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Dietary Sources of Calcium, Vitamin D, and the Pattern of Dairy Products Consumption in Five Ethnic Groups in the United States

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Abstract

The objective of this study was to describe dietary sources of calcium and vitamin D among five ethnic groups in the United States. Cross-sectional dietary data were collected using a quantitative food frequency questionnaire from 186,916 participants in the Multiethnic cohort representing five ethnic groups (African American, Latino, Japanese American, Native Hawaiian, and Caucasian), aged 45-75 years living in Los Angeles County and the state of Hawaii between 1993 and 1996. Nutrient intakes for calcium and vitamin D were analyzed based on a unique food composition table which was extended and adapted from the USDA food composition database. Dairy products were the greatest contributor to calcium intake in all groups, but the percent contribution varied considerably between ethnic sex groups from 18.6% (Japanese American men) to 37.8% (Caucasian women). Dairy products were also the greatest contributors to vitamin D intake among all ethnic-sex groups except Native Hawaiian and Japanese American men, for whom fish was the top contributor (40.7 and 42.5% respectively). Low-fat milk was the top source (16.0-21.9%) of dairy products in all ethnic-sex groups except Japanese American men and women and Caucasian women. The data identified dietary sources that can be targeted by nutrition intervention programs and dietitians working with ethnic/racial populations at high risk of inadequate intake of calcium and vitamin D.

Keywords: diet, calcium, vitamin D, dairy product, ethnicity

1. Introduction

Forty-four million Americans have osteoporosis or low bone mass density (NIH Osteoporosis and Related Bone Diseases National Resource Centre, 2012). Estimated national direct expenditures (by hospitals and nursing homes) for osteoporosis and related fractures are approximately $14 billion each year (NIH Osteoporosis and Related Bone Diseases National Resource Centre, 2012). An inadequate supply of calcium and vitamin D throughout the lifespan contributes significantly to the development of osteoporosis and osteomalacia (Holick, 2007; NIH Osteoporosis and Related Bone Diseases National Resource Centre, 2012). In addition, low calcium intake has been associated with increased risk for hypertension, diabetes, colon cancer and recurrent colon polyps (Choi, Willett, Stampfer, Rimm, & Hu, 2005; Hartman et al., 2005; Kesse, Boutron-Ruault, Norat, Riboli, & Clavel-Chapelon, 2005; Miller, Jarvis, & McBean, 2001).Vitamin D deficiency has been linked to several types of cancer, type 2 diabetes, cardiovascular disease, infectious diseases and autoimmune diseases (such as type 1 diabetes, multiple sclerosis and rheumatoid arthritis) (Holick, 2007; Kulie, Groff, Redmer, Hounshell, & Schrager, 2009; Maruotti & Cantatore, 2010; Van, Stoffels, Gysemans, Mathieu, & Overbergh, 2008). Vitamin D is required for optimal calcium absorption; only 10-15% of dietary calcium is absorbed with vitamin D insufficiency (Holick, 2007).

Calcium and vitamin D deficiency are important public health concerns for older Americans. Results from national surveys indicate that only about 4% of women and about 14% of men aged ≥50 years consume 100% of the recommended calcium intake (Miller et al., 2001). NHANES III data indicate that up to 90% of older individuals (≥ 51 years) did not meet vitamin D needs from diet and supplements (Calvo, Whiting, & Barton, 2004). Calcium and vitamin D deficiency is also a concern for ethnic groups. It has been reported that minority populations consume substantially less than recommended amounts of calcium, which can limit attainment of optimal bone mass, increasing risk of osteoporosis (Jackson & Savaiano, 2001). Additionally, about 25% of adults in the U.S. are lactose intolerant (Institute of Medicine, 1997). Lactose intolerant people often avoid milk products and, therefore, may have low calcium and vitamin D intakes (Ginde, Liu, & Camargo, Jr., 2009; Miller et al., 2001). The prevalence of lactose intolerance is the highest among Asians (about 85%), intermediate among African Americans (50%) and low among Caucasians (10%) (Institute of Medicine, 1997). As the number of minority populations and elderly increases, there is great cause for concern that rates of osteoporosis and other chronic diseases will increase. Therefore, there is a need to find appropriate sources to increase the intakes of calcium and vitamin D among different ethnic/racial groups in the U.S.

Although sunlight exposure is the principal source of vitamin D for many people, dietary intake is essential when sun exposure is not adequate. Dietary intake is also critical for certain groups that are at high risk of deficiency, including the elderly, people with dark skin pigmentation and those who are obese (Calvo, Whiting, & Barton, 2005; Ginde et al., 2009). Dairy products are good sources of calcium, vitamin D, and other nutrients, including magnesium, potassium, zinc, iron, vitamin A, riboflavin, and folate (Moore, Murphy, Keast, & Holick, 2004; Sharma et al., 2003b; Sharma et al., 2004; Weinberg, Berner, & Groves, 2004). The U.S. Department of Health and Human Services' Healthy People 2010 objectives for the Nation identified low calcium intake as one of the priority nutrition problems in the U.S. This remains a proposed objective for Healthy People 2020 (U.S.Department of Health and Human Services, 2012).

Understanding the ethnic differences in dietary sources of calcium and vitamin D and as well as the patterns of dairy product consumption can help provide culturally appropriate dietary information to tailor nutrition education and intervention programs for specific ethnic groups (Weinberg et al., 2004). Furthermore, identifying the dietary sources of nutrients and consumption of main types of dairy products among ethnic groups is important for developing effective dietary food-based guidelines. This study aimed to determine the dietary sources of calcium, vitamin D, and dairy products for five main ethnic groups in the U.S.: African Americans, Latinos, Japanese Americans, Native Hawaiians, and Caucasians.

2. Methods

This study was developed based on the data collected in the large Multiethnic Cohort (MEC) study in the U.S. The MEC study procedures and dietary assessment instruments have been described in detail elsewhere (Kolonel et al., 2000; Stram et al., 2000). Briefly, during 1993-1996, the MEC recruited 201,257 men and women aged 45-75 years from five ethnic/racial groups , including African Americans, Latinos (born in Mexico and Central/South America: Latino-Mexican; born in the US: Latino-US), Japanese Americans, Native Hawaiians, and Caucasians in Hawaii and Los Angeles. Ethnicity was self-defined.

A 26-page questionnaire, including questions about demographic information and a 17-page quantitative food frequency questionnaire (QFFQ) was mailed to all eligible participants in the study catchment areas, and was self-administered by the participants. The QFFQ was developed specifically for the study population based on 3-day measured food records from approximately 60 men and 60 women from each ethnic group (Kolonel et al., 2000). Ethnic-specific foods were also included irrespective of their contribution to daily nutrient intake. Acceptable correspondence between the QFFQ and three 24-hour recalls (as the reference dietary assessment method) for the ethnic groups was shown in a calibration substudy (Stram et al., 2000). This QFFQ collected usual dietary intake over the previous 12 months.

After excluding individuals with extreme energy intake (mean ± 3SD) (6% of participants) and Latinos born in the Caribbean (n=1,726) due to their small sample size, this analysis included 31,852 African Americans, 13,629 Native Hawaiians, 51,248 Japanese Americans, 42,951 Latinos, and 47,236 Caucasians. It has been shown that food consumption patterns differ substantially between Latinos by birthplace (Kolonel et al., 2000). Therefore, we separated Latino-Mexicans (n=21,083) and Latino-US (n=21,868).

The detailed methods of developing and calculating servings of food groups using the U.S. Department of Agriculture food grouping scheme have also been described previously (Kolonel et al., 2000; Sharma et al., 2003a; Sharma et al., 2003b; Sharma et al., 2004). Each individual's serving intakes of total dairy products were computed by summing the servings across the appropriate food items on the QFFQ, and these data were previously reported (Sharma et al., 2003b; Sharma et al., 2004). Nutrient intakes were analyzed based on a unique food composition table which was extended and adapted from the USDA food composition database (Sharma et al., 2003a). Similar foods were combined to rank the contribution to nutrients and calculate the total intake of dairy products because there were a large variety of foods that contained these items.

The study protocol was approved by the Institutional Review Boards of the University of Hawaii and the University of Southern California.

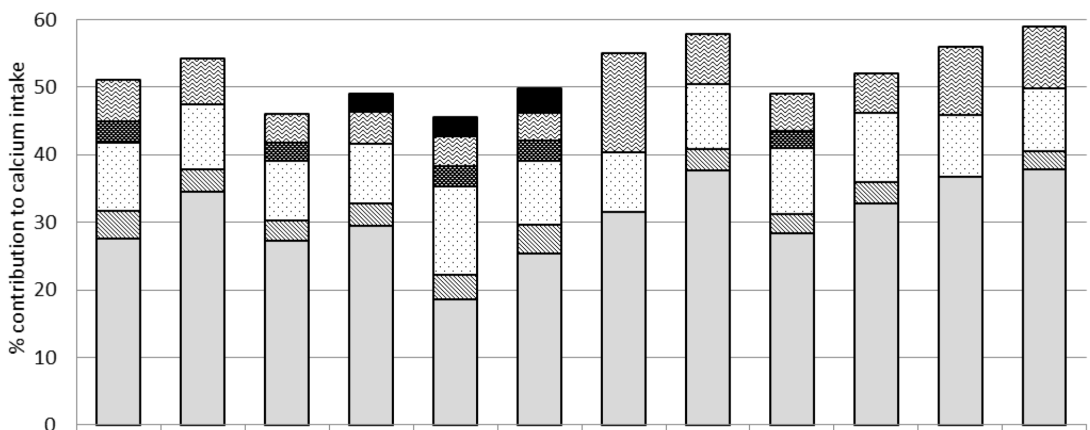
3. Results

In total, 186,916 men and women were included in this study. Table 1 shows the demographic information of participants in the MEC, including BMI and estimated daily energy intake. The average age ranged from 56 among Native Hawaiian women to 62 among African American men. Average body mass index was lowest among Japanese Americans of both sexes and highest among Native Hawaiians men and women, as well as African American women. Average energy intake ranged from 1,808 kcal/day in Japanese American women to over 2700 kcal/day among Native Hawaiian men. Adherence with dietary recommendations for dairy intake was comparable among sexes within the ethnic groups, but ranged considerably across ethnic groups, from only 3% and 5% among Japanese American men and women, respectively, up to 35% among Latino-Mexicans.

Table 1. Demographic information of participants in the Multiethnic Cohort

	African American	**Native Hawaiian**	**Japanese American**	**Latino-Mexico**	**Latino-US**	**Caucasians**
Men (n)	11,722	5,979	25,893	10,180	10,613	21,933
Age (year), Mean (SD)	62 (8.9)	57(8.7)	61 (9.2)	59(7.7)	61(7.6)	59(9.1)
BMI (kg/m^2), Mean (SD)	26.7(4.3)	28.5(5.1)	24.7 (3.3)	26.7(3.7)	26.7(4.1)	26.0(4.0)
Energy (kcal/day), Mean (SD)	2,194 (1,166)	2,760 (1,311)	2,255 (833)	2,716 (1,401)	2,468 (1,261)	2,283 (899)
Adherent with recommendations for intake of dairy products, %	15	16	3	35	26	19
Women (n)	20,130	7,650	25,355	10,903	11,255	25,303
Age (year), Mean (SD)	61 (9.0)	56 (8.7)	61 (8.9)	58(7.6)	60(7.9)	59(9.0)
BMI (kg/m^2), Mean (SD)	28.4 (5.8)	28.0 (6.1)	23.1 (3.8)	27.0(4.8)	27.6(5.4)	25.2(5.2)
Energy (kcal/day), Mean (SD)	1,879 (993)	2,370 (1,263)	1,808 (678)	2,316 (1,238)	2,056 (1,104)	1,805 (703)
Adherent with recommendations for intake of dairy products, %	14	12	5	35	24	24

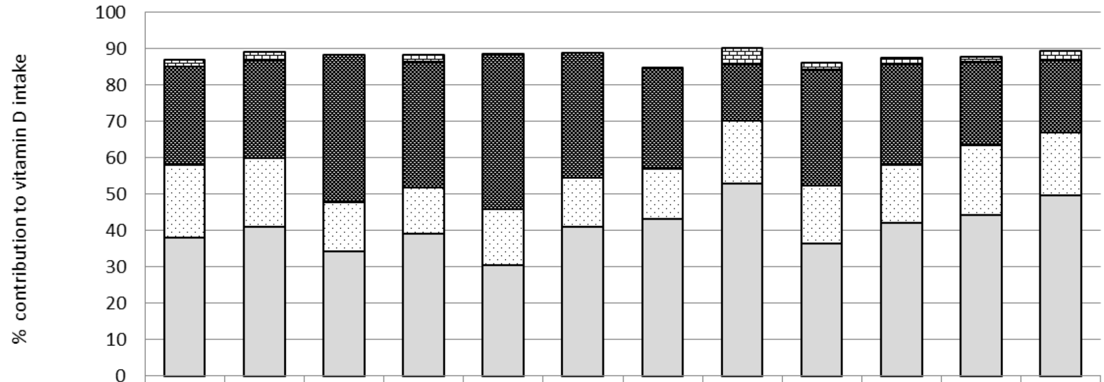
*Recommendations from the US Department of Agriculture Food Guide Pyramid



	African American		Native Hawaiain		Japanese Ameircan		Latino Mexican		Latino American		Caucasian	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
Vegetables	0	0	0	2.7	2.9	3.5	0	0	0	0	0	0
Mixed dishes	6.1	6.7	4.3	4.7	4.4	4.1	14.7	7.4	5.4	5.8	10	9.1
Meats	3.1	0	2.7	0	3	3.1	0	0	2.6	0	0	0
Grains	10.2	9.6	8.7	8.9	13	9.4	8.8	9.6	9.7	10.3	9.2	9.3
Fruits	4	3.4	3	3.3	3.6	4.3	0	3.2	2.9	3.1	0	2.7
Dairy	27.6	34.4	27.3	29.4	18.6	25.3	31.5	37.6	28.3	32.8	36.7	37.8

Figure 1. Food groupings for the top 10 dishes contributing to dietary sources of calcium, by ethnicity and sex

Figure 1 presents the food groupings for the top ten major dietary sources of calcium and the percent contribution to the total daily intake of calcium among men and women of each ethnic group. In total, the top ten dietary sources of calcium contributed 45.5-58.9% of its daily intake among all groups (Figure 1). Dairy products were the main contributor to calcium intake, although the percent contribution ranged considerably, from 18.6% among Japanese American women, to 37.8% among Caucasian women. In addition, the contribution of dairy products to calcium was higher among women compared to men within each ethnic group. Grains were the second major contributor to calcium intake. The percent contribution of grains were comparable among most ethnic-sex groups (ranging from 8.7% to 10.3%), with the exception of Japanese American men, for whom grains contributed 13% to calcium intake. Mixed dishes were also among the top 10 sources of calcium intake; the percent contribution was relatively low (approximately 4%) in some groups, but ranged up to 9.1 and 10.0% among Caucasian women and men, respectively, and as high as 14.7% among Latino-Mexican men. The mixed dishes included taco salad, cheese enchiladas, pizza, and pastas with tomato or cheese sauce, of which all four were among top contributors for the Latino-Mexican men. Fruits, orange/grapefruit, and pomelo specifically, also contributed modestly (2.7% to 4.3%) to calcium intake among all ethnic-sex groups except for Latino-Mexican and Caucasian men.



	African American		Native Hawaiain		Japanese Ameircan		Latino Mexican		Latino US		Caucasian	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
Fortified beverages	1.9	2.6	0	1.9	0	0	0	4.6	2	1.6	1.3	2.5
Fish (combined dishes)	27.1	26.7	40.7	34.5	42.5	34.2	27.8	15.5	31.9	28	23.1	19.9
Grains	19.9	18.9	13.5	12.7	15.5	13.6	13.9	17.2	15.7	15.9	19.1	17.3
Dairy	38	40.8	34	39.1	30.3	40.9	43	52.7	36.4	41.9	44.1	49.6

Figure 2. Food groupings for the top 10 dishes contributing to vitamin D intake, by ethnicity and sex

Figure 2 presents the food groupings for the ten major dietary sources of vitamin D and the percent contribution to the total daily intake among men and women of each ethnic group. The top ten dietary sources of vitamin D contributed to 84.7-90.0% of total daily vitamin D intake among all ethnic-sex groups (Figure 2). Dairy products were also the top contributor to vitamin D intake for all ethnic-sex groups, except Native Hawaiian and Japanese American men, for whom fish dishes were the top contributor (40.7% and 42.5%, respectively). Again, there was a considerable range (30.3% to 49.6%) in the contribution of dairy product to nutrient intake among the ethnic-sex groups. Fish was the second most significant contributor among most ethnic-sex groups, followed by grains. The contribution of grain intake was relatively high among African Americans and Caucasians of both sexes (17.3% to 19.9%), and lowest among Native Hawaiians and Japanese Americans of both sexes, and Latino-Mexican men (12.7% to 15.5%). Fortified beverages were also among the top 10 food sources for vitamin D intake among one or both sexes in each ethnic group, except for Japanese Americans. Among the Latino-Mexicans, fortified beverages were not included in the top 10 contributors to vitamin D intake for men, but contributed 4.6% among women.

Table 2 presents the top ten food items of dairy products among each ethnic-sex group. In total, the top ten sources contributed 69.1-78.8% to total daily intake of dairy products of all ethnic-sex groups. Low-fat milk was the most common dairy product for all groups (16.0-21.9%), except Japanese American men and women and Caucasian women who primarily consumed non-fat milk/buttermilk. All types of fluid milk including chocolate milk/cocoa and milkshakes/malts contributed between 39.4% in Latino-US men to 51.8% for Native Hawaiian women to the total intake of dairy products. Cheese and mixed dishes (e.g., pizza, enchiladas) contributed 15.7-27.7% to the total intake of dairy products in all ethnic-sex groups, although the types of mixed dishes and the percent contribution varied by group. Low-fat cheese was a major contributor for Japanese American women, Latinos, and Caucasians, and contributed more to the intake of dairy products in women compared to men in Latinos and Caucasians. Cappuccino (including café con leche) was a major contributor to the intake of dairy products for Latino-Mexican men and women only. Yogurt contributed more to the intake of dairy products in women than men.

Table 2. Ten major types of dairy products and the percent contribution of each food item by ethnic group

	African American		Native Hawaiian		Japanese American		Latino-Mexico		Latino-US		Caucasian	
	Food items	%	Food items	%	Food items	%	Food items	%	Food items	%	Food items	%
Men	Low-fat milk (1% or 2%)	18.8	Low-fat milk (1% or 2%)	21.0	Non-fat milk/buttermilk	20.3	Low-fat milk (1% or 2%)	16.0	Low-fat milk (1% or 2%)	20.8	Low-fat milk (1% or 2%)	19.1
	Whole milk	13.8	Non-fat milk/buttermilk	13.6	Low-fat milk (1% or 2%)	19.4	Whole milk	16.0	Whole milk	10.0	Non-fat milk/buttermilk	14.8
	Non-fat milk/buttermilk	8.2	Whole milk	11.6	Whole milk	6.1	Enchiladas with cheese	6.7	Non-fat milk/buttermilk	8.6	Other cheese	9.4
	Other cheese	7.4	Other cheese	5.9	Pizza	5.2	Other cheese	6.2	Other cheese	8.3	Whole milk	7.0
	Pasta with cheese	6.7	Ice cream	5.8	Ice cream	5.1	Cappuccino – 1 cup or mug	5.2	Enchiladas with cheese	5.6	Pizza	4.8
	Ice cream	6.1	Chocolate milk/cocoa	5.1	Other cheese	5.0	Non-fat milk/buttermilk	5.2	Pasta with cheese	3.9	Spaghetti/ravioli/ lasagna	4.8
	Spaghetti/ravioli/ lasagna	3.6	Pizza	3.6	Spaghetti/ravioli/ lasagna	4.8	Low-fat cheese	4.3	Ice cream	3.8	Yogurt	4.7
	Chocolate milk/cocoa	3.1	Spaghetti/ravioli/ lasagna	3.4	Chocolate milk/cocoa	3.2	Milkshake or malts	3.5	Pizza	3.6	Pasta with cheese	4.3
	Ice milk/frozen yogurt	3.0	Pasta with cheese	3.3	Ice milk/frozen yogurt	3.1	Pasta with cheese	3.0	Low-fat cheese	3.3	Low-fat cheese	4.0
	Yogurt	2.8	Cream soup or chowder	2.5	Pasta with cheese	3.1	Vegetable/bean burritos with cheese	3.0	Spaghetti/ravioli/lasagna	2.8	Ice cream	3.6
Total (%)		**73.5**		**75.8**		**75.3**		**69.1**		**70.7**		**76.5**
Women	Low-fat milk (1% or 2%)	19.9	Low-fat milk (1% or 2%)	21.4	Non-fat milk/buttermilk	26.9	Low-fat milk (1% or 2%)	19.3	Low-fat milk (1% or 2%)	21.9	Non-fat milk/buttermilk	19.2
	Non-fat milk/buttermilk	11.3	Non-fat milk/buttermilk	16.5	Low-fat milk (1% or 2%)	19.3	Whole milk	12.6	Non-fat milk/buttermilk	11.1	Low-fat milk (1% or 2%)	18.7
	Whole milk	9.2	Whole milk	9.6	Yogurt	6.5	Enchiladas with cheese	7.1	Whole milk	7.9	Yogurt	8.4
	Other cheese	7.0	Other cheese	5.5	Spaghetti/ravioli/ lasagna	4.3	Non-fat milk/buttermilk	6.7	Other cheese	7.5	Other cheese	8.1
	Yogurt	6.8	Yogurt	5.2	Pizza	4.3	Other cheese	6.1	Enchiladas with cheese	5.8	Low-fat cheese	5.1
	Pasta with cheese	6.5	Chocolate milk/cocoa	4.3	Other cheese	4.2	Cappuccino – 1 cup or mug	5.5	Yogurt	5.2	Spaghetti/ravioli/ lasagna	4.4
	Ice cream	4.2	Ice cream	3.6	Whole milk	4.1	Low-fat cheese	5.3	Low-fat cheese	4.3	Whole milk	4.3
	Spaghetti/ravioli/ lasagna	3.7	Pizza	3.5	Ice cream	3.2	Yogurt	5.1	Pasta with cheese	4.3	Pasta with cheese	4.0
	Ice milk/frozen yogurt	3.4	Spaghetti/ravioli/ lasagna	3.5	Ice milk/frozen yogurt	3.0	Milkshake or malts	2.9	Pizza	3.1	Pizza	3.7
	Chocolate milk/cocoa	2.8	Pasta with cheese	3.3	Low-fat cheese	2.9	Pasta with cheese	2.8	Spaghetti/ravioli/ lasagna	2.7	Ice milk/frozen yogurt	2.9
Total (%)	**74.8**		**76.4**		**78.7**		**73.4**		**73.8**		**78.8**	

4. Discussion

This study provides data on the major dietary sources of calcium, vitamin D, and pattern of dairy products consumption in the five main ethnic groups in the U.S. using a standardized approach. The data illustrates that the dietary sources of calcium and the percent contributions from each item varied between the ethnic-sex groups. Not surprisingly, dairy products were the top contributor to calcium intake in all groups. Non-dairy food sources, such as grains and fruit also contributed substantially to the intake of calcium, even though these foods are naturally low in calcium. Differences in the contribution of these non-dairy food sources to calcium intake observed in this study need to be considered for nutrition researchers and dietitians to provide culturally appropriate nutrition education and ethnic-specific intervention programs.

Similar to our results, Subar et al. (1998) found that dairy (milk, cheese) and grain (yeast breads) were the highest ranked dietary sources for calcium among the general U.S population, according to data from the 1989-1991 Continuing Survey of Food Intakes by Individuals (CSFII) (Subar, Krebs-Smith, Cook, & Kahle, 1998). In subsequent CSFII data (1994-1996 and 1998), dairy products including milk, cheese, and yogurt, which were reported as separate survey food items, contributed to 42% of total calcium intake and dairy ingredients in mixed foods such as macaroni and cheese, pizza, sandwiches, and desserts contributed to an additional 21% of dietary calcium among the general U.S. population (Cook & Friday, 2003).

The dietary sources of vitamin D were similar across the five ethnic groups, with dairy products and fish being the top two contributors to vitamin D intake. Moreover, the major dietary sources of vitamin D were limited to eight food items (fish, non-fat milk, low-fat milk, whole milk, cereals, eggs, butter, and pasta – data not shown) in all ethnic-sex groups. Fish and eggs are two of the few foods which naturally contain vitamin D, while fluid milk is the only routinely fortified food in the U.S. Our data supports that the primary source of vitamin D intake in the U.S. populations is from fortified foods, particularly fortified dairy products (Calvo et al., 2004; Moore et al., 2004; NIH Osteoporosis and Related Bone Diseases National Resource Centre, 2012).

As dairy products were the major contributors to both calcium and vitamin D, the different types of dairy products in the diet were also examined. Our data showed similar foods contributing to the intake of dairy products as other studies have found in the general U.S. population (Fishbein, 2004). However, the main types of dairy products and their percent contribution of them varied across ethnic-sex groups. In our study, milk contributed to approximately 40-50% of the intake of total dairy products across the ethnic groups, which might reflect the increased consumption of milk products in the U.S. as reported by Fishbein (2004). Similar to the 1994 statistics (Fishbein, 2004), cheese and cheese dishes contributed 16-28% and frozen dairy foods contributed up to 9.1% to total dairy product consumption in our cohort. However, ethnic differences were observed for some food items. For example, enchiladas and cappuccino were among the top dairy sources only for Latinos.

According to previously published MEC data, 65-97% of each ethnic group did not consume the recommended number of servings of dairy products (Sharma et al., 2003b, 2004). There are many factors that influence the intake of dairy products such as lactose intolerance. In the current study populations, Japanese Americans and African Americans represent populations who have higher rates of lactose intolerance (Jackson & Savaiano, 2001), which might explain their lower intake of dairy products (Sharma et al., 2003b, 2004) and could subsequently impact their calcium and vitamin D intake (Ginde et al., 2009; Miller et al., 2001). Based on the findings in this study, foods for nutrition education and intervention programs to improve calcium and vitamin D intakes among these two populations could be lactose-reduced or lactose-free milks (Miller et al., 2001), calcium-containing non-dairy products, such as dark green leafy vegetables, canned fish with soft bones (e.g., sardines), and calcium/vitamin D fortified cereals and beverages (Holick, 2007; Miller et al., 2001).

The North/South Ireland Food Consumption Survey found that increased consumption of voluntarily fortified foods was associated with increased mean daily intake of calcium in Irish men and women (Hannon, Kiely, & Flynn, 2007; Joyce, Hannon, Kiely, & Flynn, 2009). For this MEC population, fortification also explained why non-dairy foods such as grain products were good sources of calcium and vitamin D.

Recently, new dietary reference intakes for calcium and vitamin D have been published by the Institute of Medicine (Ross et al., 2011). The authors noted that, while most of the general population meets dietary intake of these nutrient, this may not be the case for specific ethnic sub-groups or those with limited sun exposure (for Vitamin D). Considering the variations in dietary sources of calcium and vitamin D observed in this study, it may become increasingly important for nutrition intervention programs and dietitians to make ethnic-specific recommendations for vitamin D and calcium-rich food sources for the growing minority populations in the U.S. to be able better to meet recommended intake for specific populations. The data from the present study will be essential to develop and update other dietary guidelines (such as the Dietary Guidelines for Americans) and public health strategies related to improving dietary adequacy (such as *Healthy People 2020*).

There were some limitations in the current study. The data available for analyses was collected over 15 years ago, thus analyses of more recent data would be useful to determine if the dietary patterns observed are still generalizable to the current populations of these ethnic groups in the U.S. In addition, the data collection was limited to two specific geographic areas of the U.S., which may also have impacted generalizability. Selection bias may also be a concern due to the relatively large number of participants that were excluded due to missing data, as the proportion of excluded participants did vary somewhat for the different ethnic-sex groups, ranging from 15% in Caucasian and Japanese American women, to only 2.5% for Native Hawaiians of both sexes. However, with the large sample sizes that remained in the analyses, considerable dietary variation would have to have occurred in order to impact these results. Recall bias may also be a concern; however the QFFQ has been shown to describe total intake reasonably well (Kolonel et al., 2000; Stram et al., 2000). The strengths of this study include the large sample size and the inclusion of five major ethnic groups in the U.S. Our sample sizes for non-Caucasian ethnic groups are substantially larger than those available from any of the U.S. national dietary surveys. We used a standard method of grouping dairy products and their subgroups for all ethnic groups based on national recommendations (U.S.Department of Agriculture, 2000). Furthermore, a standardized QFFQ that was specifically developed and validated for the five ethnic groups was used.

5. Conclusion

This study identified dietary differences in sources of calcium, vitamin D, and dairy products among ethnic populations at high risk of deficiency of calcium and vitamin D, who can be targeted by nutrition intervention programs. Nutrition researchers and dietitians can incorporate the data to provide specific advice and tailor nutrition education programs to be culturally appropriate and effective in different ethnic groups. This research also facilitates further investigation of diet-disease associations in these high-risk ethnic groups in the U.S.

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