is a change in diet from one high in fiber and low in fat to one rich in animal fats, sugars and refined products that are low in fiber. Although overall nutrient intake adequacy improves with any increasing variety of foods, the movement toward more fats, sugars and refined foods quickly moves beyond this more optimal state to one in which diets contribute to rapidly escalating rates of obesity and chronic disease. This transition, which has been documented in several countries in relation to income, now appears to be occurring at lower levels of the gross national product than it had previously, accelerated by high urbanization rates (7).

**Dietary change**

Patterns of increasing dietary excess are evident in higher-income Central and South American countries and most of the Caribbean, where intake of animal products and total fat has increased, while intake of fruits, vegetables, roots and tubers has declined (5,8). In Brazil, where dietary changes have proceeded more slowly than in many other countries, obesity is becoming more prevalent among even the lowest-income sector (9).

Analyses of the food supply in 21 Asian nations during 1975–1994 showed an overall decline in the availability of complex carbohydrates and an increase in total fats (7). In addition, hydrogenated fats increasingly replaced vegetable oils (6). Similarly, data from the 1989 China Health and Nutrition Survey showed a marked shift in the structure of the diet toward greater proportions of fat intake from both animal and vegetable sources (10). In both urban and rural populations, fat consumption and use of animal products increased with per capita income. In India, large community-based sur-
surveys showed that high socioeconomic status (SES) groups consumed an average of 32% of energy from fat, relative to 17% of energy from fat in lower income groups, and that the prevalence of coronary heart disease was three to four times greater for these high versus lower SES groups (11).

Urban Africans have also increased their consumption of refined foods and fats. Despite relatively low levels of economic development, dietary shifts have begun to appear (5). In South Africa, the transition to a Western diet is becoming evident in both rural and urban areas. Bourne et al. (12) compared the diet composition of adults in 1990 with that in 1940, confirming a 14% reduction in carbohydrate intake and an increase of 63% in fat intake over this 50-y time span.

These dietary changes, combined with the rapid growth of the aging population, suggest that we can expect an escalating epidemic of chronic diseases, particularly obesity, diabetes and heart disease, in developing countries in the coming decades. Carefully designed nutrition interventions could have a major impact on future disease risk in these countries.

Obesity

In parallel with dietary changes, there is a rapidly increasing prevalence of obesity worldwide. Factors specifically associated with obesity in developing countries were recently summarized by Caballero (13) and include urbanization, lower infant mortality, and increased life expectancy, mechanization and lower energy expending labor, television and other sedentary activities, and the growth of “fast food culture” with higher energy density diets. The role of biologic factors, including intrauterine exposures, metabolic programming and gene-mediated adaptation, is of great current research interest.

Obesity prevalence is particularly high in Latin America and the Caribbean. In Chile from 1988 to 1997, the prevalence of obesity increased from 14 to 23% in women and from 6 to 16% in men (14). A recent analysis of subsets of the population revealed that the Mapuche, the major aboriginal group in Chile, had a much higher prevalence of obesity—15% of men and 32% of women in the rural areas, and 28% of men and 45% of women in the urban areas (15). In the British Virgin Islands, >50% of adult females and 25% of adult males were obese (defined as weight for height >120% ideal body weight) in 1984 (16). Although prevalence of obesity is lower in less developed Latin American countries like Brazil, a comparison of two national surveys showed an increase in the proportion of obese adults (BMI >30 kg/m²) from 5.7% in 1974 to 9.6% in 1989. The greatest change was in the poorest 30% of women, from 3.6 to 9.7% (9). More recently, data from the 1997 survey in Brazil show that obesity prevalence has continued to increase rapidly among the rural and low income urban populations. More optimistically, obesity prevalence declined from 12.8% in 1989 to 9.2% in 1997 among the upper income quartile of Brazilian urban women (17). The authors suggest that an intense mass media campaign since 1992 may have a positive effect on this segment of the population.

In China, obesity has been clearly associated with higher income in both rural and urban regions (18). However, a closer evaluation of the impact of income on dietary change suggests shifts that may lead to greater obesity among low income groups relative to those with higher income in the urban areas (19). A longitudinal study done in a small urban area of Southern Thailand revealed an unexpectedly large proportion of overweight people. Among 2,703 men and 792 women living in urban areas, 26% of men and 21% of women had BMI >25.0 kg/m² (20).

Data on obesity in Africa are limited and, due to lower development, most African countries are behind other regions in terms of both the demographic and the nutrition transition. Albeit, evidence of transition is appearing. However, the 1997 Demographic Health Surveys of maternal nutritional status reported that the prevalence of BMI >30 kg/m² among women aged 15–49 y ranged from <1% in Burkina Faso and Malawi to 25% in Egypt. Recent reports on the Tunisian and Moroccan populations in Northern Africa showed that women were much more likely to be obese than men. In Tunisia and Morocco, respectively, the prevalences of BMI >30 kg/m² were 23 and 18% for women and 7 and 6% for men (21). In South Africa, >44% of black females and 8% of males were recently reported to have BMI >30 kg/m² (22). There have been very few studies of older Africans. What is available on nutrition and aging in Africa is summarized and discussed by Charlton and Rose, in this issue of the journal.

Obesity makes direct and powerful contributions to risk of chronic disease. Until very recently, the health systems in most developing countries have not focused on obesity prevention or treatment, and few programs are in place to address this rapidly growing problem. The experience in Brazil suggests that media campaigns can be effective, at least in some segments of the population.

The epidemiologic transition: emerging chronic disease

Of >50 million deaths worldwide in 1997, ~33% were due to infectious disease, 50% to vascular disease, and 12% to cancer (23). While deaths due to vascular disease declined from 51 to 46% of total deaths in developed countries from 1985 to 1997, they increased from 16 to 24% in developing countries. Cancer deaths increased from 6 to 9% of total deaths in developing countries during this period. At the same time, deaths from infectious and parasitic disease decreased from 5 to 1% of total deaths in the developed world and from 45 to 43% of total deaths in the developing world (23).

One of the clearest outcomes of the nutrition transition is the epidemiologic growth of type 2 diabetes. Prevalence is currently higher in developed than in developing countries, but the majority of people affected already resides in developing countries, and prevalence is increasing at a much more rapid rate in the developing countries. Figure 3 shows the projected numbers of people in developed and developing countries with diabetes in the years 1995 and 2025 (24). In the developed countries, increases in prevalence during this period will average ~27%, from 6 to 7.6%, thus increasing from 51 to 72 million people with diabetes in 2025. In the developing countries, the projections are much higher, with an increase from 14 million to 302 million persons with diabetes; this represents a much more rapid rate of growth (25).

Abbreviations: SES, socioeconomic status.
 million people. In the developing countries, a 48% increase in prevalence, from 3.3 to 4.9%, and a 170% increase in number, from 84 to 228 million, are projected. Figure 4 shows the relative prevalence projections for Latin America, India, China and Africa. Among the developing countries, the greatest prevalence of diabetes will continue to be in Latin America. The greatest projected changes are for China and India, with expected increases in prevalence of 68% and 59%, respectively. The fewest cases will remain in the least developed regions of Africa, where this transition has not yet progressed (24).

In Latin America, the prevalence of diabetes is already at levels that make it of major public health concern. A 1996 study in Mexico showed a prevalence of diabetes of 21% in the population aged 60–69 y (25). For women and men older than 60 y, prevalences were 31 and 23%, respectively. Prevalence was greater in urban areas and was associated with high fat, low carbohydrate diets and with central adiposity (26). In Brazil, the age-adjusted prevalence of diabetes among adults was 7% in 1988–1989, was also higher among women than men, and was associated with age, obesity, family history of diabetes and lower educational level (27). Along with these increases in diabetes are rapid increases in vascular disease. The most frequent cause of death in Mexico in 1995 was cardiovascular disease, followed by malignant neoplasm, accidents and diabetes (28). In Chile, the cardiovascular death rate increased from 13% in 1990 to 30% of total deaths in 1999 (29).

Diabetes, hypertension and vascular disease have also been increasing rapidly in Asia (30). In China the prevalence of diabetes in adults aged 25–64 y in 1994 (2.5%) was 300% greater than it had been in 1984 (31). Diabetes incidence was associated with age, income, family history, BMI and waist circumference, blood pressure and physical inactivity (31). The prevalence of adult diabetes has also doubled in many other Asian communities over the past two decades, from 8 to 16% in Papua New Guinea, from 2 to 5% in Hong Kong, and from 4 to -8% and 8 to 12% for adults in Singapore of Chinese and Indian origins, respectively (32). Hypertension is also increasing rapidly in Asia. Stroke was the leading cause of death in China in 1986 (33). A comparison of the prevalence of hypertension in 1960 and 1990 showed that increases from 2–3% to 15–20% in several Asian countries (34). This report also found that hypertension and stroke occurred at relatively younger ages and that hypertension was more prevalent at lower BMI in Asia compared with other regions. In Pakistan, the prevalence of hypertension in urban areas was nearly twice that of rural areas, and in India adults from higher SES groups were three to four times more likely to have coronary heart disease than those in lower SES groups (34).

There have been few studies on chronic diseases in Africa, but limited data suggest that the prevalence of diabetes is still <1% in most countries in Africa. However, it has increased to >5–8% in South Africa and 10% in Egypt, with up to 20% in urban areas. Many areas with low diabetes prevalence are showing evidence of impaired glucose tolerance, suggesting that increases in diabetes prevalence are likely to follow (32). In South Africa, coronary heart disease death rates in 1990 varied considerably by ethnicity. They were 165 and 101 per 100,000 population for whites and Asians, respectively, considerably higher than that for the mixed race group (55 per 100,000) or for black South Africans (5 per 100,000). In contrast, cerebrovascular disease was greatest among the mixed race group (74 per 100,000), followed by whites and Asians (63 per 100,000) and blacks (37 per 100,000) (35). Although Africa is currently behind in this transition, we can expect that changes in Africa will also occur rapidly in the coming years.

Theories linking earlier malnutrition with later chronic disease

Observed associations between early nutrition and later chronic disease suggest that the less developed countries may expect particularly rapid growth in these diseases as their populations age. There has been considerable interest in early nutrition and coronary heart disease since the publication of the Barker hypothesis in 1987 (36). Barker proposed that undernutrition in utero affects cells during critical periods of development, thereby influencing distribution of cell types, hormonal feedback mechanisms, metabolic activity and organ structure. This fetal programming of cells then leads to later insulin resistance and greater susceptibility to obesity, diabetes and heart disease (37).

Accumulating evidence supports the association between poor nutrition and growth in utero or in early infancy and risk of type 2 diabetes and cardiovascular disease later in life, especially when weight gain in adulthood is added to early undernutrition (38). It has been assumed that much of the difference in individual susceptibility to disease that cannot be explained by environmental factors is due to genetic causes. However, at least part of what has been regarded as the genetic contribution to ischemic heart disease may be the effect of the intrauterine or early postnatal environment (38). Several studies have examined the relationship between birth weight and later development of hypertension, diabetes and/or cardiovascular disease, and results are remarkably consistent in demonstrating a positive association between these conditions (39).

Another theory to explain these associations is that of the “thrift genotype.” In 1962, James Neel, an American geneticist, postulated the existence of the thrifty gene to explain the apparent paradox of the high prevalence of diabetes in populations where it clearly had an adverse effect on reproduction (40). He suggested that in early life, a genotype predisposing to diabetes is “thrifty,” or efficient in the utilization of food. This genotype would have a survival advantage in times of food shortage. In the nutrition transition, with change from relative food scarcity to food sufficiency, the thrifty genotype no longer confers a survival advantage, but makes individuals more susceptible to obesity and diabetes (38). Hattersley et al. (41) have also recently proposed that fetal genetics may explain the associations used to support the Barker hypothesis. Their fetal insulin hypothesis suggests that genetically determined insulin resistance may result in both low insulin-mediated fetal growth in utero and insulin resistance, and thus, susceptibility to diabetes and heart disease in later life.
It is possible that there is validity to each of these hypotheses. The observed associations are evident and further research should elucidate specific mechanisms. With the current rapidity of change in diet and lifestyle, the greater risk of obesity and chronic conditions in countries with poor intrauterine and infant nutrition means that a double burden of undernutrition and chronic disease will be increasingly faced simultaneously in those countries with the least resources to do so.

**Nutrition and food security**

While the focus of attention of the nutrition transition has been its effect on shifts in macronutrient intake, obesity and chronic disease, there are additional concerns for the aging populations in developing countries. With rapid urbanization there are profound changes in social structures. Older family members are often left behind when families migrate to the city. Alternatively, they may find themselves isolated in a new urban environment. The increasing ratio of older dependents to fewer income earners puts pressure on traditional family support systems (42). With few formal retirement programs or pensions, many in the rapidly increasing population of elderly are likely to have difficulty securing nutritious diets. Foods supplying adequate energy but poor nutrient quality may contribute to greater obesity in some food-insecure older populations. On the other hand, many elderly will likely suffer from inadequate energy and nutrient intakes and low BMI. Both obesity and undernutrition will contribute to disability among the aging population. More discussion of disability among elderly in the context of the nutrition transition is presented by Zohoori in this issue of the journal.

In most developing countries, few elder assistance programs currently exist. Elderly with declining functional ability will be at high risk for food insecurity, thereby placing them at even greater risk of progressing disease and disability. There are currently very few studies from which to understand the current and changing status of elderly in developing countries. As the size of this population grows, more documentation of the situation of elderly will be needed to formulate programs of prevention and emergency assistance.

**Nutrient status and requirements with aging**

Recent decades of research in elder populations in developed countries have documented the nutritional vulnerability of older individuals, even under relatively affluent circumstances. Although total energy intake declines with age, requirements for many nutrients go up to maintain organ systems with declining functionality (43). It is, therefore, more difficult for elderly to meet their nutrient requirements than for younger adults, and the selection of nutrient-dense foods becomes of even greater importance.

Recent research illustrates that protein adequacy is critical for maintaining functional status with age. Casteneda et al. (44) found that older adults provided with diets containing 0.45 g protein · kg body wt⁻¹ · d⁻¹ for 9 wk had significant losses in lean tissue, immune response and muscle function. Recent studies suggest that protein requirements to retard loss of muscle mass (45) and bone mass with aging (46) in older individuals may be greater than previously thought. Short-term nitrogen balance results suggest that a safe recommended protein intake for older men and women should be 1.0–1.25 g high quality protein · kg⁻¹ · d⁻¹ (45).

Aging is generally associated with a gradual decrease in muscle mass (sarcopenia) (47). Loss of muscle mass poses significant risks, including lower resting metabolic rate, reduced muscle strength and increased functional dependency. In the combined New Mexico Aging Process Study and the New Mexico Elder Health Survey (48), the prevalences of sarcopenia and sarcopenic obesity (relatively high ratios of body fat to muscle mass) were 15 and 2%, respectively, in 60–69 yr olds and 40 and 10%, respectively, in those >80 yr of age. Elders at greatest risk for disability and for several chronic diseases in this population were those who were both sarcopenic and obese (48). In addition to adequate protein intake, resistance exercise has shown great promise in preventing sarcopenia. One study demonstrated that nitrogen excretion decreased 10–15% at the beginning of resistance training and persisted for 12 wk (45). Research on sarcopenia is still quite limited in developing countries. New studies in China and Chile are presented in articles by Stookey and Bunuot in this issue of the journal.

Micronutrient inadequacies are common among elderly, even in the most developed countries, and they have increasingly been linked to risk of chronic disease. For example, vitamins B-6, B-12, and folate are required to prevent the accumulation of homocysteine, an amino acid that has been consistently associated with risk of vascular disease (49), and recent studies have also shown associations between low concentrations of these B vitamins and cognitive decline (50). In addition, vitamin B-12 is needed to maintain neurological function (51). Data from several studies suggest that inadequate blood concentrations of these B vitamins are prevalent in older populations. In the Netherlands, 10–45% of adults aged 65 yr and older were deficient in vitamin B-6 (52). Older persons have greater difficulty absorbing vitamin B-12 because of atrophic gastritis, a degenerative stomach condition estimated to affect 25–40% of U.S. elderly (53). Despite apparently adequate intakes of vitamin B-12, relative to recommendations, >16% of elders in the U.S. Framingham Study had low vitamin B-12 concentrations (54). One of the few studies on B vitamins in elderly in Latin America (55) found prevalences of folate deficiency (<7 nmol/L) of 51% in men and 33% in women and prevalences of vitamin B-12 deficiency (<148 pmol/L) of 51% in men and 31% in women. On the other hand, in a small sample of elderly in Bangkok, Thailand, folate deficiency was found for 21% and vitamin B-12 deficiency was found for only 7% of cases (56). More information is needed about the B vitamin status of elderly in developing countries, where deficiency is likely to be common.

Calcium and vitamin D are also nutrients of particular concern for elderly populations. With age, declining renal function leads to malabsorption of calcium and accelerated bone loss (57). Requirements for vitamin D also increase with aging. Despite the greater availability of sunlight in most developing countries, relative to most developed countries, older individuals often have less exposure than younger adults. Furthermore, with age, there is decreased ability to form previtamin D-3 in skin with UV light exposure (58). The low calcium and vitamin D in the diets of many developing countries, together with the dietary and physical activity changes associated with the nutrition transition, suggest that osteoporosis will become an increasingly major problem as these populations age.

Antioxidant vitamins, including vitamin C, vitamin E, and a variety of phytochemicals, are important in maintaining effective antioxidant defenses against oxidant stress-related diseases, including cancer, cataract and Alzheimer’s disease. Vitamin E has also been shown to be effective in promoting immune function and in fighting infections (59). Very few studies of antioxidant status in developing countries are available. With the nutrition transition toward higher fat, lower fiber diets, attention to maintaining and increasing intakes of traditional...
fruits, vegetables and whole grains is of considerable importance in helping to control the worldwide increases in incidence of chronic disease.

Interestingly, the nutrients that have received the most attention for maternal and child nutrition—iron and vitamin A—are required in lower amounts by elderly than by younger adults. There is decreased clearance of vitamin A by hepatic and other peripheral tissues with age (60). Similarly, iron stores accumulate with age, and high serum ferritin has been associated with greater risk of coronary heart disease (61). Consequently, micronutrient fortification programs should consider the possible effects on the growing elderly segment of their populations.

Nutrition policy for aging populations in developing countries

At this time, few developing countries have placed elder nutrition on their list of priorities. However, the demographic pressures are becoming apparent. In 1992 at the International Conference on Nutrition, a formal recommendation was made that "... each country should make a firm commitment to promoting the nutritional well-being of its people, with priority given to the most nutritionally vulnerable groups." It was noted that older people are such a group, and it was further recommended "... that governments, in collaboration with other concerned parties, should promote caring for older persons" (3).

This recommendation was followed with a joint consultation of the World Health Organization with the Jean Mayer USDA Human Nutrition Research Center on Aging at Tufts University in 1998, where these issues were discussed in detail. An effort to utilize the growing knowledge about aging in developed countries lead to a list of priority concerns, for which more data are needed in developing countries (Fig. 5). Prominent on this list are the need to document the nutritional status of elderly, to better determine nutrient requirements, and to identify factors affecting dietary intake and nutrient absorption in differing cultural and environmental settings. It was also recognized that international dietary guidelines for older individuals are lacking, and that these are needed to guide community awareness and support of nutrition for elderly and for the development of community-based interventions.

Priority concerns and information needs for nutrition and aging identified at the 1998 joint consultation of WHO and the USDA Human Nutrition Research Center on Aging at Tufts University

- Epidemiological and social aspects of aging
- Factors affecting dietary intake and nutrient absorption
- Nutritional requirements of older persons
- Nutrition and immune function among older persons
- Dietary guidelines for older persons
- Community support for improved nutrition for older persons
- Community-based interventions

There are considerable challenges to research on the nutritional status of elderly in developing countries. Dietary intakes remain difficult to assess in many locations because of incomplete information in nutrient databases, particularly in regard to the nutrients of concern to elderly, including vitamins B-6 and B-12, folate, vitamins D and E and carotenoids. Many local foods have not been analyzed and others have been analyzed only for a limited set of nutrients and preparations. Unlike growth charts for children, there are no universal standards for anthropometric status and particularly for body composition of elderly. Equations for existing measures, such as knee height and bioelectrical impedance, have been developed in Western populations and are unlikely to be transferable to groups of elderly of diverse backgrounds (62). Clearly there is much work to be done.

Existing knowledge about nutrition and aging suggests that nutrition has the power to make a substantial impact on the health and functional status of older individuals. The size and rapid increase in the growing elderly segment of the world population makes the challenge of meeting the nutritional needs of this group even more pressing. The many local foods have not been analyzed and others have been analyzed only for a limited set of nutrients and preparations. Unlike growth charts for children, there are no universal standards for anthropometric status and particularly for body composition of elderly. Equations for existing measures, such as knee height and bioelectrical impedance, have been developed in Western populations and are unlikely to be transferable to groups of elderly of diverse backgrounds (62). Clearly there is much work to be done.

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