Racial Bias in Federal Nutrition Policy, Part I: The Public Health Implications of Variations in Lactase Persistence

Patricia Bertron, RD, Neal D. Barnard, MD, and Milton Mills, MD
Washington, DC

The *Dietary Guidelines for Americans* form the basis for all federal nutrition programs and incorporate the Food Guide Pyramid, a tool to educate consumers on putting the Guidelines into practice. The Pyramid recommends two to three daily servings of dairy products. However, research has shown that lactase nonpersistence, the loss of enzymes that digest the milk sugar lactose, occurs in a majority of African-, Asian-, Hispanic-, and Native-American individuals. Whites are less likely to develop lactase nonpersistence and less likely to have symptoms when it does occur. Calcium is available in other foods that do not contain lactose. Osteoporosis is less common among African Americans and Mexican Americans than among whites, and there is little evidence that dairy products have an effect on osteoporosis among racial minorities. Evidence suggests that a modification of federal nutrition policies, making dairy-product use optional in light of other calcium sources, may be a helpful public health measure. (*J Natl Med Assoc.* 1999;91:151-157.)

Key words: lactose intolerance ◆ ethnicity ◆ calcium ◆ osteoporosis

The *Dietary Guidelines for Americans* form the basis for all federal nutrition programs. Despite major advances in recent years in our understanding of the role of diet in health, the *Guidelines* reflect persistent cultural and racial biases that undermine the health status of Americans.

The Food Guide Pyramid was designed as a tool to put the *Guidelines* into practice and provide direction on the types and amounts of foods to consume daily.[1] The pyramid continues to recommend the use of dairy products by all Americans, even though research in the 1960s and 1970s found a high prevalence of lactose intolerance among adults in racial groups other than whites.[2] This article examines issues in lactase persistence and calcium balance, raising important implications for federal dietary policies.

Current US dietary policies evolved from food guides from the early part of this century, in the context of the US Department of Agriculture's (USDA) dual and sometimes conflicting legislative mandates to promote the health of Americans and to encourage sales of American agricultural products.[3]

The USDA and the Department of Health and Human Services first released the *Dietary Guidelines for Americans* in 1980 and subsequently have revised them every five years. The Food Guide Pyramid,

From the Physicians Committee for Responsible Medicine, Washington, DC. Requests for reprints should be addressed to Dr Neal D. Barnard, Physicians Committee for Responsible Medicine, 5100 Wisconsin Ave, NW, #404, Washington, DC 20016.

introduced in its current form in 1992, is a graphic interpretation of the total diet and is included in the *Guidelines* as a tool for putting them into practice.[1] It visually suggests that recommended intakes of dairy products and meat are reduced in proportion to those of grains, vegetables, and fruits. The Food Guide Pyramid recommends two to three daily servings from the meat, poultry, fish, dry beans, eggs, and nuts groups for a total of five to seven ounces of meat per day. One ounce of meat can be replaced with one-half cup cooked beans, one egg, or two tablespoons of peanut butter.[4]

LACTASE PERSISTENCE

The recommendation that all individuals >2 years of age consume cow's milk products daily (currently two to three servings per day) began with the 1916 food guide.[4] It has remained essentially unchanged despite later research showing dramatic differences between racial groups in their ability to digest dairy products and in susceptibility to osteoporosis, as well as differences in preferences for calcium-rich green vegetables and legumes.

Virtually all infants and small children have the lactase enzymes that split lactose into glucose and galactose. Lactase persistence, the retention of the lactase enzyme into adulthood, is not consistent across ethnic groups.[2] A decline in lactase activity with age is normal, termed lactase nonpersistence. Those who lack or have a greatly reduced amount of the lactase enzyme may experience the signs and symptoms of lactose intolerance–abdominal pain, bloating, flatulence, and diarrhea–after consumption of foods containing lactose.[5]

In 1965, researchers from the Johns Hopkins University tested 60 hospital patients for lactose digestibility. Nonabsorption occurred in about 15% of whites and 70% of African Americans.[6] The researchers speculated that the contrasting figures resulted from differences in the habitual diets of these two groups. In 1966, researchers studied inmates at the Maryland House of Correction, offering 20 whites and 20 African Americans extra canteen money in exchange for their participation in lactose challenge tests. Symptoms developed in 10% of whites and 90% of African Americans.[7] The differences were attributed to genetics, rather than to diet or other environmental factors.

In a 1968 study, 20 Asians and 20 whites were given 50 g of lactose. Gastrointestinal symptoms occurred in 95% of Asians compared with 10% of whites. The mean rise in blood glucose among Asians was 14.5 mg per 100 mL compared with 37.6 mg per 100 mL in whites, indicating that hydrolysis of lactose to glucose and galactose occurred at a higher rate in whites.[8]

A 1977 study of Mexican Americans, using 50 g of lactose, showed that 53% were lactose maldigesters, of whom 76% had gastrointestinal symptoms.[9] A study of 104 Native Americans conducted the same year used 2 g of lactose per kg of body weight, up to a maximum of 50 g, and found that 74% were lactose maldigesters, based on breath tests (measuring hydrogen produced by intestinal bacteria during the fermentation of undigested lactose).[10] Other studies showed that a substantial reduction in lactase activity was common among those who were African, Asian, Native American, Arab, Jewish, Hispanic, Italian, or Greek.[11]

In 1988, a study in the *American Journal of Clinical Nutrition* reported, "it rapidly became apparent that this pattern was the genetic norm, and that lactase activity was sustained only in a majority of adults whose origins were in Northern European or some Mediterranean populations."[2] In other words, whites tolerate milk sugar only because of an inherited genetic trait.

Not only are whites less likely to have lactose maldigestion, but they also are much less likely to have troublesome symptoms when it occurs. A 1994 study tested the effects of 360 mL of whole milk (containing 16.5 g lactose) in 46 whites and 52 African Americans, aged 20 to 89 years, in Huntsville, AL. In individuals ⩾50 years, breath testing revealed lactose maldigestion in 20% of whites compared with 71% of African Americans. For individuals <50 years, 15% of whites and 36% of African Americans had positive breath tests. Of those with maldigestion indicated by breath tests, only 25% of whites had symptoms compared with 73% of African Americans, who experienced abdominal cramps, flatulence, diarrhea, and bloating.[12]

Symptoms can occur even with modest milk servings. In a 1996 double-blind randomized study, 13 adult lactose maldigesters (racial composition unspecified) consumed 0, 2, 6, 12, and 20 g of lactose in water. In the ensuing eight hours, hydrogen production was significantly higher after the 6-g dose than the 2-g dose. Both hydrogen production and abdominal symptoms (pain and gas) were greater after 12 g of lactose than after 6 g. Overall, the study showed maldigestion, as evidenced on

breath testing, was clearly present after ingestion of only 6 g of lactose (the amount in 120 mL or one-half cup of milk), and symptoms were present after doses of 12 g and 20 g.[13]

Research sponsored by the National Dairy Council attempted to determine if lactase-nonpersistent individuals could digest two cups of milk in one day, the minimal amount of dairy product consumption recommended by the Food Guide Pyramid. Among subjects for whom breath testing revealed lactose maldigestion, the researchers succeeded in minimizing symptoms by serving one-cup test doses in combination with other foods and spacing them widely apart over time. These subjects may have been those least bothered by digestive difficulties, as 15 of the original 34 subjects declined further testing after their first lactose test, and most subjects were Asian or whites; only three were African American.[14] A follow-up study by the same group reached similar conclusions, again based on a subject sample that was predominantly white and Asian and included only two African Americans.[15]

The same investigators noted that some subjects reported symptoms related to milk despite normal lactose digestion on breath testing. While the researchers attributed this to misreporting, it may be that milk components other than lactose also cause symptoms. Milk proteins, for example, are a common cause of infantile colic and exert this effect even at low concentrations.[16] The role of milk proteins in digestive complaints in adults is unclear.

Overall, about 75% of the world's population, including 25% of those in the United States, lose their lactase enzymes after weaning.[13] Recognition of this fact has resulted in an important change in terminology in the nutrition literature. Individuals who were unable to digest milk were once called "lactose intolerant" or "lactase deficient." The reduction in lactase activity is now considered a normal physiologic pattern, while adults who retain the enzymes that allow them to digest milk are called "lactase persistent."[5]

Although the research that led to this new understanding came 25 years before the introduction of the Food Guide Pyramid, the pyramid's recommendation for dairy product consumption is essentially unchanged from that of previous guides (and is incorporated in the "Eat a Variety of Foods" guideline in the fourth edition of the *Dietary Guidelines for Americans*).

Yogurt and cheese products are less likely to cause digestive symptoms. Most cheese is high in fat, although some skim and nonfat varieties are available. Also, commercial milk products can be enzymatically modified to cleave lactose into glucose and galactose, obviating the symptoms of lactose maldigestion. The health effects of galactose are matters of ongoing research, particularly with regard to cataracts and ovarian toxicity, as manifested by an association between dairy product consumption and ovarian cancer and infertility in women.[17,18] Many people may prefer to obtain calcium from other sources, something for which the Food Guide Pyramid makes no specific allowance.

OTHER CALCIUM SOURCES

Calcium is a necessary component of the diet, although optimal intake is controversial, particularly for those at risk for osteoporosis. There are many different calcium sources whose nutritional characteristics vary considerably.

Many green vegetables have calcium absorption rates >50% compared with about 32% for milk.[19] A 1994 study reported calcium absorption of approximately 53% for broccoli, 64% for brussels sprouts, 58% for mustard greens, and 52% for turnip greens.[19] The reported fractional calcium absorption from kale ranges from 40% to 59%.[19,20] Fortified orange juice contains 350 mg of calcium per 8-oz serving, with a 36% to 38% absorption fraction (manufacturer's data). Beans (eg, pinto beans and red and white beans) and bean products, such as tofu, are also rich in calcium, with absorption rates ranging from 17% to 31%.[19]

A cup of boiled mustard greens contains roughly 128 mg of calcium. At a 58% absorption rate, the absorbable fraction is 74 mg compared with 93 mg of absorbable calcium in milk (291 mg total at 32% absorption), without accounting for the effects of animal protein and sodium in milk, both of which may reduce calcium retention by increasing excretion. Beans and green leafy vegetables have nutritional advantages that differentiate them from dairy products. They are excellent sources of carotenoids and other antioxidants, complex carbohydrate, fiber, and iron. They contain no animal proteins or cholesterol, little or no saturated fat, and very little sodium unless it is added during cooking (Table 1). High concentrations of oxalic acid or phytate have a negative impact on calcium absorption in spinach, rhubarb, or sweet potatoes.[21]

Preferences for beans and green leafy vegetables are not uniform across demographic groups. In

Table 1. Nutritional Composition of Selected Green Vegetables and Milk*

	Mustard Greens†	Broccoli†	Whole Milk‡	Skim Milk‡
Calories	25	48	150	86
Gross calcium (mg)	128	83	291	302
Calcium absorption (%)§	57.8	52.6	32.1	32.1
Absorbable calcium (mg)	74	43.7	93.4	96.9
Beta-carotene (mg)	422	241	0	0
Vitamin C (mg)	36	96	2	2
Iron (mg)	1.3	1.2	0.1	0.1
Fiber (g)	2.8	4.5	0	0
Fat (g)	0.4	0.4	8.2	0.4
Saturated fat (g)	0	50	5.1	0.3
Cholesterol (mg)	0	0	3	4
Sodium (mg)	15	42	120	126
Protein (g)	3.4	5.2	8	8.4
Carbohydrate (g)	3.8	8.9	11.4	11.9

*Data from Pennington JAT. *Bowes and Church's Food Values of Portions Commonly Used.* Philadelphia, PA: Lippincott; 1994; and First Databank. Nutritionist IV Diet Analysis for Windows, version 4.1. 1st quarter, 1997.
†1 cup cooked.
‡8 oz.
§Weaver CM, Plawecki KL. Dietary calcium: adequacy of a vegetarian diet. *Am J Clin Nutr.* 1994;59(suppl):1238S-1241S.

August 1997, Opinion Research Corporation International surveyed 1000 adults for the Physicians Committee for Responsible Medicine on their willingness to consume green leafy vegetables, such as broccoli, collard greens, or kale, at least three times per week, or if they would eat beans, such as pinto beans, black-eyed peas, or baked beans, at least three times per week, if government nutritionists said that these foods were healthful sources of calcium. Overall, 77% of those surveyed responded affirmatively with regard to green vegetables, and 67% reported their willingness to eat beans. For both questions, affirmative response rates were higher for African Americans (80% for green vegetables and 75% for beans), compared with whites (76% for green vegetables and 66% for beans) although differences did not reach statistical significance. The percentage of favorable responses for beans was significantly higher in southern states (76%) compared with other regions (61% for the northeast, 60% for north central states, and 66% for western states) (Opinion Research Corporation International, Princeton, NJ, unpublished data, 1997).

These figures suggest that federal nutrition guides have emphasized the use of milk products for calcium. Other sources may be preferred by those who develop symptoms in response to lactose ingestion, who habitually use greens or legumes, or who seek the nutritional advantages offered by green vegetables and legumes.

RACIAL DIFFERENCES IN BONE INTEGRITY

Milk is currently advocated for one primary nutritional purpose–as a convenient fluid source of calcium to slow osteoporosis. However, bone metabolism and susceptibility to osteoporosis differ dramatically between ethnic groups. It has not been established that milk has any effect on osteoporosis among members of racial minorities.

A study of 503 women, aged 20 to 80 years, found that compared with whites, African Americans had higher bone mineral densities at the spine, hips, and forearm.[22] Compared with whites, African Americans have a higher average peak bone mass, slower bone loss, and reduced urinary calcium excretion.[22-26] In contrast to the female predominance in osteoporosis cases as seen in whites, several studies have shown nearly an equal female/male ratio among African Americans, suggesting that factors responsible for osteoporosis may differ between races.[25]

Osteoporosis is less common in non-Hispanic blacks and Mexican Americans than non-Hispanic whites. The Third National Health and Nutrition Examination Survey (NHANES III, 1988-1991)

reported that the age-adjusted prevalence of osteoporosis was 21% in US non-Hispanic white women ≥50 years compared with 16% in Mexican Americans and 10% in non-Hispanic blacks.[27]

Fracture rates are much lower in African Americans and Mexican Americans compared with non-Hispanic whites. A study of residents from Bexar County, TX, identified 576 individuals with hip fractures unrelated to severe trauma. Ethnic-specific incidence rates were calculated and age-adjusted based on 1980 census data. Hip fracture rates were much lower among African-American women (55 per 100,000) and Mexican-American women (67 per 100,000) than non-Hispanic white women (139 per 100,000).[28]

Most research studies of the dietary calcium effects on bone have explicitly excluded blacks or all non-white races, presumably because of anticipated differences in bone density and risk of osteoporosis.[29-38] A 1994 National Institutes of Health Consensus Development Conference concluded that based on present evidence, it is not known whether optimal calcium requirements are the same for all ethnic groups.[39]

In white women, supplemental calcium has been shown to slow bone loss in several studies, although not all.[38] However, studies assessing the effect of dairy products, rather than calcium supplements, on fracture rates have yielded mixed results.

A 1988 study of white middle-aged and elderly men and women in Rancho Bernardo, CA, indicated that high dietary calcium intake was associated with significantly reduced risk of hip fracture.[29] In contrast, a 1994 study of elderly men and women in Sydney, Australia (racial composition unspecified), showed that higher dairy product consumption was associated with increased fracture risk. Those with the highest dairy product consumption had approximately double the risk of hip fracture compared with those with the lowest consumption.[40]

Similarly, in the Harvard Nurses' Health Study of 77,761 women, aged 34 to 59 (98% of whom were white), individuals who consumed more calcium from dairy products had slightly, but significantly, higher risk of hip or arm fractures over a 12-year follow-up period compared with those who consumed little or no milk, even after adjustment for weight, menopausal status, smoking, and alcohol use.[41]

A 1992 review revealed that fracture rates differ widely between various countries, and in this context, a higher calcium intake demonstrated no clear protective role. For example, South-African blacks had an average daily calcium intake of 196 mg and a fracture incidence of only 6.8 per 100,000 person-years, far below that of North American or European countries. Within the United States, African Americans had half the fracture rate compared with whites (60.4 versus 118.3 per 100,000 person-years, respectively).[42] Overall, those populations with the highest calcium intakes had higher, not lower, fracture rates than those with more modest calcium intakes. This review suggests that environmental factors other than calcium intake, along with genetics, play important roles in bone integrity.

One observational study of hip fractures among Chinese men and women in Hong Kong showed that those consuming more calcium from green vegetables, small fish, and tofu had a reduced risk of hip fracture, as did those engaging in daily physical activity.[43] We are aware of no controlled intervention trials specifically testing the effects of calcium-rich diets or calcium supplements on fracture rates in African Americans, Mexican Americans, Native Americans, or Asian Americans.

OTHER CONTRIBUTORS TO OSTEOPOROSIS

Bone integrity is influenced, not by calcium intake alone, but by calcium balance, which is affected by genetic, dietary, and lifestyle factors, including animal protein, sodium, tobacco, physical activity, vitamin D, medications, and possibly caffeine.

Animal protein increases calcium losses. This is due in part to the action of sulfate produced in the metabolism of sulfur-containing amino acids. Sulfate filters through the kidneys, carrying calcium with it. Doubling protein intake increases urinary calcium losses by about 50%.[44] The Harvard Nurses' Health Study, which included 85,900 women in 1980, showed that high consumption of animal protein was associated with an increased risk of forearm fracture. Over a 12-year period, individuals consuming more than 95 g of protein daily had an increased fracture risk >20% compared with those who consumed <68 g per day (relative risk = 1.22, 95% confidence interval, 1.04-1.43).[45]

The 1992 review of fracture rates in various countries as previously mentioned found a positive relationship between animal protein intake and fracture rates. The high fracture rate in the United States was in the context of a high average animal protein intake (72 g per day) compared with only 10.4 g per day for South-African blacks.[42] Sodium also encour-

ages calcium to pass through the kidneys and is an acknowledged contributor to urinary calcium losses in the fourth edition of the *Dietary Guidelines for Americans.*[46]

The contribution of smoking to fracture risk was illustrated in a study of identical twins discordant for smoking. Long-term smokers had a 44% increased fracture risk compared with their nonsmoking twins.[47]

Vitamin D is important for calcium absorption and helps maintain bone integrity. In the elderly, vitamin D deficiency can be caused by lack of sun exposure or impaired conversion to the active metabolite 1,25-dihydroxyvitamin D in the kidney.[39] Physical inactivity also is associated with increased risk of hip fracture among whites.[32,33,48]

Corticosteroid medications have a powerful adverse effect on bone metabolism and are associated with an increased risk of hip fracture.[49] Endocrine conditions (eg, hypogonadism or hyperthyroidism), gastrointestinal diseases, neoplastic disease, alcoholism, diabetes, and liver disease also contribute to osteoporosis.[50]

The role of caffeine in osteoporosis remains controversial. Its diuretic effect may lead to the loss of both water and calcium. However, this effect is probably only significant at consumption levels equivalent to $\geq$2 cups of coffee per day.[51]

The relative contribution of these factors in osteoporosis among racial minorities is unclear. On average, non-Hispanic white women compared with African-American and Mexican-American women also are leaner, which may affect risk of osteoporosis due to adipose tissue in estrogen production.[52] The authors were unable to find evidence that dairy product consumption offers any protection from fracture among members of racial minorities. For many, regular milk consumption could be expected to cause gastrointestinal symptoms, while providing little or no benefit for the bones.

CONCLUSION

The 1994 NIH Consensus Statement on Optimal Calcium Intake held that individuals who are sensitive to milk products or who avoid them for other reasons can obtain calcium from other sources.[39] The *Guidelines* and the Food Guide Pyramid, however, continue to encourage dairy products for daily consumption by all Americans, despite differences in tolerances for dairy products, preferences for other calcium-rich foods and susceptibilities to osteoporosis, as well as the lack of scientific evidence of benefit from dairy products for members of racial minorities. In this regard, federal nutrition policies do not yet address the needs of all Americans.

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