

living necessarily induces depression, but such life changes may be associated with poor self-esteem, which, in turn, can lead to significant changes in eating patterns (Letsov and Price 1987). Depression is one psychiatric disorder that can be treated successfully, but recent advances in therapy are not disseminated to health professionals widely or rapidly enough to make maximum impact (NIA 1987).

Economic and Social Changes

Older Americans as a group have a lower economic status than other adults in the United States (U.S. Census Bureau 1977; U.S. Senate 1987/88). Although the percentage of older individuals living below the poverty level (12.4 percent in 1984) has decreased substantially over the past two decades and is now less than the percentage of those under 65 living in poverty (14.7 percent in 1984), poverty continues to be too high. The decline in income most often results from retirement from the workforce, the effects of inflation on fixed incomes, death of a wage-earning spouse, or failing health (U.S. Senate 1987/88). Income and health status have been found to be important determinants of life satisfaction in the older population (Chatfield 1977). Low income is also a major risk factor for inadequate nutrition in older individuals (DHEW 1974; Guthrie, Black, and Madden 1972).

Most older people do not live in institutions, but older Americans as a group are more likely to be institutionalized temporarily or permanently (Kane 1984). Although institutional food is likely to meet minimal standards for nutrient content, factors such as a lack of choice or limited day-to-day variety may increase the risk of inadequate consumption. Many residents of nursing homes consume a therapeutic diet (NCHS 1981) that may further discourage adequate intake. An important issue for demented institutionalized individuals is that they may not consume the food, not that the menu is inadequate (Sandman et al. 1987).

Evaluation of the Nutritional Status of the Older Population

Methodological Issues

Assessing the nutritional status of the older population—and other populations—requires clinical studies to evaluate physical signs of nutritional health or disease, dietary studies to evaluate nutrient intakes with accepted standards, and laboratory investigations to provide data about quantities of particular nutrients in the body or to evaluate certain biochemical functions that are dependent on an adequate supply of a particular nutrient. Because use of a single measure is rarely sufficient to establish the level of malnutrition in a population, nutritional assessment is best accomplished using a

combination of these methods. The greater the number of measurements yielding values below standard, the more likely a population is to suffer from poor nutritional status.

Nutritional status evaluation of older people is complicated, and a number of methodological caveats should be kept in mind when evaluating the results. Clinical and dietary standards for younger adults may not be appropriate for older persons, yet few data are available on nutritional requirements or recommended intakes of older adults. The Recommended Dietary Allowances (RDA's), for example, were developed largely from research on the nutrient needs of young healthy people. The present standards for adults over age 50 are, for the most part, identical to those for people ages 23 to 50 (NRC 1980). Because these standards fail to consider the great heterogeneity of adults whose ages may differ by as much as 50 years (Schneider et al. 1986) and because they were often not developed from actual measurements on older populations, their appropriateness for older Americans is not known (Suter and Russell 1987).

Collection of dietary data in older individuals based on recording or recalling food eaten over a specified period of time is complicated by an increased prevalence of dementia and forgetfulness in older persons, which may result in underreported nutrient intakes (Beaton 1985; Hunt et al. 1983). It has also been difficult to separate behavioral changes in dietary intakes from the effects of aging processes on dietary and nutritional status. For example, 70 percent of a sample of older subjects indicated some change in food habits in recent years for health reasons, changes in living status, beliefs, or finances (Todhunter 1976). The Ten State Nutrition Survey found that two-thirds of the older population had changed their diets in the 4 years before the study (DHEW 1972). Male participants in the Baltimore Longitudinal Study of Aging reduced their cholesterol intake significantly during the period 1961-75 (Elahi et al. 1983). Whether advice from health professionals is responsible for such changes has not been established. However, these changes need to be considered when making inferences about the effects of aging processes on nutrition in older persons taken only from surveys conducted at a single point in time.

Similar issues apply to use of laboratory tests, body measurements, and body weights to assess the older population's nutritional status. Evaluation of height and weight measurements to define obesity, for example, is complicated by the loss of stature that accompanies aging (Bowman and Rosenberg 1982). Measurements of actual heights, weights, and body skinfolds in older populations have led to the development of standards substantially different from those for younger adults (Frisancho 1984).

Health status also affects such measurements; nutritional measures of older homebound individuals differ significantly from those of younger and less restricted groups (Sherman et al. 1983).

It is also difficult to make generalizations about clinical signs of undernutrition in older persons. For example, changes in subcutaneous tissue and skin that occur normally with age may mask clinical signs of vitamin deficiency (McClellan, Dodds, et al. 1976). However, NHANES did not find high percentages of older people with biochemical indications of nutrient deficiencies.

Perhaps the most serious problem in nutritional status assessment of older people is the lack of correlation between dietary intake data and clinical and laboratory assessment methods. For example, over the past 20 years, several comprehensive nutritional surveys that included persons over age 60 have been performed in this country (DHEW 1972, 1974; Agricultural Research Service 1972; USDA 1980; DHHS 1983). All of these studies have identified a substantial proportion of older men and women who fell below the RDA for calories—as well as for protein, vitamins, calcium, and iron (Bidlack, Kirsch, and Meskin 1986; Young and Rivlin 1982). However, estimates of obesity from anthropometric (body) measurements generally show an increase in percent of body fat for both sexes as age increases (Schlenker et al. 1973). NHANES I (DHEW 1974) and the Ten State Nutrition Survey (DHEW 1972) found obesity to be a substantial problem in the aged, especially in women. The findings of diminished calorie intake and increased obesity are difficult to reconcile. The contradiction may result from differences in criteria for evaluating the adequacy of dietary versus biochemical data (DHHS/USDA 1986), the diversity of the study populations, diminished physical activity among many older persons, or as yet unknown metabolic factors. However, it is well established that body composition changes in older people: the extremities lose fat that is redistributed to the trunk, and lean body mass is lost. Thus, the term obesity in older populations may need redefinition.

Energy and Nutrient Status of the Older Population

Bearing in mind the methodological considerations discussed above, this section highlights results from clinical, laboratory, anthropometric, and dietary assessments of energy and nutrient status of the older population.

Energy. The national dietary and food consumption surveys conducted during the 1970's reported lower energy intakes among older persons than among younger adults (DHEW 1979a; DHHS 1983; USDA 1984), a finding

that has been supported by smaller studies. A study of male executives in the Baltimore Longitudinal Study of Aging, for example, found a steady decline in average energy expenditure from 2,700 kcal/day at age 30 to 2,100 kcal/day at 80 years of age. The decline in energy expenditure was attributed to reduced physical activity (400 kcal) and to a 200 kcal decline in basal energy metabolism as a result of a reduction in lean body mass with age (McGandy et al. 1966). Aging was also inversely associated with energy intake among 180 male participants (35 to 74 years old) in the same study of aging (Elahi et al. 1983). A 4-year longitudinal study of free-living healthy older men and women whose average age was 71 showed a decline in energy intake of 162 and 152 kcal, respectively, to an average energy intake of 2,118 kcal/day for men and 1,545 kcal/day for women (Garry, Goodwin, and Hunt 1985). These levels of energy intake were determined from 3-day diet records and were substantially higher than those recorded for older subjects between 65 and 74 years of age in NHANES I and II and in the 1977-78 NFCS (DHEW 1979a; DHHS 1983; USDA 1984).

NHANES I reported lower caloric intake among older black Americans than among white Americans (DHEW 1979a), as did the 1977-78 NFCS for older black versus white men (USDA 1984). NHANES II did not present data by race within age, sex, and income groups because the number of black persons within those groups was too small to provide reliable estimates (DHHS 1983). However, NHANES II indicates that the percentages of overweight women are greater than men, although both sexes increase in weight until late mid-life when rates plateau and then decline into old age. Black women become overweight earlier in life than whites, but weight patterns of black males are similar to their white counterparts. Of the approximately 3,500 older persons examined in the NHANES I sample, which is representative of the U.S. civilian, noninstitutionalized population between 65 and 74 years of age, the mean energy intakes for the white and black males were 1,828 and 1,571 kcal/day, respectively; for white and black older females, the mean energy intakes were 1,319 and 1,186 kcal/day (NCHS 1977). These energy intakes represented 77 percent of the RDA's for white females and 69 percent for black females. The percents of the RDA standard were 75 and 64 for white and black males, respectively. Even when a conservative estimate of the 67 percent of the RDA standard is used, about 50 percent of the individuals 65 years and older met this level of intake. These levels were related to income: energy intake for those with income below the poverty level was less than the population mean regardless of sex and race. These surveys were conducted on healthy free-living individuals; most surveys of institutionalized older individuals have reported even less energy intake than that of individuals living at home (Stiedemann, Jansen, and Harrill 1978; Harrill and Cervone 1977; Jordan 1976).

Although it is difficult to interpret dietary intake studies of older Americans because of methodological problems, existing studies almost always reveal decreases in energy intake with age that may also be influenced by income, race, food preference, and drug use. A low-calorie diet may not impair health as long as the nutrient density of the diet is high and can provide adequate amounts of essential nutrients. However, this issue has not been examined in great detail because nutrient requirements in old age remain largely unknown.

Consequently, the increasing level of obesity among older persons, as indicated by higher weight-for-height with age (Frisancho 1984), requires explanation. Whether the inconsistency between reported low energy intake and increasing body weight is due to measurement errors, inappropriate standards, loss of height with age (Bowman and Rosenberg 1982), or lack of physical activity has not been established.

Protein. A 30-day continuous metabolic balance study of seven men and eight women over 70 years of age who consumed RDA levels of protein and energy found that about half were unable to maintain nitrogen balance on this level of protein (0.8 g of protein/kg/day). The results suggested that higher intakes were required (Gersovitz et al. 1982) to meet protein requirements. Other studies that examined protein requirements of older persons have also concluded that protein requirements may be higher (Munro 1983) even though mean protein intake usually exceeds the RDA (Brown et al. 1977; Jordan 1976; McClean, Weston, et al. 1976; Grotkowski and Sims 1978; Garry, Goodwin, Hunt, Hooper, et al. 1982; McGandy et al. 1986). Other studies reported lower protein intakes: at least 24 percent of the women in nursing homes and 29 percent in private homes consumed less than the RDA for protein (Jansen and Harrill 1977; Justice, Howe, and Clark 1974), and in another study, 12 percent of the men and 40 percent of the women living at home failed to meet this criterion (Jordan 1976). Because the RDA for protein includes a substantial safety margin and because clinical measurements have rarely found signs of protein deficiency among healthy older persons, it is not possible to conclude from these data that persons with intake below the RDA are protein deficient or that they would benefit from additional protein intake.

Calcium. Older people, especially Caucasian women, lose bone mineral and have a higher incidence of fractures than younger persons (Seeman and Riggs 1981). The mechanism behind the age-related loss of bone calcium is discussed in the chapter on skeletal diseases. Metabolic and absorptive factors as well as low intake may contribute to chronic negative calcium balance (Heaney, Recker, and Saville 1978; Horsman et al. 1980; Spencer,

Kramer, and Osis 1982). Reduced efficiency of intestinal calcium absorption (Avioli, McDonald, and Lee 1965; Gallagher et al. 1979; Alevizaki, Ikkos, and Singuelakis 1973; Bullamore et al. 1970; Ireland and Fordtram 1973) may be due to inadequate dietary intake (Heaney, Recker, and Saville 1977; Vinther-Paulsen 1981; Garry, Goodwin, Hunt, Hooper, et al. 1982; Omdahl et al. 1982; Koplan et al. 1986), age-related changes in gastric acidity, and/or interactions of intestinal constituents such as fiber, bacteria, and other nutrients. Perhaps in some individuals a negative effect on calcium nutriture may be caused by age-related changes in hormonal control (parathyroid hormone, calcitonin, prolactin, steroids, growth hormones), aberrations in vitamin D metabolism, and imbalances of protein, phosphorus, alcohol, and electrolytes with calcium (Riggs and Melton 1986).

The RDA for calcium of 800 mg/day (NRC 1980) may not be sufficient to maintain calcium balance in populations consuming Western-type diets (Heaney, Recker, and Saville 1978; Matkovic et al. 1979; Recker and Saville 1977; Recker and Heaney 1985; Consensus Development Panel 1984).

NHANES and NFCS reported mean intakes of about 700 to 720 mg for older men and 540 to 590 mg for older women (DHEW 1979a; DHHS 1983; USDA 1984). Other surveys have also reported that dietary calcium intake by older people is often marginal. For example, 43 percent of women in nursing homes failed to get two-thirds of their calcium requirement (Stiedemann, Jansen, and Harril 1978; Brown et al. 1977). Women living at home consumed even less calcium than those in nursing homes (Brown et al. 1977). One study reported that women, on the average, consumed only two-thirds of the RDA for calcium (Grotkowski and Sims 1978). Whereas some studies have reported similarly low calcium intakes among men (660 mg/day) (Brown et al. 1977; McClean, Weston, et al. 1976), others have found that intakes among older males equaled or exceeded the RDA of 800 mg/day (Stiedemann, Jansen, and Harrill 1978; Grotkowski and Sims 1978). Older people may have reduced calcium intake because they avoid dairy products containing lactose, to which they are intolerant (Goodwin, Hunt, et al. 1985; Heaney et al. 1982).

Iron. As with people of all ages, the frequency with which anemia occurs in the older population and determination of its etiology depend on the criteria used for diagnosis (see chapter on anemia). Few data on the iron status of older persons in the United States are available, and most studies report conclusions based on hemoglobin and hematocrit values with, at most, only one other index of iron nutrition (Lynch et al. 1982). One

national study—NHANES I (DHEW 1979b) and three regional studies (O'Neal et al. 1976; Fisher, Hendricks, and Mahoney 1979; Htoo, Kofkoff, and Freedman 1979), for example, found that more than 10 percent of older white men were anemic (when a hemoglobin level less than 14 g/dl was considered diagnostic). When a hemoglobin level less than 12 g/dl was used to identify anemia in women, these same studies found older white women to have a lower prevalence of anemia than men. These studies included older men who were not screened for diseases that can greatly reduce red blood cell production, such as chronic infections, renal disease, and neoplasms that result in chronic blood loss. Such data may indicate that the standard for low hemoglobin levels for men are too high, although age-related lower testosterone levels may reduce hematopoiesis and might also account for this difference (Lipschitz, Mitchell, and Thompson 1981).

Another study examined biochemical measures of iron status in healthy older persons and concluded that anemia or impaired iron status was no more prevalent in this population than in younger healthy adults when identical criteria were used to assess iron nutritional status (Garry, Goodwin, and Hunt 1983). A later longitudinal study revealed significant variability in the population mean values for all biochemical measures of iron nutriture except plasma iron; however, none of the changes suggested an increased risk of anemia. Comparison of older subjects who took iron supplements with those who did not showed no clinically significant differences in the biochemical measures of iron status (Garry, Goodwin, and Hunt 1985).

Because iron stores or reserves, as determined by plasma ferritin measurements, increase with age, studies that examine only dietary intake of iron in older people need to be interpreted cautiously (Casale et al. 1981). Low dietary iron intake at one point in time does not necessarily increase the risk for anemia because iron may still be available from body stores and because absorption increases when intake and stores are low. In addition, the type of iron and other components of a meal such as ascorbate also influence the amount absorbed (see anemia chapter).

Some clinicians believe that an increased incidence of anemia in some older people, compared with younger groups, is a direct and common physiologic response to aging (Lipschitz, Mitchell, and Thompson 1981). Evidence that bone marrow erythroid precursors are reduced in some anemic older individuals supports this theory; whether this reduced blood-forming capacity is due to aging *per se* or to some age-associated phenomenon such as chronic disease or use of medications is not certain (Lipschitz et al. 1984). Studies of very old healthy individuals find little evidence of

anemia and, therefore, support the contention that this condition is rare in healthy older people (Zauber and Zauber 1987).

Data from NHANES II are illustrative here. The mean iron intakes for men ages 65 to 74 years were 14.1 mg (about 1.4 times the RDA) and the prevalence of impaired iron status correspondingly low. The values for women of the same age were 10.2 mg, or about equal to the RDA for women age 55 and over, with a corresponding low prevalence of impaired iron status (DHHS 1983; LSRO 1984).

B Vitamins. Vitamin deficiency may be a result of decreased dietary intake, absorption defects, decreased hepatic avidity for folate in Laennec's cirrhosis, decreased storage and conversion to active metabolic forms, or excessive utilization, destruction, or excretion (Cherrick et al. 1965).

No comprehensive study of all the vitamins and their related enzyme systems has been conducted, perhaps because laboratory facilities and analytical technology are not sufficient to do all the necessary biochemical evaluations (Brin and Bauernfeind 1978). Most studies have examined the status of one or two vitamins. For example, a Boston study of older subjects reported that 37 percent had inadequate blood levels of riboflavin and 21 percent had low thiamin levels (Davidson et al. 1962). Biochemical pyridoxine deficiency in older individuals has also been noted in enzyme functional tests (Hoorn, Filkweert, and Westerink 1975). A number of studies have indicated a great risk for vitamin deficiencies in older persons on the basis of low dietary intakes, but such deficiencies are not always confirmed by biochemical or clinical results (Garry and Hunt 1986). In addition, interpretation of biochemical parameters is hampered by lack of data on normal standards for the older population (Kirsch and Bidlack 1987). For example, a New Mexico study revealed that more than one-fourth of the older population consumed less than 75 percent of the RDA's for folate and vitamins B₆ and B₁₂ from diet alone (Garry, Goodwin, Hunt, Hooper, et al. 1982). However, biochemical studies failed to confirm that these individuals were at risk for developing clinical symptoms associated with low intakes of these vitamins (Garry, Goodwin, and Hunt 1984). Intake of vitamin supplements may explain part of this apparent discrepancy, although analysis showed little statistical difference in mean dietary intake for those individuals taking a specific supplement compared with those who did not take the supplement (Garry, Goodwin, Hunt, Hooper, et al. 1982).

Vitamin C. Studies have shown that the total body pool of ascorbic acid reaches a maximum of approximately 20 mg/kg and that this level can be

achieved at a steady state plasma concentration of 1.0 mg/dl (Kallner, Hartman, and Hornig 1979). Women require an intake of 75 mg/day and men require an intake of 150 mg/day to achieve this ascorbic acid level in plasma (Garry, Goodwin, Hunt, and Gilbert 1982). This finding was supported by a clinical trial that showed that a daily intake of 60 mg was insufficient to maintain this plasma concentration (VanderJagt, Garry, and Bhagavan 1987). The clinical significance of maintaining maximal plasma ascorbic acid levels, however, has not been determined.

Some studies have reported low vitamin C intake and blood levels in both institutionalized and free-living older persons (Leevy et al. 1965; Davidson et al. 1962). Other studies reported intakes significantly greater than RDA levels and very few individuals with clinical symptoms of hypovitaminosis C (Garry, Goodwin, Hunt, and Gilbert 1982; Garry, Goodwin, Hunt, Hooper, et al. 1982). For instance, one study found that less than 2 percent of 270 free-living and healthy older persons over 60 years of age were at risk for developing clinical symptoms of hypovitaminosis C, as measured by plasma vitamin C concentrations below 0.2 mg/dl (Garry, Goodwin, Hunt, and Gilbert 1982). The mean steady state plasma vitamin C level for persons not taking supplemental vitamin C was 1.02 mg/dl—a level reported to be sufficient to maintain a maximal body pool. Additional supplemental intake had little effect in raising plasma levels. Mean intakes of vitamin C from the diet in that population were 137 mg/day and 142 mg/day for women and men, respectively—approximately 2.4 times the RDA (Garry, Goodwin, Hunt, Hooper, et al. 1982). In addition, over half were taking supplemental vitamin C—mean levels of approximately 600 mg/day.

Vitamin A. Vitamin A deficiency does not seem to be a particular problem in older persons. Although NHANES I and NHANES II reported that about half the study population over age 65 had vitamin A intakes at or less than two-thirds of the RDA, only 0.3 percent of the NHANES I older population had low vitamin A blood levels (Bowman and Rosenberg 1982; DHHS 1983). Serum vitamin A was not available for adults from NHANES II (LSRO 1985). Whether vitamin A supplement use can account for the observed discrepancy is unknown, but similar data suggest that older individuals can maintain normal vitamin blood levels even with reportedly low dietary intakes (Yearick, Wang, and Piasias 1980; Garry et al. 1987).

Vitamin D. Previous studies have revealed a generally lowered vitamin D status in older people, chronically ill individuals (Petersen, Hall, and Briggs 1981; Weisman et al. 1981), and those living in institutions (Weisman et al. 1981; Corless et al. 1979; Vir and Love 1978) with little or no exposure to sunlight (Lund and Sorensen 1979; Baker, Peacock, and Nordin 1980;

Lawson et al. 1979). Because the vitamin D endocrine system is the major regulator of intestinal calcium absorption (Christakos and Norman 1978), a reduced vitamin D status might promote a negative calcium balance in older people (see chapter on skeletal diseases).

Two recent studies in the United States have found dietary intake of vitamin D to be approximately 50 percent of the RDA for older subjects (Garry, Goodwin, Hunt, Hooper, et al. 1982; Lee, Lawler, and Johnson 1981), and inadequate intake (especially of vitamin D-supplemented dairy products) was well correlated with low blood levels of 25-hydroxyvitamin D (Omdahl et al. 1982). However, ultraviolet light induced endogenous production of vitamin D is the main external factor in maintaining adequate vitamin D status. Because sunlight exposure activates vitamin D precursors in skin, it has been recommended that older people obtain at least minimal sunlight exposure (10 to 15 minutes) two or three times a week (Holick 1986). Increased sun exposure may help compensate for aging skin's decreased capacity to produce these precursors (MacLaughlin and Holick 1985; Holick 1986). Supplements may be necessary to compensate for inadequate sunlight exposure due to seasonal variation in northern latitudes (Bouillon et al. 1987). Moderation in sun exposure should be recommended because overexposure to the sun is a strong risk factor for skin cancer.

Vitamin E. There is no evidence that older individuals are deficient either in dietary intake or tissue levels of vitamin E (Kelleher and Losowsky 1978; Vatassery, Johnson, and Krezowski 1983; Garry and Hunt 1986), despite statements that megadose vitamin E supplements retard the aging process and prevent atherosclerosis and cancer (Bieri, Corash, and Hubbard 1983). Therapeutic doses of vitamin E have prolonged survival of red blood cells in some inherited hemolytic anemias (Corash, Spielberg, and Bartsocas 1980), but its use to treat or prevent other conditions has not been established (Bieri, Corash, and Hubbard 1983).

Nutritional Supplements. It has been estimated that 37 percent of American adults consume a daily multivitamin preparation, fueling a more than \$2 billion per year industry (the Gallup Organization 1982; Herbert 1980; Koplan et al. 1986). NHANES II indicated that the persons most likely to take supplemental nutrients are less likely to need them, and those most in need of them are least likely to take them (Koplan et al. 1986). In older persons, vitamin use has increased dramatically in the past decade (Garry, Goodwin, Hunt, Hooper, et al. 1982; Scheider and Nordlund 1983). Whether such supplements improve the health of these people cannot be determined from existing data (Mann et al. 1987), but it is clear that

excessive supplementation may be harmful. High doses of the fat-soluble vitamins A and D are toxic.

Drug-Nutrient Interactions

Although older Americans constitute about 12 percent of the U.S. population, they use about 25 percent of all prescription drugs (Lecos 1984/85). This is not surprising because many chronic diseases associated with aging are managed with prescription drugs. Over half of the older people take at least one medication daily and many take six or more a day for multiple diseases (Lecos 1984/85). Cardiovascular drugs (e.g., diuretics) are most widely used by the aging population, followed by drugs to treat arthritis, neurologic disorders, and respiratory and gastrointestinal conditions. Many unwanted drug-nutrient interactions in older persons have been documented (see chapter on drug-nutrient interactions). The drug-nutrient interactions outlined in another chapter of this Report apply to the older person. However, this population requires special consideration because aging *per se* changes the absorption, disposition, and elimination of drugs. The older person with multiple diseases is at risk for additional drug-nutrient interactions linked to separate drug therapies for primary and secondary health problems. Even over-the-counter antacids, laxatives, analgesics, and vitamin and mineral supplements may result in unwanted drug-nutrient side effects in the older person (Roe 1985).

Effects of Nutritional Deficiencies on the Older Population

Morbidity and Mortality

Severe malnutrition—protein, calorie, vitamin, or mineral—is associated with increased morbidity and mortality, and the relationship of malnutrition to morbidity and mortality in older persons is of current interest. While less severe forms of malnutrition may be detrimental to health, the evidence has been more difficult to establish. Among severely ill or injured hospital patients of any age, protein-energy malnutrition greatly increases the risk for postoperative complications and overall morbidity and mortality (Mullen et al. 1979; Kaminski, Fitzgerald, and Murphy 1977). This association between nutritional status and survival does not prove a causal relationship because poor nutritional status may be the result of the illness or injury and not its cause. It is also difficult to demonstrate that moderate nutrient deficiencies increase morbidity and mortality.

Several investigators have tried to correlate blood levels of vitamin C, for example, with morbidity and mortality in an aging population. Among patients admitted to an acute care geriatric unit, those with low ascorbate

levels had a significantly higher mortality, but vitamin C supplements did not improve survival in these patients (Wilson et al. 1972, 1973). One prospective study reported dietary intake of vitamin C to be a significant predictor of mortality in an aging population (Hodkinson and Exton-Smith 1976), although it was not possible to separate cause from effect in this instance. Some older subjects with low vitamin C levels in blood exhibit clinical signs of scurvy (Andrews and Brook 1966), but some do not (McClellan, Dodds, et al. 1976). Signs of scurvy may be slow to resolve with supplementation in older subjects (Andrews, Letcher, and Brook 1969). The clinical significance of this observation has not been established.

Immune Status

Considerable evidence documents an age-related decline in immune competence, characterized by losses in T-lymphocyte and other functions. Certain of these changes resemble those induced by malnutrition (Thompson, Robbins, and Cooper 1987), but whether malnutrition is a significant cause of depressed immune function in large numbers of older individuals is uncertain. The large number of rodent studies that describe well-nourished old animals regularly displaying weak immune responses argues against the hypothesis that immunosenescence is due to malnutrition (Shock et al. 1984).

As described in the chapter on infections and immunity, protein-energy malnutrition in individuals of any age alters the proportion of T cell types, depresses T cell function, impairs delayed hypersensitivity reactions, and impairs thymic factor activity. Such changes are strongly associated with increased susceptibility to infectious diseases (Mullen et al. 1979; Falchuk et al. 1977). Impairment of delayed hypersensitivity and thymic factor activity have also been documented for deficiencies of single nutrients (Beisel 1982). Severe malnutrition is clearly related to impaired immune function in some older people, and improved dietary intake can at least partially correct these impairments. Current evidence is insufficient, however, to decide which, if any, age-related losses in T cell function are caused by nutritional deficiencies or some other physiologic or environmental factor (Thompson, Robbins, and Cooper 1987). The possible role of zinc deficiency in loss of immune function in older people has received considerable attention (Sandstead et al. 1982; Gershwin, Beach, and Hurley 1983).

If nutritional deficiencies are related to impaired immune function in older people, correcting the deficiencies should improve this function. Among hospitalized patients, intensive nutritional support does increase immu-

nocompetence (Law, Dudrick, and Abdou 1973). Among older people, dietary supplements have been associated with improved antibody responses to viral vaccines (Chandra and Puri 1985), and several studies have reported improved immune function as a result of zinc supplementation (Duchateau et al. 1981; Thompson, Robbins, and Cooper 1987); others have not (Brader et al. 1988). Whether these effects represent correction of nutrient deficiencies or are secondary to some nonspecific effect of supplementation is uncertain (Goodwin and Garry 1983).

Nervous System and Cognitive Function

Whether mental functions necessarily decline with age is questionable, and whether dietary factors can influence mental status in older persons is also uncertain. Results of psychometric testing in older people vary depending on the group studied. Although large population studies have reported gradual decreases in many mental functions with age (Nandy and Sherwin 1977), healthy, active older subjects do not display significant decrements (Botwinick 1977). This discrepancy suggests that the reported decrements in mental function are not inevitable age-associated events; rather, such changes are secondary to the various diseases and physical conditions that frequently accompany aging (Palmore 1974).

Alzheimer's Disease

Alzheimer's disease affects between 2 and 3 million Americans. The prevalence of this disease increases with age; while only 5 to 8 percent of people age 65 and over are affected, 35 percent of those over age 85 are affected. The cost of institutional care alone for Alzheimer's disease patients is estimated to exceed \$38 billion per year in direct costs and up to \$80 billion per year if indirect costs are considered (Huang, Cartwright, and Hu 1988).

The causes of Alzheimer's disease have not been established, but potential risk factors include age, family history of Alzheimer's disease, and head injuries. Further studies are needed to determine the validity and reliability of these risk factors. Whether nutritional factors can alter the risk for this condition is not known. High concentrations of aluminum have been found in the neurofibrillary-containing neurons of deceased patients, suggesting a relationship between aluminum and Alzheimer's disease. Such foci are not observed in the brains of people who die from other causes (Perl and Brody 1980). Despite these observations, there is no evidence that renal dialysis or use of aluminum antacids, antiperspirants, or cookware increases the risk for Alzheimer's disease (Katzman 1986), and the significance of the increased brain aluminum concentrations is unknown. The roles of certain

dietary antioxidants and toxic amino acids (Spencer et al. 1987) are under study.

Because Alzheimer's disease is a neurodegenerative syndrome involving cell loss and dysfunction, and because there is evidence that nutrient variables can affect brain metabolism, it might be speculated that neurotoxins acquired through the food chain may be involved in brain cell death. Therefore, researchers and clinicians should consider nutritional factors in the etiology of Alzheimer's disease.

Implications for Public Health Policy

Dietary Guidance

General Public

Aging is accompanied by a variety of physiologic, psychologic, economic, and social changes that may compromise nutritional status. However, ways in which the aging process affects energy balance, specific nutrient requirements, and nutrient status remain to be fully elucidated. Older adults may not necessarily have the same nutritional requirements as younger adults, yet current estimates of the nutrient requirements of older persons are based almost entirely on values extrapolated from data from studies of younger adults. The ways in which nutritional status might influence changes in tissue and organ function change with age and may influence the relationships between dietary components and the occurrence of chronic diseases of old age. Until more appropriate age-specific RDA's are established, the current RDA's should continue to be used as standards for nutrient intake of healthy older persons.

Until more is known, older Americans should consume sufficient nutrients and energy and maintain levels of physical activity that maintain desirable body weight and may prevent or delay the onset of chronic disease. Because it is often difficult to maintain adequate nutrient intake on low-calorie diets, older people should be advised to maintain at least moderate levels of physical activity so as to increase caloric needs. Recommendations to the general population about calcium intake (see chapter on skeletal diseases) are true for older Americans. Because many of the chronic diseases common to older persons may originate earlier in life (see chapter on maternal and child nutrition), dietary guidance to prevent them should be provided throughout life (as discussed in other chapters).

Health promotion messages from the public and private sectors should utilize advanced communication techniques, recognizing different lifestyles, decrements in vision and hearing, different cultural experiences, and different learning styles that may be common to older people. Federal and State agencies should provide information about successful public-private sector models for nutrition, health promotion, and education for older adults—for example, Healthy Older People, Age Well, and OASIS (Older Adult Service Information System).

Special Populations

Sedentary older individuals should be counseled on appropriate methods to increase caloric expenditure. Older persons who do not (or cannot) consume adequate levels of nutrients from food sources and those with dietary, biochemical, or clinical evidence of inadequate intake should receive advice on the proper type and dosage of nutrient supplements. Such supplements may be appropriate for some older persons, but self-prescribed supplementation, especially in large doses, may be harmful and should be discouraged. Older people who suffer from diet-related chronic diseases should receive dietary counseling from credentialed health professionals, and those who take medications should be given professional advice on diets that minimize food-drug interactions.

Nutrition Programs and Services

Food Labels

Evidence related to the role of diet in the aged currently holds no special implications for change in policy related to food labeling, although the size of the type on the label is a factor for most older consumers. Information provided on food labels should be scientifically sound, understandable, and nonmisleading.

Food Services

Food services, especially those receiving Government funds, should be required to pay special attention to meeting the caloric and nutrient needs of older clients. Nutritional assessment and guidance should be done at hospital admission or enrollment in or discharge from institutional or community-based services for older adults (e.g., acute and long-term care inpatient services, hospital-based outpatient services, alcohol and drug treatment programs, community health services, and home-delivered meals programs).

Food Products

Evidence suggests that older people would benefit from food products that provide a high proportion of available nutrients to calories, that have taste appeal, and that are easy to prepare.

Special Populations

Older people who are homebound, who live in isolation, or who suffer from chronic disease have special needs for nutrition services that are tailored to their particular conditions. Considerable evidence supports the nutritional and health benefits of dietary, economic, and social support programs for the older population.

Research and Surveillance

Research on nutrition and aging currently focuses on two general areas—the nutritional requirements and status of aging people and the influence of diet on aging processes and related pathologies. Psychosocial interactions with nutrition cut across both areas.

Research and surveillance issues of special priority related to the role of nutrition in the aged should include investigations into:

- The nutrient and energy requirements of older adults, currently extrapolated from younger age groups.
- The effects of dietary restriction and overconsumption on longevity and age-related pathology.
- The interactions among nutritional status, lifestyle and behavior, and the environment in older Americans.
- The effects of nutrition on age-related impairment of the cardiovascular, gastrointestinal/oral, immune, musculoskeletal, and nervous system functions and on prevention and treatment of disorders of those systems.
- The effects of marginal nutrient and energy deficiencies on the mental and physical health of older persons.
- Interactions among nutrients and between nutrients and drugs in older adults.
- Development of data bases for use by pharmacists and dietitians in counseling older persons on drug-nutrient interactions.
- Age-specific methods and standards to assess the nutritional status and body composition of older adults.

- The educational methods and program strategies that best promote adequate food consumption by older persons.
- Improved methods to monitor the nutritional status of older populations and individuals, including institutionalized older adults, over time.
- The educational and public health strategies that can be used to eliminate nutrition-related health fraud directed toward older citizens.

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