The Relationship Between Dairy Foods and Health: Utilization of NHANES Data

Chris Cifelli, PhD

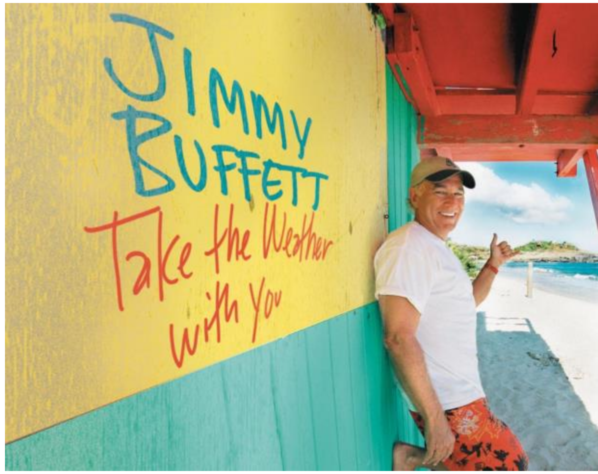
Senior Vice President, Nutrition Research
National Dairy Council

chris.cifelli@dairy.org

Objectives

- Provide an overview of NDC Nutrition Research Program
- NHANES overview
- Discuss research studies utilizing NHANES:
  - Dairy intake data
  - Nutrient intakes
  - Mortality
  - Cost and tradeoffs

About Me



NATIONAL DAIRY COUNCIL™

Bringing to life the dairy community's shared vision of a healthy, happy, sustainable world, with science as our foundation

HEALTH & WELLNESS SCIENCE

Public Health

Dairy as a Food Group

PROTECT

- Food Based Dietary Guidelines
- Dietary Patterns
- Childhood Health
- Whole Milk/Dairy Matrix
- Health Disparities

Prove New Benefits

Commercialize More Science

DISCOVER

- Discover & validate new health conditions
- Fuel new product innovation
- Provide support for stronger claims & messaging
- Utilizing new technologies to improve research (e.g., AI)
- Identify new, powerful research collaborations

Demonstrate Socio-economic

Prove Global Value

PROMOTE

- Build relationships with leading research universities domestically and globally
- Address gaps in socio-economic research and research to support FBDG.

National Health and Nutrition Examination Survey (NHANES)

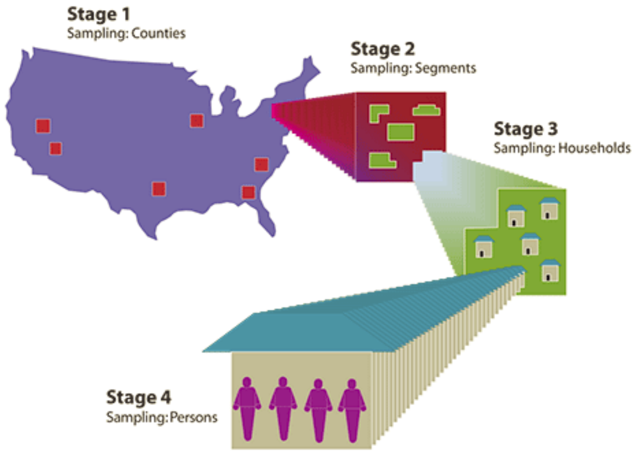
What is NHANES?

- Program of studies **designed to assess the health and nutritional status of adults and children in the U.S.**
- The survey is a **combination of interviews and physical examination** performed in specially-designed and equipped mobile centers.
- Started in early 1960's. **Continuous two-year cycles** since 1999.

nhanes
The Nation's Mobile Health Survey

Sample Population

- Participants **randomly selected** through a complex statistical process to represent the U.S. population of all ages.
- Civilian, non-institutionalized household population from all states and the District of Columbia.
- To produce reliable statistics, NHANES **over-samples persons 60 and older, African Americans, and Hispanics.**
- **~5,000 people** each year.



Source: https://www.cdc.gov/nchs/nhanes/participant.htm

Dietary Intake Interview Component of NHANES: What We Eat in America (WWEIA)

Two, nonconsecutive days of dietary intake using 24-hour recalls

1. In-person at the Mobile Exam Center
2. Central NHANES telephone center

For each food and beverage, the following is collected:

- Name (USDA food code and description)
- Amount consumed
- Amounts of food energy and 64 nutrients/food components provided by each food/beverage
- Identification of items eaten in combination (e.g., cereal with milk added)
- Separate ingredients coded for mixed foods
- Day of week
- Eating occasion – name (breakfast, lunch, etc.)
- Time when each item was consumed
- Source of food/beverage (where obtained)
- Whether the food/beverage was eaten at home or not

Source: https://www.cdc.gov/nchs/nhanes/participant.htm

Uses of NHANES

- **Findings from the survey are used in a wide variety of ways, including:**
  - Determining the prevalence of major diseases and risk factors for diseases.
  - Assessing nutritional status and its association with health promotion and disease prevention.
  - Setting the basis for national standards for measurements such as height, weight and blood pressure.
  - Research to help develop sound public health guidance, direct and design health programs and services, and expand the health knowledge for the Nation.
  - Modelling intakes of food groups for the Dietary Guidelines for Americans Committee.

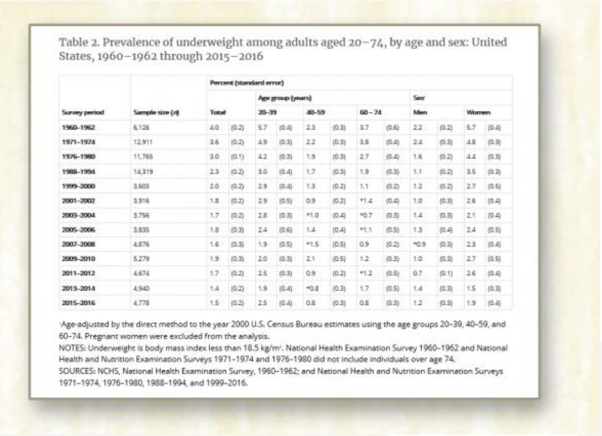


Table 2. Prevalence of underweight among adults aged 20–74, by age and sex: United States, 1960–1962 through 2015–2016

		Percent (standard error)											
				Age group (years)						Sex			
Survey period	Sample size (n)	Total		20–39		40–59		60–74		Men		Women	
1960–1962	6,126	4.0	(0.2)	5.7	(0.4)	2.3	(0.3)	3.7	(0.6)	2.2	(0.2)	5.7	(0.4)
1971–1974	12,911	3.6	(0.2)	4.9	(0.3)	2.2	(0.3)	3.8	(0.4)	2.4	(0.3)	4.8	(0.3)
1976–1980	11,765	3.0	(0.1)	4.2	(0.3)	1.9	(0.3)	2.7	(0.4)	1.6	(0.2)	4.4	(0.3)
1988–1994	14,319	2.3	(0.2)	3.0	(0.4)	1.7	(0.3)	1.9	(0.3)	1.1	(0.2)	3.5	(0.3)
1999–2000	3,603	2.0	(0.2)	2.9	(0.4)	1.3	(0.2)	1.1	(0.2)	1.2	(0.2)	2.7	(0.5)
2001–2002	3,916	1.8	(0.2)	2.9	(0.5)	0.9	(0.2)	*1.4	(0.4)	1.0	(0.3)	2.6	(0.4)
2003–2004	3,756	1.7	(0.2)	2.8	(0.3)	*1.0	(0.4)	*0.7	(0.3)	1.4	(0.3)	2.1	(0.4)
2005–2006	3,835	1.8	(0.3)	2.4	(0.6)	1.4	(0.4)	*1.1	(0.5)	1.3	(0.4)	2.4	(0.5)
2007–2008	4,876	1.6	(0.3)	1.9	(0.5)	*1.5	(0.5)	0.9	(0.2)	*0.9	(0.3)	2.3	(0.4)
2009–2010	5,279	1.9	(0.3)	2.0	(0.3)	2.1	(0.5)	1.2	(0.3)	1.0	(0.3)	2.7	(0.5)
2011–2012	4,674	1.7	(0.2)	2.5	(0.3)	0.9	(0.2)	*1.2	(0.5)	0.7	(0.1)	2.6	(0.4)
2013–2014	4,940	1.4	(0.2)	1.9	(0.4)	*0.8	(0.3)	1.7	(0.5)	1.4	(0.3)	1.5	(0.3)
2015–2016	4,778	1.5	(0.2)	2.5	(0.4)	0.8	(0.3)	0.8	(0.3)	1.2	(0.3)	1.9	(0.4)

[1]Age-adjusted by the direct method to the year 2000 U.S. Census Bureau estimates using the age groups 20–39, 40–59, and 60–74. Pregnant women were excluded from the analysis.

NOTES: Underweight is body mass index less than 18.5 kg/m^2. National Health Examination Survey 1960–1962 and National Health and Nutrition Examination Surveys 1971–1974 and 1976–1980 did not include individuals over age 74.

SOURCES: NCHS, National Health Examination Survey, 1960–1962; and National Health and Nutrition Examination Surveys 1971–1974, 1976–1980, 1988–1994, and 1999–2016.

Source: https://www.cdc.gov/nchs/nhanes/nhanes_products.htm

Relationship Between Dairy Intake and Health and Wellness Outcomes

Disparities in Dairy Servings Exist by Ethnicity and Age

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Current Developments in Nutrition CDN

journal homepage: www.journals.elsevier.com/current-developments-in-nutrition

Original Research

Disparity in Dairy Servings Intake by Ethnicity and Age in NHANES 2015–2018

Christopher J. Cifelli [1,*], Kristin Fulgoni [2], Victor L. Fulgoni III [2], Julie M. Hess [3]

[1] National Dairy Council, Rosemont, IL, USA; [2] Nutrition Impact LLC, Battle Creek, MI, USA; [3] US Department of Agriculture, Agriculture Research Services, Grand Forks Human Nutrition Research Center, Grand Forks, ND, USA

ABSTRACT

Methods

NHANES cycles 2015–2016 and 2017–2018 used to determine dairy intake from foods included in USDA-defined dairy food groups as well as from "other foods," such as mixed dishes and nonmilk and dairy foods containing dairy.

Results:

- **Total dairy and milk consumption was 21% and 43% less**, respectively, in adults (19+ years) as compared to children (2 – 18 years) in this analysis.
- **Non-Hispanic Black and non-Hispanic Asian children and adults consumed the least number of dairy servings** as compared to the other race/ethnic groups.
- The "**other foods" category** (e.g., pizza, Mexican dishes, sandwiches, soups) **makes a significant contribution** to dairy consumption and could represent an important opportunity to help Americans meet the DGAs.

Cifelli CJ, Fulgoni K, Fulgoni VL, Hess JM. Disparity in dairy servings intake by ethnicity and age in NHANES 2015-2018. *Current Developments in Nutrition*. 2023; 7(2): https://doi.org/10.1016/j.cdnut.2022.100010.

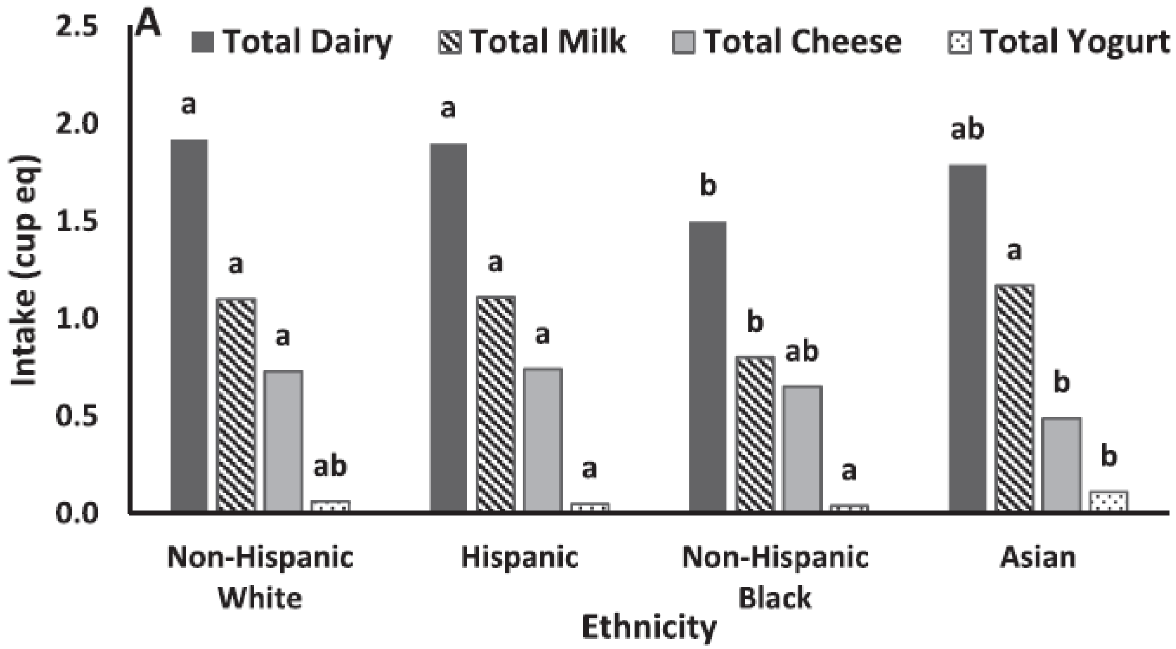
Daily Servings of Dairy Foods in Americans by Age Group (cup equivalents ± SE)

	2+ y	2-18 y	19+ y	2-8 y	9-18 y	19-50 y	51-70 y	71+ y
Total Dairy Intake	1.56 (0.03)	1.87 (0.04)	1.47 (0.03)	1.93 (0.04)	1.83 (0.06)	1.55 (0.04)	1.40 (0.04)	1.35 (0.07)
Total Milk Intake	0.72 (0.02)	1.07 (0.03)	0.61 (0.02)	1.22 (0.03)	0.98 (0.03)	0.58 (0.02)	0.61 (0.03)	0.75 (0.05)
Total Cheese Intake	0.74 (0.02)	0.72 (0.02)	0.74 (0.02)	0.61 (0.02)	0.79 (0.03)	0.85 (0.03)	0.67 (0.03)	0.49 (0.03)
Total Yogurt Intake	0.07 (0.004)	0.06 (0.005)	0.07 (0.005)	0.08 (0.01)	0.04 (0.005)	0.07 (0.01)	0.08 (0.01)	0.07 (0.01)

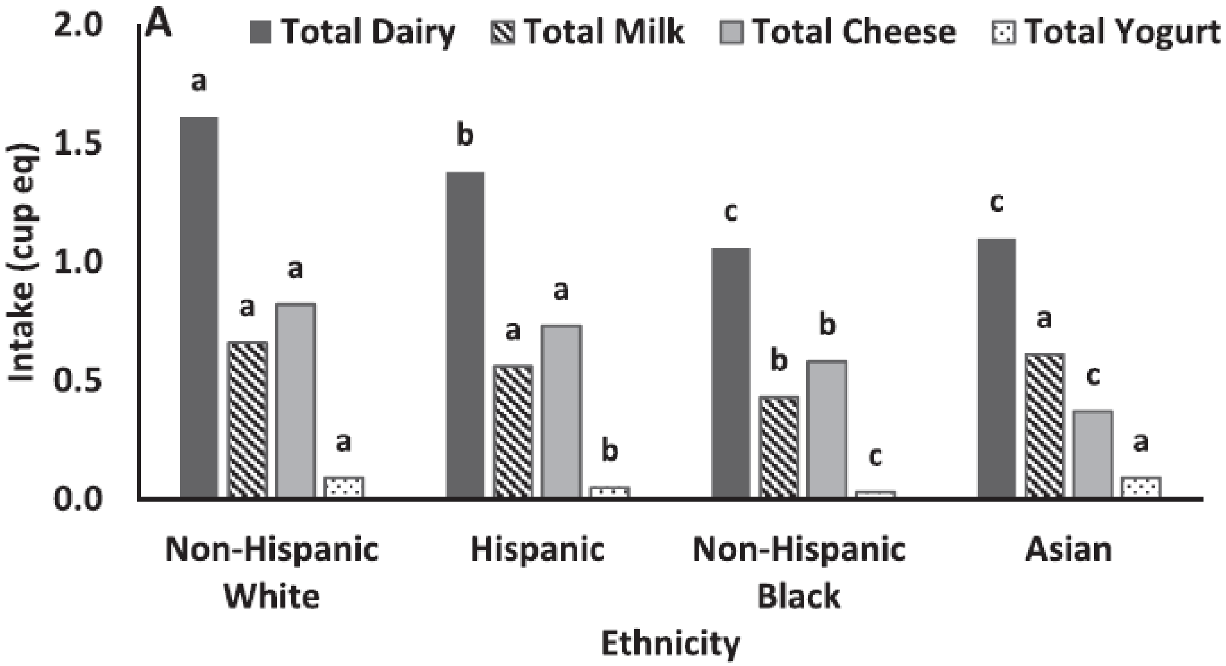
Cifelli CJ, Fulgoni K, Fulgoni VL, Hess JM. Disparity in dairy servings intake by ethnicity and age in NHANES 2015-2018. *Current Developments in Nutrition*. 2023; 7(2): https://doi.org/10.1016/j.cdnut.2022.100010.

Daily Servings of Dairy Foods (cup equivalents) by Ethnicity in Americans Aged 2-18 and 19+ Years

Children 2-18 years



Adults 19+ years



Cifelli CJ, Fulgoni K, Fulgoni VL, Hess JM. Disparity in dairy servings intake by ethnicity and age in NHANES 2015-2018. *Current Developments in Nutrition*. 2023; 7(2): https://doi.org/10.1016/j.cdnut.2022.100010.

Nutrient Contribution of Dairy Foods by Age

Table 1: Average contribution of dairy foods to calorie and nutrient intakes in children 2 – 18 years old

	Total Milk, Cheese, Yogurt[1]	Milk	Flavored Milk	Cheese	Yogurt	Dairy Drinks and Substitutes
Calories						
Calories/day	266	104	38.4	111	12.7	10.9
Calories, % total	14.2	5.5	2.1	5.9	0.68	0.58
Nutrient intakes, % of total daily nutrient intake						
Calcium	61.6	25.5	6.6	27.2	2.3	1.9
Vitamin D	65.8	42.7	12.2	7.6	3.3	1.7
Potassium	22.8	14.6	4.3	2.5	1.4	0.8
Protein	23.7	10.2	2.6	9.7	1.2	0.4
Vitamin A	38.5	19.2	5.2	13.6	0.4	1.7
Vitamin B12	38.3	23.7	4.2	8.6	1.7	0.9
Riboflavin	31.1	17.2	5.2	7.1	1.7	2.0
Vitamin B6	9.5	6.0	1.5	1.7	0.4	0.2
Phosphorus	36.3	16.1	4.3	14.5	1.5	0.6
Magnesium	18.1	10.1	3.2	3.9	0.9	0.7
Zinc	22.7	9.1	2.6	9.9	1.1	0.5
Sodium	13.9	2.9	1.2	9.5	0.3	0.3
Total Fat	19.0	5.7	1.1	11.9	0.3	0.6
Saturated Fat	31.1	9.7	2.0	19.0	0.6	1.0
Cholesterol	20.8	7.4	1.5	11.5	0.4	0.6
Carbohydrate	8.1	4.1	2.5	0.7	0.8	0.6
Total Sugar	16.3	9.2	4.8	0.8	1.5	1.0
Added Sugar	4.7	0.0	3.7	0.0	1.0	1.0

Table 2: Average contribution of dairy foods to calorie and nutrient intakes in adults 19+ years old

	Total Milk, Cheese, Yogurt[1]	Milk	Flavored Milk	Cheese	Yogurt	Dairy Drinks and Substitutes
Calories						
Calories/day	206	68.8	6.0	116	15.2	10.1
Calories, % total	9.7	3.2	0.28	5.5	0.71	0.47
Nutrient intakes, % of total daily nutrient intake						
Calcium	49.5	17.4	0.8	28.6	2.6	2.3
Vitamin D	45.9	30.9	1.6	9.5	3.8	2.6
Potassium	11.6	7.9	0.5	2.0	1.3	0.6
Protein	15.7	5.5	0.3	8.4	1.5	0.3
Vitamin A	26.6	11.8	0.6	13.3	0.8	1.7
Vitamin B12	24.9	14.1	0.5	8.3	2.0	1.2
Riboflavin	18.6	9.6	0.6	6.4	1.9	1.5
Vitamin B6	5.2	3.2	0.2	1.4	0.4	0.2
Phosphorus	25.0	9.7	0.5	13.1	1.7	0.5
Magnesium	9.4	5.2	0.4	3.1	0.8	0.6
Zinc	15.5	5.2	0.3	8.9	1.1	0.4
Sodium	10.1	1.6	0.2	8.1	0.3	0.3
Total Fat	14.2	3.1	0.2	10.6	0.3	0.5
Saturated Fat	24.8	5.6	0.3	18.2	0.6	0.8
Cholesterol	13.1	3.5	0.2	9.0	0.4	0.4
Carbohydrate	4.6	2.7	0.4	0.7	0.8	0.5
Total Sugar	9.6	6.3	0.8	0.8	1.6	1.0
Added Sugar	1.8	0.0	0.7	0.0	1.0	1.0

Data from NHANES 2015-2018 (n=14,851). Disaggregated values were calculated by removing nutrients from non-dairy foods and reassigning them to specific dairy foods. [1]This does not include Dairy Drinks and Substitutes column, ice cream, frozen dairy desserts, pudding, cream, smoothies, cream cheese, sour cream, whipped cream, butter. Values across rows may not sum to total dairy due to rounding of individual values

Cifelli CJ, Fulgoni K, Fulgoni VL, Hess JM. Disparity in dairy servings intake by ethnicity and age in NHANES 2015-2018. *Current Developments in Nutrition*. 2023; 7(2): https://doi.org/10.1016/j.cdnut.2022.100010.

Nutrient Contribution of Dairy Foods by Ethnicity

Table 3: Average contribution of dairy foods to calcium, vitamin D, and potassium intakes in children 2 – 18 years old by ethnicity

	Total Dairy[1]		Milk		Flavored Milk		Cheese		Yogurt		Dairy Drinks and Substitutes	
All	**Mean**	**% Daily**	**Mean**	**% Daily**	**Mean**	**% Daily**	**Mean**	**% Daily**	**Mean**	**% Daily**	**Mean**	**% Daily**
Calcium (mg)	618	64%	249	26%	64	7%	264	27%	23	2%	18.3	2%
Vitamin D (µg)	3.4	67%	2.2	43%	0.6	12%	0.4	8%	0.2	4%	0.1	2%
Potassium (mg)	491	24%	305	15%	89	4%	52	2%	30	1%	16	0%
Hispanic												
Calcium (mg)	629	64%	257	26%	63	6%	272	28%	20	2%	17	2%
Vitamin D (µg)	3.5	66%	2.3	43%	0.6	11%	0.4	8%	0.2	4%	0.1	2%
Potassium (mg)	498	24%	314	15%	87	4%	53	3%	27	1%	18	0%
Non-Hispanic White												
Calcium (mg)	635	64%	253	25%	69	7%	268	27%	24	2%	22	2%
Vitamin D (µg)	3.5	69%	2.2	43%	0.7	14%	0.4	8%	0.2	4%	0.1	2%
Potassium (mg)	509	25%	311	15%	96	5%	52	3%	32	2%	18	0%
Non-Hispanic Black												
Calcium (mg)	509	60%	180	21%	52	6%	249	29%	15	2%	12	1%
Vitamin D (µg)	2.7	63%	1.6	37%	0.5	12%	0.4	9%	0.1	2%	0.1	2%
Potassium (mg)	374	19%	220	11%	75	4%	50	2%	20	0%	9	0%
Non-Hispanic Asian												
Calcium (mg)	569	62%	299	33%	42	5%	172	19%	44	5%	11	1%
Vitamin D (µg)	3.7	66%	2.7	48%	0.4	7%	0.2	4%	0.3	5%	0.1	2%
Potassium (mg)	525	23%	363	16%	58	3%	36	2%	57	3%	10	0%

Table 4: Average contribution of dairy foods to calcium, vitamin D, and potassium intakes in adults 19+ years old by ethnicity

	Total Dairy[1]		Milk		Flavored Milk		Cheese		Yogurt		Dairy Drinks and Substitutes	
All	**Mean**	**% Daily**	**Mean**	**% Daily**	**Mean**	**% Daily**	**Mean**	**% Daily**	**Mean**	**% Daily**	**Mean**	**% Daily**
Calcium (mg)	495	52%	167	17%	8	0%	273	29%	25	3%	22	2%
Vitamin D (µg)	2.1	48%	1.4	32%	0.1	2%	0.4	9%	0.2	5%	0.1	2%
Potassium (mg)	321	12%	206	8%	13	0%	53	2%	33	1%	16	0%
Hispanic												
Calcium (mg)	479	49%	151	15%	10	1%	278	28%	19	2%	21	2%
Vitamin D (µg)	2.1	47%	1.3	29%	0.1	2%	0.4	9%	0.1	2%	0.1	2%
Potassium (mg)	293	11%	186	7%	15	0%	52	2%	25	1%	15	0%
Non-Hispanic White												
Calcium (mg)	536	54%	180	18%	9	1%	297	30%	29	3%	22	2%
Vitamin D (µg)	2.3	51%	1.5	33%	0.1	2%	0.5	11%	0.2	4%	0.1	2%
Potassium (mg)	350	13%	223	8%	14	0%	59	2%	38	1%	16	0%
Non-Hispanic Black												
Calcium (mg)	374	46%	112	14%	5	0%	222	27%	11	1%	25	3%
Vitamin D (µg)	1.5	39%	0.9	24%	0	0%	0.4	11%	0.1	3%	0.1	3%
Potassium (mg)	220	10%	139	6%	8	0%	41	2%	14	1%	19	1%
Non-Hispanic Asian												
Calcium (mg)	358	44%	166	20%	8	1%	133	16%	33	4%	17	2%
Vitamin D (µg)	1.9	39%	1.4	29%	0.1	2%	0.2	4%	0.2	4%	0.1	2%
Potassium (mg)	301	11%	206	8%	13	0%	26	1%	43	2%	13	0%

Data from NHANES 2015-2018 (n=14,851). Disaggregated values were calculated by removing nutrients from non-dairy foods and reassigning them to specific dairy foods. [1]Total dairy includes all milk and dairy food subgroups. Values across rows may not sum to total dairy due to rounding of individual values. .

Cifelli CJ, Fulgoni K, Fulgoni VL, Hess JM. Disparity in dairy servings intake by ethnicity and age in NHANES 2015-2018. *Current Developments in Nutrition*. 2023; 7(2): https://doi.org/10.1016/j.cdnut.2022.100010.

Dairy and Vitamin Intakes


nutrients
MDPI
Article
Association between Intake of Total Dairy and Individual Dairy Foods and Markers of Folate, Vitamin B_6 and Vitamin B_{12} Status in the U.S. Population
Christopher J. Cifelli, Sanjiv Agarwal and Victor L. Fulgoni III

Public Health Nutrition: 26(5), 1828–1839
doi:10.1017/S136898002300071X
Dairy food consumption is beneficially linked with iodine status in US children and adults: National Health and Nutrition Examination Surveys 2001–2018
Yue Qin[1], Christopher J Cifelli[2,*], Sanjiv Agarwal[3] and Victor L Fugoni[4]
Abstract
Keywords
National Health and Nutrition Examination Surveys
Urinary iodine concentration
Dairy foods
Iodine
Milk

Higher intakes of total dairy as well as individual dairy foods (especially milk and yogurt) were **positively associated with serum and RBC folate, serum vitamin B6 and serum B12,** and generally, with 9–57% lower risk of inadequate or deficient levels of these vitamins.

Total dairy and milk intake was positively associated with UIC, the recommended method to assess iodine adequacy, among children, inversely associated with percentage of iodine insufficient among all ages and inversely associated with percentage of iodine severely deficient among adults 19 years and older.

These findings suggest that encouraging dairy consumption may be an effective strategy for improving micronutrient status and provide continued evidence to support the current dietary recommendations for dairy and dairy products.

1. Cifelli CJ, Agarwal S, Fulgoni VL. Association between intake of total dairy and individual dairy foods and markers of folate, vitamin B6 and vitamin B12 status in the U.S. population. *Nutrients*. 2022; 14(12):2441. doi: 10.3390/nu14122441.
2. Qin Y, Cifelli CJ, Agarwal S, Fulgoni VL. Dairy food consumption is beneficially linked with iodine status in US children and adults: NHANES 2001 – 2018. *Public Health Nutrition*. 2023; In press.

Replacing Dairy with Plant Based Foods: Nutrient Tradeoffs

- Increasing or decreasing certain foods within current consumption patterns in the diet results in profound effects on nutrient adequacy.
- When plant-based foods were increased in both children and adults**, the percent not meeting the Estimated Average Requirement (EAR):**
  - **Decreased** for vitamin C, magnesium, vitamin E, folate and iron
  - **Increased** for calcium, protein, vitamin A, and vitamin D
- **Specific recommendations to increase low fat and nonfat dairy foods in conjunction to increasing healthy plant-based foods will help to close some of the nutrient gaps currently present among Americans of all ages.**

nutrients

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Article

Increasing Plant Based Foods or Dairy Foods Differentially Affects Nutrient Intakes: Dietary Scenarios Using NHANES 2007–2010

Christopher J. Cifelli [1,*], Jenny A. Houchins [1], Elieke Demmer [1] and Victor L. Fulgoni III [2]

1 National Dairy Council, 10255 West Higgins Road, Suite 900, Rosemont, IL 60018-5616, USA; jenny.houchins@dairy.org (J.A.H.); elieke.demmer@dairy.org (E.D.)
2 Nutrition Impact, LLC, 9725 D Drive North, Battle Creek, MI 49014, USA; vic3rd@aol.com
* Correspondence: chris.cifelli@dairy.org; Tel.: +1-847-627-3282; Fax: +1-847-803-2077

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Abstract: Diets rich in plant foods and lower in animal-based products have garnered increased attention among researchers, dietitians and health professionals in recent years for their potential to, not only improve health, but also to lessen the environmental impact. However, the potential effects of increasing plant-based foods at the expense of animal-based foods on macro- and micronutrient nutrient adequacy in the U.S. diet is unknown. In addition, dairy foods are consistently under consumed, thus the impact of increased dairy on nutrient adequacy is important to measure. Accordingly, the objective of this study was to use national survey data to model three different dietary scenarios to assess the effects of increasing plant-based foods or dairy foods on macronutrient intake and nutrient adequacy. Data from the National Health and Nutrition Examination Survey (NHANES) 2007–2010 for persons two years and older (n = 17,387) were used in all the analyses. Comparisons were made of usual intake of macronutrients and shortfall nutrients of three dietary scenarios that increased intakes by 100%: (i) plant-based foods; (ii) protein-rich plant-based foods (i.e., legumes, nuts, seeds, soy); and (iii) milk, cheese and yogurt. Scenarios (i) and (ii) had commensurate reductions in animal product intake. In both children (2–18 years) and adults (⩾19 years), the percent not meeting the Estimated Average Requirement (EAR) decreased for vitamin C, magnesium, vitamin E, folate and iron when plant-based foods were increased. However the percent not meeting the EAR increased for calcium, protein, vitamin A, and vitamin D in this scenario. Doubling protein-rich plant-based foods had no effect on nutrient intake because they were consumed in very low quantities in the baseline diet. The dairy model reduced the percent not meeting the EAR for calcium, vitamin A, vitamin D, magnesium, and protein, while sodium and saturated fat levels increased. Our modeling shows that increasing plant-based foods could lead to unintended dietary outcomes without simultaneous changes in the types and amounts of plant foods currently consumed. Increasing dairy foods, which are currently under-consumed, could assist in improving the intakes of many nutrients of concern.

Keywords: plant-based foods; dairy; nutrient adequacy; sustainability

Cifelli CJ, Houchins JA, Demmer E, Fulgoni VL. Increasing Plant Based Foods or Dairy Foods Differentially Affects Nutrient Intakes: Dietary Scenarios Using NHANES 2007-2010. Nutrients. 2016;8(7):422. Published 2016 Jul 11. doi:10.3390/nu8070422

Simple Beverage Swaps Could Improve Nutrient Intakes in Children

Current Developments in Nutrition 7 (2023) 102020

ASN EST. 1928 American Society for Nutrition Excellence in Nutrition Research and Practice

Current Developments in Nutrition CDN

journal homepage: https://cdn.nutrition.org/

Original Research

Assessment of Beverage Trends and Replacing Nondairy Caloric Beverages with Milk at Meals across Childhood Improves Intake of Key Nutrients at Risk of Inadequate Consumption: An NHANES Modeling Study

Check for updates

Kristin Ricklefs-Johnson [1,*], Matthew A. Pikosky [1], Christopher J. Cifelli [1], Kristin Fulgoni [2], Victor L. Fulgoni III [2], Sanjiv Agarwal [3]

[1] *National Dairy Council, Rosemont, IL, United States;* [2] *Nutrition Impact, LLC, Battle Creek, MI, United States;* [3] *NutriScience, LLC, East Norriton, PA, United States*

ABSTRACT

Background: Milk is a key source of important nutrients including the nutrients of public health concern. However, most Americans do not meet current (dairy) United States Department of Agriculture (USDA) dietary guideline recommendations, and the intake has been declining.

Objective: The aim of this study was to investigate milk and beverage intake trends and nutrient intakes from these products in United States children aged 6–18 y and to model the effect of isocaloric substitution of nondairy beverages with milk.

Methods: Data from National Health and Nutrition Examination Survey (NHANES) 2001–2018 for children age 6–8 ($N = 4696$), 9–13 ($N = 8117$) and 14–18 y ($N = 8514$) were used with milk and other beverage intakes determined from the first 24-h in-person dietary recall. Nutrient intake was determined using the NHANES cycle-specific total nutrient intake files. Nutrient modeling was performed by isocaloric substitution with milk of all nondairy beverages consumed during lunch and dinner meals combined. Sample-weighted analyses were performed using SAS 9.4.

Results: Between ages 6–8 and 14–18 y, daily intake of milk and flavored milk decreased by 10% and 62%, respectively, while daily intake of caloric beverages excluding milk increased by 96%. Daily intake from caloric beverages and milk combined decreased for fiber, protein, fat, saturated fat, calcium, magnesium, potassium, vitamin A, and vitamin D and increased for energy, carbohydrates, added sugars, and

- Milk consumption declines across childhood and is often replaced with less nutrient dense beverage options which can result in poorer nutritional status.
  - **Decreased** essential nutrient intakes; **Increased** intakes of calories and added sugars
- **The results of this modeling study showed that including or substituting caloric beverages, especially sugar-sweetened beverages, with milk can significantly improve the intake of essential micronutrients without substantially increasing total or saturated fat.**

Ricklefs-Johnson K, Pikosky MA, Cifelli CJ et al. Assessment of beverage trends and replacing nondairy caloric beverages with milk at meals across childhood improves intake of nutrients at risk of inadequate consumption: An NHANES modeling study. *Curr Dev Nutr*, 2023; https://doi.org/10.1016/j.cdnut.2023.102020

Protein Quality is Important for Ensuring Protein Requirements Are Met

- New research shows that protein intake is insufficient to meet minimal requirements in certain segments of the US population, particularly adolescents and older adults.
- If protein quality of the diet is low, then the proportion of the population not meeting protein needs increased.
- **Dairy is a source of high-quality protein; thus, it can be a solution for helping at-risk people meet their protein requirements**


The Journal of Nutrition 154 (2024) 804–814

American Society for Nutrition

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Perspectives

The Importance of Dietary Protein Quality in Mid- to High-Income Countries

Paul J Moughan [1,*], Victor L Fulgoni III [2], Robert R Wolfe [3]

[1] Riddet Institute, Massey University, Palmerston North, New Zealand; [2] Nutrition Impact, LLC, Battle Creek, MI, United States; [3] University of Arkansas for Medical Sciences, Little Rock, AR, United States

ABSTRACT

In wealthy countries, the protein intake of adults is usually considered to be adequate, and considerations of protein quality are often deemed irrelevant. The objective was to examine dietary protein intakes of adults in developed countries in the context of dietary protein quality. An analysis of NHANES population data on actual protein intakes in the United States (a developed country) demonstrated that for a dietary Digestible Indispensable Amino Acid Score (DIAAS) of 100%, 11% of the adult (19–50 y) population had habitual protein intakes below the Estimated Average Requirement (EAR) and 22% below the Recommended Dietary Allowance. The percentage of the population with utilizable protein intakes potentially falling below the EAR increased as the assumed DIAAS declined. Analysis of the NHANES data and several other datasets also indicated that total protein intakes can be limiting or close to limiting for the elderly and some vegetarians and vegans. Here, lower dietary protein quality can potentially lead to inadequate utilizable protein intakes. For many people in specific physiological states (e.g., weight loss, endurance sports, resistance exercise) attempting to meet higher dietary protein targets often with accompanying lowered energy intakes, low dietary protein quality can lead to protein calories expressed as a proportion of total calories, falling outside what may be acceptable limits (maximum of 30% protein calories from total calories). In general, individuals within the adult population may be susceptible to macronutrient imbalance (whenever total protein intakes are high, daily energy intakes low) and for diets with lower protein quality (DIAAS <100%). Our analysis shows that dietary protein quality is relevant in mid- to high-income countries.

Keywords: protein, protein quality, DIAAS, protein requirements

Introduction

Dietary proteins supply the body with amino acids, which are the building blocks used for protein synthesis to grow and maintain lean body mass. Amino acids also serve in the synthesis of a myriad of molecules with essential biological functions. Many amino acids have specific regulatory functions.

It is of critical importance, therefore, that humans of all ages

amino acids relative to the requirement, they are said to differ in their "protein quality."

Protein quality describes the potency of a food protein to supply the body with amino acids relative to requirements [1]. It is largely a function of a protein's indispensable (essential) amino acid content and profile, as well as the digestibility or availability of the amino acids. There are many measures of protein quality, the most common in practice being the Protein

Moughan Pj, Fulgoni VL, Wolfe RR. The importance of protein quality in mid- to high-income countries. *J Nutr*. 2024; 154: 804.814.

Dairy Food Consumption Linked to Lower Risk of Heart Disease Mortality

nutrients

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Article

Dairy Food Consumption Is Associated with Reduced Risk of Heart Disease Mortality, but Not All-Cause and Cancer Mortality in US Adults

Yanni Papanikolaou [1,*] and Victor L. Fulgoni III [2]

1 Nutritional Strategies, 59 Marriott Place, Paris, ON N3L 0A3, Canada
2 Nutrition Impact, 9725 D Drive North, Battle Creek, MI 49014, USA
* Correspondence: papanikolaou.yanni@gmail.com

Abstract: Previous evidence has linked animal protein intake, including dairy foods, with an increased risk in mortality from all-causes and certain chronic diseases, including cancer and heart disease. The objective of the current analysis was to examine associations between total dairy consumption with mortality from all-causes, cancer, and heart disease. Data for adults (≥19 y; n = 54,830) from the *Third National Health and Nutrition Examination Survey* (NHANES) and NHANES 1999–2014 were linked with mortality data through 2015. Individual usual intake for dairy foods were estimated using the National Cancer Institute method. Hazard ratio (HR) models were fit for mortality types (all cause, cancer, heart disease) and measures of usual intakes of dairy. Multivariable analysis further adjusted for age, gender, ethnicity, waist circumference, smoking status, education level, chronic condition status (i.e., based on cancer, myocardial infarct, and diabetes/diabetes medication reported), weight loss attempts, and % kcal from animal protein. No associations were seen between dairy food intake and mortality risk from all-causes [HR = 0.97; confidence intervals (CI): 0.85–1.11; $p = 0.67$], and cancer [HR = 0.95; CI: 0.75–1.20; $p = 0.65$] when comparing the lowest quartile to the highest quartile of consumption. Dairy food consumption was associated with a 26% reduced risk for heart disease mortality when comparing the lowest quartile to the highest quartile [HR = 0.74; CI: 0.54–1.01; $p = 0.05$]. Further analyses in different age groups showed that dairy food consumption was associated with 39% and 31% reduced risk for heart disease mortality in older adults 51–70 and ≥51 y, respectively [adults 51–70 y: HR = 0.61; CI: 0.41–0.91; $p = 0.01$; adults ≥51 y: HR = 0.69; CI: 0.54–0.89; $p = 0.004$]. These results contradict previous findings that have linked dairy foods to increased mortality risk. Further, dairy foods as part of a healthy dietary pattern, may help lower heart disease mortality risk.

Keywords: dairy foods; usual intake; NHANES; mortality; cancer; cardiovascular disease

check for updates

Citation: Papanikolaou, Y.; Fulgoni, V.L., III Dairy Food Consumption Is Associated with Reduced Risk of Heart Disease Mortality, but Not All-Cause and Cancer Mortality in US Adults. *Nutrients* **2023**, *15*, 394. https://doi.org/10.3390/nu15020394

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1. Introduction

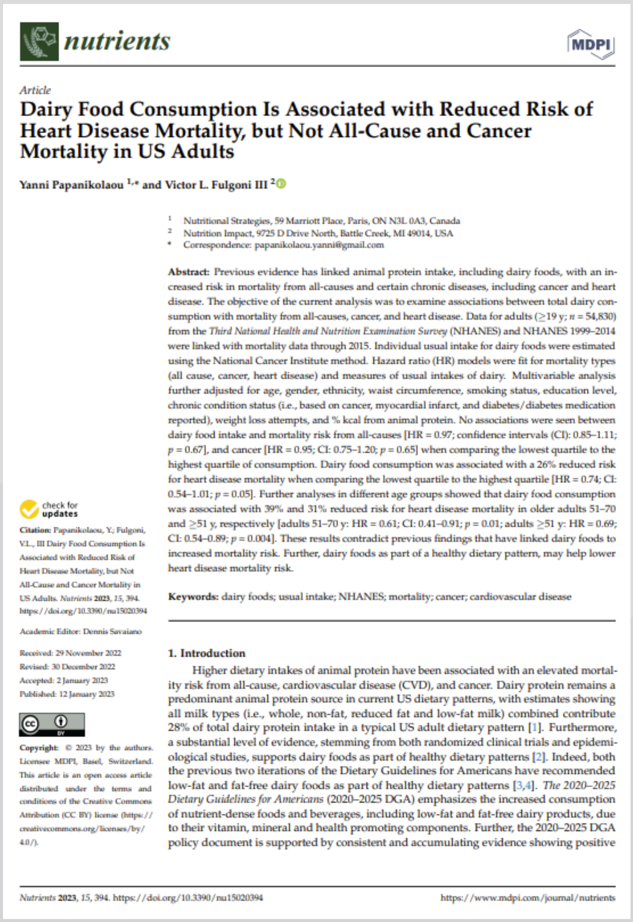
Higher dietary intakes of animal protein have been associated with an elevated mortality risk from all-cause, cardiovascular disease (CVD), and cancer. Dairy protein remains a predominant animal protein source in current US dietary patterns, with estimates showing all milk types (i.e., whole, non-fat, reduced fat and low-fat milk) combined contribute 28% of total dairy protein intake in a typical US adult dietary pattern [1]. Furthermore, a substantial level of evidence, stemming from both randomized clinical trials and epidemiological studies, supports dairy foods as part of healthy dietary patterns [2]. Indeed, both the previous two iterations of the Dietary Guidelines for Americans have recommended low-fat and fat-free dairy foods as part of healthy dietary patterns [3,4]. *The 2020–2025 Dietary Guidelines for Americans* (2020–2025 DGA) emphasizes the increased consumption of nutrient-dense foods and beverages, including low-fat and fat-free dairy products, due to their vitamin, mineral and health promoting components. Further, the 2020–2025 DGA policy document is supported by consistent and accumulating evidence showing positive

Nutrients **2023**, *15*, 394. https://doi.org/10.3390/nu15020394 https://www.mdpi.com/journal/nutrients

- <u>Goal</u>: to examine the **link between consumption of dairy foods and mortality risk** in US adults.
- <u>Methods</u>:
  - Data for adults from the Third NHANES and NHANES 1999–2014 were *linked* with CDC mortality data through 2015.
  - Hazard ratio (HR) models were fit for mortality types (all cause, cancer, heart disease) and measures of usual intakes of dairy.

Papanikolaou and Fulgoni. Dairy food consumption is associated with reduced risk of heart disease mortality, but not all-cause and cancer mortality in US adults. *Nutrients*. 2023. https://pubmed.ncbi.nlm.nih.gov/36678263/.

Dairy Food Consumption Linked to Lower Risk of Heart Disease Mortality


nutrients

MDPI

Article

Dairy Food Consumption Is Associated with Reduced Risk of Heart Disease Mortality, but Not All-Cause and Cancer Mortality in US Adults

Yanni Papanikolaou [1,*] and Victor L. Fulgoni III [2]

[1] Nutritional Strategies, 59 Marriott Place, Paris, ON N3L 0A3, Canada
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Keywords: dairy foods; usual intake; NHANES; mortality; cancer; cardiovascular disease

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- The results showed that:
  - Dairy foods were **not linked** with all-cause or cancer mortality risk.
  - Dairy foods were **associated with a 26% reduced risk for heart disease mortality** in those 19+
  - In adults 51+, there was a 7% risk reduction associated with 1% higher percentage of calories coming from animal protein

Papanikolaou and Fulgoni. Dairy food consumption is associated with reduced risk of heart disease mortality, but not all-cause and cancer mortality in US adults. *Nutrients*. 2023. https://pubmed.ncbi.nlm.nih.gov/36678263/.

… Which May Explain the Paradox with CV Risk

Emerging research shows neutral to beneficial outcomes of full-fat dairy, highlighting the nuance and complexity of the dairy matrix

Full-fat dairy foods have shown protective effects on cardiometabolic risks/outcomes:

- CVD[1-5]
- Type 2 DM[2,3,5]
- Mortality[2,3,5]
- CVD Mortality[3]
- Stroke[3,5]
- Hypertension[5]
- Waist circumference and body compisition.[4-7]

The New York Times

Whole Milk May Be Better When It Comes to Children's Weight

Kids who drank whole milk were at a 39 percent reduced risk for being overweight than those who drank low-fat milk.

The Washington Post

Good news about cheese — it's much healthier than you thought

1. Trieu et al. PLOS Medicine. 2021;18(9):e1003763.
2. Astrup et al. Journal of the American College of Cardiology. 2020;76(7):844-857.
3. Dehghan et al. The Lancet. 2018;392(10161):P2288-2297
4. Duarte et al. Crit Rev Food Sci Nutr. 2020;61(3):450-461
5. Hirahtake et al. Adv in Nutr. 2020;11(3):533-547.
6. Geng T, Huang T. Mol Nutr Food Res. 2018;6(21)
7. Vanderhout et al. Clinical Nutrition. 2019;111(2):266-279.

Fat Flexibility Modeling

- Objective: Assess the **impact of replacing one serving of fat-free dairy foods** in the Healthy U.S.-Style Eating Pattern from the DGA with **one serving of whole- or reduced-fat dairy foods.**
- Food pattern modeling indicates that one of the three recommended servings of dairy foods for Americans 9 years and older can be a **whole- or reduced-fat option** while staying within the 2015 DGA's recommended ranges for saturated fat, energy, and sodium intake.

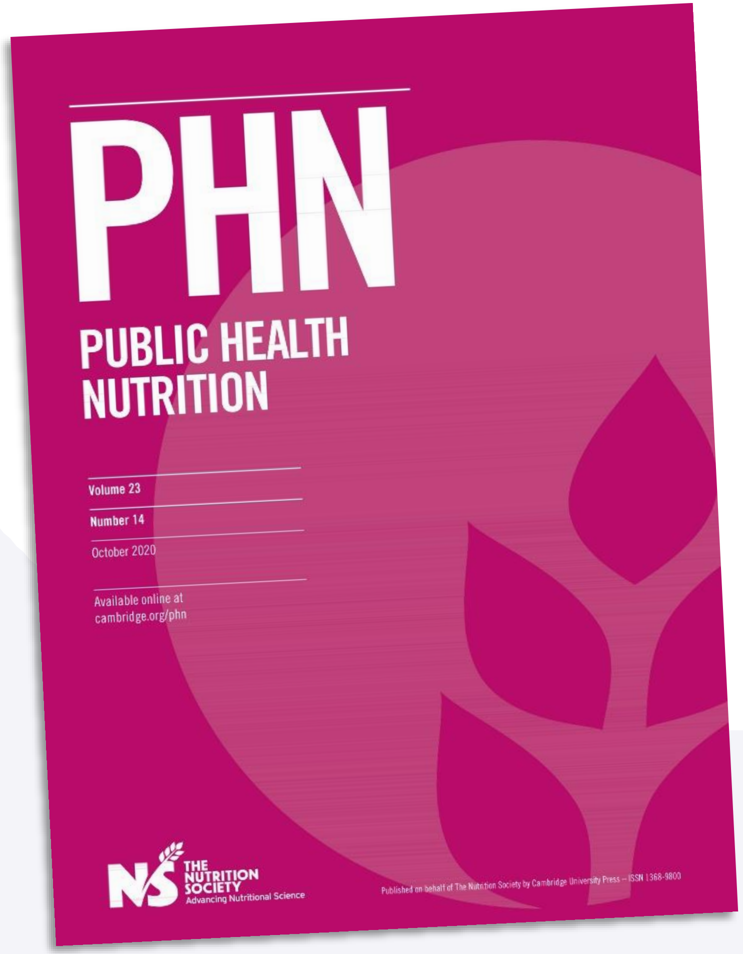
TABLE 4 | Comparing food pattern modeling from **Tables 2**, **3** to dietary goals for sample age/sex groups with 2,000 kcal diets, taken from Table E3.1.A4 of 2015 DGAC Scientific Report (% goal; % Recommended Dietary Allowance, RDA; % Adequate Intake, AI; % Upper Limit, UL; %kcal).

	MODEL 1[iii]		MODEL 2[iv]		MODEL 3[v]		MODEL 4[vi]		MODEL 5[vii]		MODEL 6[viii]		MODEL 7[ix]	
Nutrients, % goal	**Females 19–30 years**	**Males 51+ years**	**Females 19-30 years**	**Males 51+ years**	**Females 19-30 years**	**Males 51+ years**	**Females 19-30 years**	**Males 51+ years**	**Females 19-30 years**	**Males 51+ years**	**Females 19-30 years**	**Males 51+ years**	**Females 19-30 years**	**Males 51+ years**
MACRONUTRIENTS														
Kcal, % goal	100	100	103	103	104	104	104	104	102	102	105	105	103	103
Protein, % RDA	207	170	204	167	202	166	201	165	202	166	204	167	205	169
Protein, % kcal	19	19	18	18	18	18	18	18	18	18	18	18	18	18
Carbohydrate, % RDA	199	199	199	199	198	198	201	201	201	201	196	196	196	196
Carbohydrate % kcal	52	52	50	50	49	49	50	50	51	51	48	48	50	50
Fiber, % AI	109	109	109	109	109	109	109	109	109	109	109	109	109	109
Saturated fat, % kcal	8	8	9	9	10	10	9	9	9	9	10	10	10	10
Monounsaturated fat, % kcal	11	11	12	12	12	12	12	12	12	12	12	12	12	12
Polyunsaturated fat, %vkcal	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Linoleic acid, % AI	162	139	164	140	165	142	165	141	164	140	166	142	164	140
Linolenic acid, % AI	207	142	211	145	217	149	223	153	208	143	211	145	214	147

Hess JM, Cifelli CJ, Fulgoni VL 3rd. Modeling the Impact of Fat Flexibility With Dairy Food Servings in the 2015-2020 Dietary Guidelines for Americans Healthy U.S.-Style Eating Pattern. Front Nutr. 2020;7:595880. Published 2020 Oct 22. doi:10.3389/fnut.2020.595880

Dairy and Economics

It is Difficult to Replace Dairy’s Nutrients



- The US Dietary Guidelines for Americans recommends increased consumption of the dairy group to three daily servings for ages 9+ years to help achieve adequate intakes of prominent shortfall nutrients.

- Identifying **affordable, consumer-acceptable foods** to replace dairy's shortfall nutrients is important, especially for people who avoid dairy.

- **Method:** Linear programming was used to find unique combinations of non-dairy foods in the 2011-2014 WWEIA food categories that would substitute for protein and 10 shortfall nutrients in one USDA cup-equivalent of dairy
  - Phase 1: Only dairy foods, including the dairy component in mixed dishes, were excluded from the WWEIA food categories.
  - Phase 2: Select foods and beverages that were not reasonable non-dairy options on a population basis also were excluded.

Cifelli CJ, Auestad N, Fulgoni VL. Replacing the nutrients in dairy foods with non-dairy foods will increase the cost, calories, and require large amounts of food: NHANES 2011-2014. Public Health Nutrition. 2020.

Constraints for the WWEIA Food Categories to Replace the Nutrients in 1 USDA Cup-Equivalent Serving

Phase 1:	Phase 2:

• **Optimization priorities:**
  • Lowest cost non-dairy food combinations
  • Fewest calories in non-dairy food combinations
  • Smallest amount of food by weight (g) in non-dairy food combinations
• **Consumption constrains for all three scenarios**:
  • None
  • No more than the 90th percentile of current consumption
	• Optimization priorities and consumption constrains same as Phase 1
	• Foods and beverages that are not reasonable replacement foods on a population basis: baby foods, protein and nutritional powders [9802]; nutritional beverages [7208]
	• Beverages with virtually no calories, but that contain small amounts of micronutrients: coffee [7302]; tap water [7702]; bottled water [7704]; diet soft drinks [7102]; other diet drinks [7106]

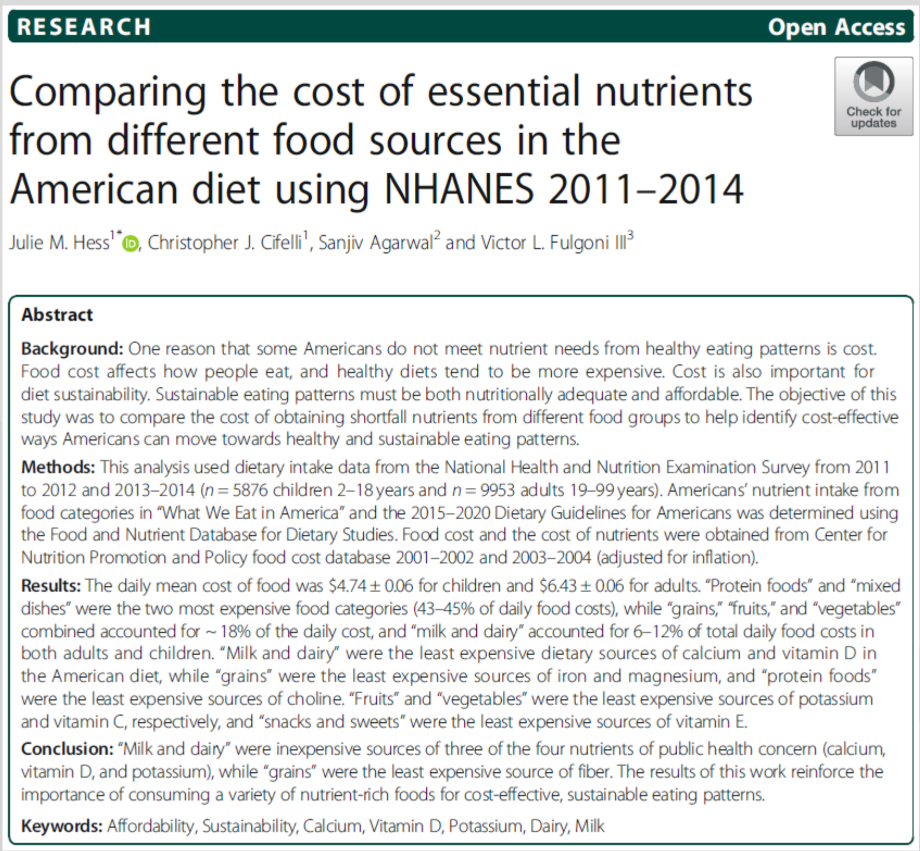
Cifelli CJ, Auestad N, Fulgoni VL. Replacing the nutrients in dairy foods with non-dairy foods will increase the cost, calories, and require large amounts of food: NHANES 2011-2014. Public Health Nutrition. 2020.

Results

- **Non-dairy food combinations are not reasonable substitutes for dairy foods.**
- Identifying affordable, consumer-acceptable foods that can replace dairy's shortfall nutrients at both current and recommended dairy intakes remains a challenge.
- **Replacing dairy will require tradeoffs**.
  - The limiting nutrients in all of the non-dairy food combinations were **vitamin D and calcium** whether optimized for the lowest cost, fewest number of calories, or the smallest amount of food by weight.
  - In some of the optimized food combinations, **sodium, added sugars, and/or saturated fat were higher** than in a USDA cup equivalent of dairy.
    - Saturated fat in all the optimized food combinations was 1.3 to 2.0 times higher than in USDA servings of dairy.
  - Only 12 out of the approximately 150 WWEIA food categories were represented in the optimized food combinations.

Cifelli CJ, Auestad N, Fulgoni VL. Replacing the nutrients in dairy foods with non-dairy foods will increase the cost, calories, and require large amounts of food: NHANES 2011-2014. Public Health Nutrition. 2020.

Cost of Nutrient Shortfalls



RESEARCH Open Access

Comparing the cost of essential nutrients from different food sources in the American diet using NHANES 2011–2014

Check for updates

Julie M. Hess[1*], Christopher J. Cifelli[1], Sanjiv Agarwal[2] and Victor L. Fulgoni III[3]

Abstract

Background: One reason that some Americans do not meet nutrient needs from healthy eating patterns is cost. Food cost affects how people eat, and healthy diets tend to be more expensive. Cost is also important for diet sustainability. Sustainable eating patterns must be both nutritionally adequate and affordable. The objective of this study was to compare the cost of obtaining shortfall nutrients from different food groups to help identify cost-effective ways Americans can move towards healthy and sustainable eating patterns.

Methods: This analysis used dietary intake data from the National Health and Nutrition Examination Survey from 2011 to 2012 and 2013–2014 (n = 5876 children 2–18 years and n = 9953 adults 19–99 years). Americans' nutrient intake from food categories in "What We Eat in America" and the 2015–2020 Dietary Guidelines for Americans was determined using the Food and Nutrient Database for Dietary Studies. Food cost and the cost of nutrients were obtained from Center for Nutrition Promotion and Policy food cost database 2001–2002 and 2003–2004 (adjusted for inflation).

Results: The daily mean cost of food was $4.74 ± 0.06 for children and $6.43 ± 0.06 for adults. "Protein foods" and "mixed dishes" were the two most expensive food categories (43–45% of daily food costs), while "grains," "fruits," and "vegetables" combined accounted for ~ 18% of the daily cost, and "milk and dairy" accounted for 6–12% of total daily food costs in both adults and children. "Milk and dairy" were the least expensive dietary sources of calcium and vitamin D in the American diet, while "grains" were the least expensive sources of iron and magnesium, and "protein foods" were the least expensive sources of choline. "Fruits" and "vegetables" were the least expensive sources of potassium and vitamin C, respectively, and "snacks and sweets" were the least expensive sources of vitamin E.

Conclusion: "Milk and dairy" were inexpensive sources of three of the four nutrients of public health concern (calcium, vitamin D, and potassium), while "grains" were the least expensive source of fiber. The results of this work reinforce the importance of consuming a variety of nutrient-rich foods for cost-effective, sustainable eating patterns.

Keywords: Affordability, Sustainability, Calcium, Vitamin D, Potassium, Dairy, Milk

- **Objectives**
  - Compare the cost to the consumer of obtaining shortfall nutrients from different food groups and different food sources.
  - Help identify cost-effective ways to help Americans move towards healthy and sustainable eating patterns.
- **Methods**
  - Analysis using dietary intake data from NHANES, nutrient intake from the Food and Nutrient Database for Dietary Studies, and food cost for nutrients from Center for Nutrition Promotion and Policy food cost database 2001-2002 and 2003-2004 (adjusted for inflation).

Hess JM, Cifelli CJ, Agarwal S, Fulgoni VL 3rd. Comparing the cost of essential nutrients from different food sources in the American diet using NHANES 2011-2014. *Nutr J*. 2019;18(1):68. Published 2019 Nov 9. doi:10.1186/s12937-019-0496-5

WWEIA: Food Groups

Milk and dairy	Mixed dishes
Milk, flavored milk, dairy drinks and substitutes, cheese, and yogurt	Meat, poultry, seafood; Grain-based; Asian; Mexican; Pizza; Sandwiches; Soup

Protein foods	Grains
Meats, poultry, seafood, eggs, cured meats/poultry, plant-based foods	Cooked grains; Bread, rolls, tortillas; Quick bread and break products; Ready-to-eat cereals; Cooked Cereals

Fruits	Vegetables
Fruits	Vegetables excluding potatoes; White potatoes

Snacks and sweets
Savory snacks; Crackers; Snack/Meal bars; Sweet bakery products; Candy; Other desserts

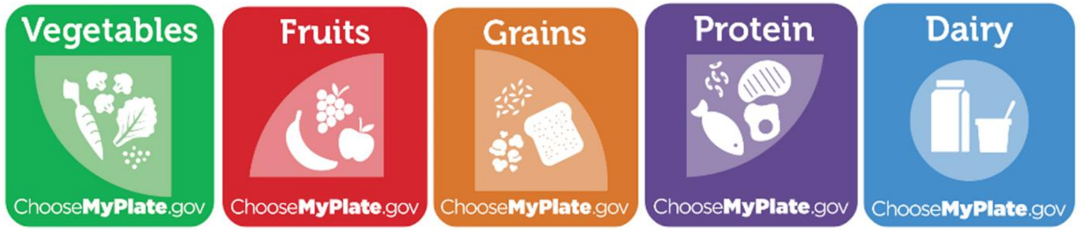
Hess JM, Cifelli CJ, Agarwal S, Fulgoni VL 3rd. Comparing the cost of essential nutrients from different food sources in the American diet using NHANES 2011-2014. *Nutr J*. 2019;18(1):68. Published 2019 Nov 9. doi:10.1186/s12937-019-0496-5

Cost of Nutrient Shortfalls: Results

- **These results reinforce the importance of consuming a variety of nutrient-rich foods for cost-effective, sustainable eating patterns.**

- **Daily mean cost of food**
  - Children (2-18 years): $4.74 ± 0.06
  - Adults (19-99 years) : $6.43 ± 0.06

- **Most expensive:**
  - Protein foods (~18-23% of total daily food cost)
  - Mixed dishes (~22-25% of total daily food cost)



Children:

- “Grains” were least expensive sources of vitamin A, vitamin E, iron and magnesium
- **“Milk and dairy” were least expensive sources of calcium, vitamin D, and potassium**
- “Vegetables” were least expensive sources of potassium
- “Fruits” were the least expensive sources of vitamin C

Adults:

- “Grains” were least expensive sources of magnesium and iron
- **“Milk and dairy” were least expensive sources of calcium and vitamin D**
- “Vegetables” were least expensive sources of potassium and vitamin A
- “Fruits” were the least expensive sources of vitamin C
- “Snacks and sweets” were the least expensive sources of vitamin E

Hess JM, Cifelli CJ, Agarwal S, Fulgoni VL 3rd. Comparing the cost of essential nutrients from different food sources in the American diet using NHANES 2011-2014. *Nutr J*. 2019;18(1):68. Published 2019 Nov 9. doi:10.1186/s12937-019-0496-5

Animal Sourced Foods for Nutritional Adequacy

ARTICLES
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nature food
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Animal-sourced foods are required for minimum-cost nutritionally adequate food patterns for the United States

Sylvia M. S. Chungchunlam[1]✉, Paul J. Moughan[1], Daniel P. Garrick[2,3] and Adam Drewnowski[4]

The amounts of animal-sourced foods required to achieve a least-cost nutritious diet depend on the food prices prevalent in each country. Using linear programming, we determine least-cost dietary patterns in the United States and the constituent amounts of animal-sourced foods. We considered local foods and prices from 2009–2010, and the average energy and nutrient requirements of adults. Nutrient-adequate food patterns were estimated at US$1.98 per day and included animal and plant products. Limiting nutrients were α-linolenic acid, potassium, choline, and vitamins C, D, E and K. The prices of animal-based foods had to be increased by 2–11.5 times to be excluded from the modelled food pattern, with the least cost of a plant-only diet at US$3.61. Given relative food prices in the United States, we show that animal-based foods are needed to secure adequate nutrition at the lowest cost, underscoring the role of price and market mechanisms in the choice of nutrient-adequate, sustainable diets.

The Food and Agriculture Organization of the United Nations has defined sustainable diets relative to four principal domains: nutrition, the environment, society and economics[1]. Guided by these domains, food patterns need to be nutrient adequate, sparing of natural resources and the environment, culturally acceptable and affordable[2]. Food choices should consider all of these aspects; for example, the environmental impact of animal food production may in some cases be higher than that of plant food production, but environmental costs that are not reflected in the price (that is, externalities) need to be assessed against attributes such as nutrient density and cultural and social value.

This study, which is focused on the economic domain, seeks to identify the best combination of food groups to minimize daily dietary cost while meeting energy and nutrient requirements in the United States. We used the most up-to-date, comprehensive and reliable food composition data (2016)[3] and national food prices (2009–2010)[4] available for the country. Although the detail and robustness of the dataset is a strength, that the data pertain only to the United States is also a limitation in terms of the generalizability of the findings to other regions. Yet, the price hierarchy of different food items has been shown to be the same in countries as diverse as France, the United Kingdom, the Netherlands, China, India and Australia[5,6].

In linear programming, diet formulation is determined by minimizing or maximizing (that is, optimizing) a given function while subjecting this function to several constraints[7,8]. In the present study, a linear programming algorithm was applied to verify the amounts of animal- and plant-based foods in least-cost diets and in the face of numerous constraints (such as energy and nutrient requirements, upper limits to nutrient intakes, food serving sizes, and available foods and their relative pricing). This allows a rational assessment to be made as to whether—from an economic perspective alone—animal-based foods need to be included in mixed diets for adult humans.

The linear programming analysis gives a unique solution of the combination of foods that meet all nutrient requirements at the lowest cost. The analysis is limited to the effect of food costs; the resultant food pattern has not been optimized from a health viewpoint, nor does it address other relevant aspects of food production, such as greenhouse gas emissions, natural resource use and environmental pollution. Although linear programming has been used in previous studies to evaluate diets for humans[9,10], the objective of those studies was to assess the impact of cost constraints on food choices, and to evaluate altered food intake and nutrient patterns. The linear programming modelling exercise is illustrative only, and does not purport to formulate a balanced recommended diet in a public health sense. Consistent with this, the combinations of different food items in the modelled diets are at times referred to as modelled food patterns. This study applies linear programming to derive economically optimal food patterns and identify food groups that need to be included in a nutritionally adequate modelled diet, to ensure that all nutrient requirements are met at the lowest cost. In other words, the hypothesis to be tested was whether animal-based foods, due to their high nutrient density, would be found in least-cost modelled diets for adult humans, given foods and food prices in the United States.

In total, five linear programming analyses were conducted. Linear programming analysis 1 investigated a dietary scenario whereby a modelled food pattern that met the total energy requirement of 2,600 kcal and the requirements for all key macronutrients and micronutrients (28 in total) was formulated at the lowest cost. The subsequent linear programming analyses 2 and 3 examined the effects of incremental changes in animal food prices. Linear programming analysis 4 considered a nutritional scenario whereby the requirements for the vitamins would be met by dietary supplements. Linear programming analysis 5 utilized a lower potassium recommended intake level of 3,400 mg d^{-1} (ref. [11]). Linear programming includes inherent sensitivity analysis features

[1]Riddet Institute, Massey University, Palmerston North, New Zealand. [2]Theta Solutions, Atascadero, CA, USA. [3]AL Rae Centre for Genetics and Breeding, School of Agriculture and Environment, Massey University, Hamilton, New Zealand. [4]Center for Public Health Nutrition, University of Washington, Washington, DC, USA. ✉e-mail: sylvia.lawrence.17@gmail.com

- When linear programming was applied to commonly available foods and food prices prevailing in the United States (2009–2010), **animal-based foods (milk, eggs, fish, and meat) were found to meet the energy and nutrient requirements of healthy adults at the lowest cost.**
- Given relative food prices in the United States, the results show that **animal-based foods are needed to secure adequate nutrition** at the lowest cost, underscoring the role of price and market mechanisms in the choice of nutrient-adequate, sustainable diets.

Chungchunlam, S.M.S., Moughan, P.J., Garrick, D.P. et al. Animal-sourced foods are required for minimum-cost nutritionally adequate food patterns for the United States. Nat Food 1, 376–381 (2020). https://doi.org/10.1038/s43016-020-0096-8

Following DGA-Healthy Eating Pattern Projected To Save Billions In Healthcare Costs

- **Research Method:**
  - Relative risk (RR) estimates of the association between dairy consumption and health outcomes were estimated based on the available scientific literature.
  - Mean total dairy intake was estimated to be 1.49 cup equivalents per day.
  - Direct and indirect costs associated with each health outcome were determined.
- **Increased conformance with the Healthy US-Style and Healthy Mediterranean-Style eating patterns as measured by the Healthy Eating Index and the Mediterranean diet score resulted in cost savings of more than $15 billion in the US adult population.**

Schwingshackl L, Bogensberger B, Hoffmann G. Diet Quality as Assessed by the Healthy Eating Index, Alternate Healthy Eating Index, Dietary Approaches to Stop Hypertension Score, and Health Outcomes: An Updated Systematic Review and Meta-Analysis of Cohort Studies. J Acad Nutr Diet. 2018;118(1):74-100.e11. doi:10.1016/j.jand.2017.08.024

Increased Consumption Of Dairy Foods Associated With Healthcare Cost Savings in the U.S.

nutrients MDPI

Article

Health Care Costs and Savings Associated with Increased Dairy Consumption among Adults in the United States

Carolyn G. Scrafford [1,*], Xiaoyu Bi [1], Jasjit K. Multani [2], Mary M. Murphy [1], Jordana K. Schmier [3] and Leila M. Barraj [1]

1 Center for Chemical Regulation and Food Safety, Exponent, Inc., Washington, DC 20036, USA; xbi@exponent.com (X.B.); mmurphy@exponent.com (M.M.M.); Lbarraj@exponent.com (L.M.B.)
2 IQVIA, Health Economics and Outcomes Research, Falls Church, VA 22042, USA; jasjit.multani@iqvia.com
3 Health Sciences, Exponent, Inc., Alexandria, VA 22314, USA; Jschmier@exponent.com
* Correspondence: cscrafford@exponent.com; Tel.: +1-202-772-4928

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Abstract: Background: The purpose of this study is to estimate the impact on health care costs if United States (US) adults increased their dairy consumption to meet Dietary Guidelines for Americans (DGA) recommendations. Methods: Risk estimates from recent meta-analyses quantifying the association between dairy consumption and health outcomes were combined with the increase in dairy consumption under two scenarios where population mean dairy intakes from the 2015–2016 What We Eat in America were increased to meet the DGA recommendations: (1) according to proportions by type as specified in US Department of Agriculture Food Intake Patterns and (2) assuming the consumption of a single dairy type. The resulting change in risk was combined with published data on annual health care costs to estimate impact on costs. Health care costs were adjusted to account for potential double counting due to overlapping comorbidities of the health outcomes included. Results: Total dairy consumption among adults in the US was 1.49 cup-equivalents per day (c-eq/day), requiring an increase of 1.51 c-eq/day to meet the DGA recommendation. Annual cost savings of $12.5 billion (B) (range of $2.0B to $25.6B) were estimated based on total dairy

- <u>Results</u>:
  - Total dairy consumption among adults in the US was 1.49 cup-equivalents per day (c-eq/day), requiring an increase of 1.51 c-eq/day to meet the DGA recommendation.
  - Modeling analysis showed that increasing total dairy intake to meet recommendations would result in an average **healthcare cost savings of $12.5 billion**.

Scrafford CG, Bi X, Multani JK, Murphy MM, Schmier JK, Barraj LM. Health Care Costs and Savings Associated with Increased Dairy Consumption among Adults in the United States. *Nutrients*. 2020; 12(1):233. https://doi.org/10.3390/nu12010233

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Conclusions

- Despite being an important source of key nutrients, both children and adults under-consume dairy foods. Also, race/ethnicity impacts usual dairy intakes.

- Dairy foods are were associated with reduced risk for heart disease mortality. There was no link between dairy foods and all-cause or cancer mortality.

- Modelling studies unitizing NHANES show that dairy foods are difficult to replace without increasing the cost or amount of food consumed. Moreover, meeting dietary recommendations could lead to reduced health care costs.