Association of Pasta Consumption with Diet Quality and Nutrients of Public Health Concern in Adults: National Health and Nutrition Examination Survey 2009–2012

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Abstract

Background: Pasta is a commonly consumed food in the United States; however, little is known about pasta consumption and nutrient intake and diet quality.

Objective: This study examined the association between pasta consumption and diet quality.

Methods: This was a cross-sectional data analysis of 10,697 US adults from the NHANES 2009–2012, a nationally representative survey. The main outcome measures were diet quality as assessed by the Healthy Eating Index–2010 (HEI-2010), nutrient intakes, and dietary patterns. Cluster analysis was used among pasta consumers to characterize dietary patterns. Regression analyses determined differences between groups.

Results: Overall mean diet quality was similar between pasta consumers and nonconsumers. However, consumers of "pasta, noodles" had 5.6% higher HEI-2010 scores; HEI-2010 scores were 7.9% lower in those who ate "macaroni and cheese." Consumers of pasta, "pasta, noodles," and "pasta mixed dishes, excluding macaroni and cheese" ("pasta mixed dishes") had higher dietary fiber intakes by 11.0–13.6% (range: 1.89–2.35 g/d). Consumption of "pasta mixed dishes" was associated with a 5% increase in both potassium and sodium intakes (~150 and 190 mg/d, respectively). Cluster analyses identified pasta-eating patterns that are associated with both increased and decreased diet quality compared with nonconsumers.

Conclusions: Different dietary patterns exist with regard to pasta consumption. These pasta patterns contribute in different ways to diet quality and intakes of fiber, sodium, and potassium. Therefore, it is critical to separate types of pasta and pasta dishes before relating to dietary intakes. *Curr Dev Nutr* 2017;1:e001271.

Keywords: diet quality, nutrient intake, National Health and Nutrition Examination Survey (NHANES), Healthy Eating Index (HEI), cluster analysis, pasta

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Abbreviations used: DGA, Dietary Guidelines for Americans; FNDDS, Food and Nutrient Database for Dietary Studies; HEI-2010, Healthy Eating Index–2010; MEC, mobile examination center; PIR, poverty-income ratio; SOFAAS, solid fats, alcohol, and added sugars; WWEIA, What We Eat in America.

Introduction

Pasta is a commonly consumed food in the United States (1); however, "pasta" is often used as an umbrella term to describe several types of dishes, some of which are considered to be healthy and others less healthy. Furthermore, very little is known about how pasta contributes to the quality of the American diet or its effects, if any, on overweight and obesity. When pasta is cooked correctly (al dente), it can have a low glycemic index (2), may possibly slow digestion rates (3), and may contribute to longer satiety (4, 5) and when it is consumed with tomato products provides a high source of dietary lycopene (5). Increasing epidemiologic evidence has also associated the consumption of foods rich in phytochemicals (e.g., fruit, vegetables, and whole grains), often consumed in combination with pasta, to reduced incidence of cardiovascular disease, obesity, diabetes, cancer, and other chronic degenerative diseases (6, 7); yet there are few epidemiologic data on contributions of pasta and pasta-containing foods to nutrient intake and diet quality. Therefore, the purpose of this analysis was to use data from the NHANES 2009–2012 (8) to determine the associations between pasta

consumption and nutrient intake, with a focus on the nutrients of public health concern as identified by the 2015–2020 Dietary Guidelines for Americans (DGA) (1), diet quality, and dietary patterns of pasta consumers.

Methods

Study population

The NHANES is a series of cross-sectional surveys of noninstitutionalized, civilian US residents conducted to assess the health and nutrition status of the US population. The study population was limited to adult participants ≥19 y of age (n = 10,697) participating in the 2009–2010 and 2011–2012 NHANES with reliable 24-h recall dietary interview data (as defined by USDA staff) and excluded pregnant or lactating women (n = 170). The data from the 2 NHANES cycles were merged to increase the sample size. Complete details of the NHANES study design, implementation, data sets, analytic considerations, and other documentation are available online (9–12). The Research Ethics Review Board at the National Center for Health Statistics approved the NHANES protocol, and all of the participants and proxies provided written informed consent (13). Because this was a secondary data analysis that lacked personal identifiers, additional institutional review was not necessary.

NHANES combines an in-home interview with a physical examination (8). Participants are administered a series of detailed questionnaires at an in-home interview, followed by a visit to a mobile examination center (MEC). There they undergo health examinations and an in-person dietary interview known as the What We Eat in America (WWEIA) (14) component of the NHANES. At the MEC dietary interview, a set of 3-dimensional food models are available for participants to use when reporting amounts of foods (14). A second dietary recall interview is collected by telephone 3–10 d after the MEC interview (14). Demographic data [including age, sex, race/ethnicity, poverty-income ratio (PIR), physical activity, smoking status, and alcohol intake] were collected during the household interview. PIR is a measure that represents the ratio of household income to the poverty threshold after adjustments for geographic location and family size, developed by the Department of Health and Human Services. A PIR value <1.00 indicates that a family is below the official poverty threshold. Physical activity was classified as sedentary, moderate activity, or active on the basis of self-report. Participants who reported "7 days active at least 60 minutes in the past 7 days" or gave a positive response to 2 questions about vigorous recreational or work-related activity were considered active. Moderately active participants reported between 4 and 6 "days active at least 60 minutes in the past 7 days" or gave a positive response to 2 questions on moderate recreational or work-related activity. All other participants were classified as sedentary (15).

WWEIA data are collected by using the USDA's Automated Multiple-Pass Method (16), a fully computerized method for collecting 24-h dietary recalls either in person or by telephone. Each of the food and beverage items reported in WWEIA are categorized by the USDA into 1 of 6 mutually exclusive food categories (i.e., milk and dairy, protein foods, mixed dishes, grains, snacks and sweets, and fruit). This is done by linking each food code contained in the Food and Nutrient Database for Dietary Studies (FNDDS) (17) to 1 WWEIA category. A new version of the FNDDS is produced for each 2-y release cycle of WWEIA (18).

The focus of the food categorization system is on grouping similar foods and beverages together on the basis of usage and nutrient content. This classification scheme includes ~150 unique food subcategories. Each subcategory is assigned a 4-digit number and description and each FNDDS food code is linked to a unique subcategory. Subcategories contain discrete food items with no disaggregation into ingredients (e.g., pizza is reported as pizza instead of its components grain, cheese, and tomatoes) (19).

USDA pasta food categories include cooked grains and grain-based mixed dishes. The specific food subcategories used to define pasta for this analysis were "pasta, noodles, and cooked grains" ("pasta, noodles"; food category 4004), excluding cooked grains (barley, millet, bulgur, etc.) and "pasta mixed dishes, excluding macaroni and cheese" ("pasta mixed dishes"; food category 3204), and "macaroni and cheese"; food category 3206) from mixed dishes (19). Individuals were classified as pasta consumers or nonconsumers on the basis of the first 24-h dietary recall, having consumed "pasta, noodles," "pasta mixed dishes," "macaroni and cheese," or all of these (i.e., pasta consumers). Total daily energy and 6 nutrients of public health concern (saturated fat, dietary fiber, calcium, sodium, potassium, and vitamin D) (1) were determined for all participants. Overall diet quality was assessed by the Healthy Eating Index–2010 (HEI-2010) (20–22), which uses a scoring metric that assesses adherence to the DGA (1). The HEI-2010 is made up of 12 components: 9 of them assess dietary adequacy (total fruit, whole fruit, total vegetables, greens and beans, whole grains, dairy, total protein foods, seafood and plant proteins, and FA ratio), whereas 3 assess dietary components that should be consumed in moderation (refined grains, sodium, and empty calories [energy from solid fats, alcohol, and added sugars (SOFAAS)]). Higher intakes of adequacy components and lower intakes of moderation components indicate better compliance with the DGA (1) and lead to higher scores. The total HEI-2010 (22) is the sum of the component scores and is a measure of overall diet quality; the highest quality score is 100 points, which has been extensively validated (23), and was calculated on an individual participant basis.

Statistical analysis

All of the analyses were adjusted for the complex sample design of NHANES and used appropriate sample weights. Analyses were performed with SAS (version 9.2, 2010; SAS Institute, Inc.) and SUDAAN (version 11.01, 2014; Research Triangle Institute).

Regression analyses of intakes from the first-day dietary recall were conducted to assess differences between pasta consumers and nonconsumers and for the 3 specific food subcategories of pasta ("pasta, noodles," "pasta mixed dishes," and "macaroni and cheese"). Analyses of energy intake, total HEI-2010 scores, and subcomponent scores included covariate adjustments for age, sex, race/ethnicity, PIR, physical activity level, smoking status, and alcohol intake. Energy intake was an additional covariate in analyses of all nutrients.

TABLE 1 Demographic characteristics of adult (aged ≥19 y) pasta consumers and nonconsumers[1]

Variable	Nonconsumers	Consumers
All pasta[2]		
n	9210	1487
Age, y	47.20 ± 0.50	44.86 ± 1.03*
Male sex, %	50.32 ± 0.61	44.05 ± 1.70*
Ethnicity, %		
Hispanic	14.99 ± 1.99	7.90 ± 1.08*
Non-Hispanic white	66.77 ± 2.60	71.41 ± 2.61
Non-Hispanic black	11.43 ± 1.27	12.76 ± 1.80
PIR, %		
≤1.3	24.38 ± 1.32	25.36 ± 1.97
>1.3 to <1.85	10.20 ± 0.55	10.75 ± 1.02
≥1.85	65.41 ± 1.61	63.88 ± 2.32
Physical activity, %		
Sedentary	21.87 ± 0.96	21.43 ± 1.69
Moderate	39.50 ± 0.76	38.64 ± 1.68
Vigorous	38.62 ± 1.35	39.93 ± 2.32
Current smoking, %	20.97 ± 0.93	21.57 ± 1.98
BMI, kg/m^2	28.70 ± 0.11	28.52 ± 0.33
Pasta mixed dishes (excludes macaroni and cheese)		
n	9820	877
Age, y	46.92 ± 0.52	46.20 ± 1.19
Male sex, %	49.87 ± 0.60	44.61 ± 2.28*
Ethnicity, %		
Hispanic	14.42 ± 1.89	9.11 ± 1.48*
Non-Hispanic white	66.78 ± 2.58	74.34 ± 2.85*
Non-Hispanic black	11.72 ± 1.33	10.67 ± 1.49
PIR, %		
≤1.3	24.67 ± 1.24	23.14 ± 2.75
>1.3 to <1.85	10.24 ± 0.57	10.73 ± 1.63
≥1.85	65.09 ± 1.56	66.13 ± 3.25
Physical activity, %		
Sedentary	21.67 ± 0.97	23.18 ± 2.09
Moderate	39.71 ± 0.79	35.99 ± 1.77
Vigorous	38.62 ± 1.44	40.83 ± 2.15
Current smoking, %	21.01 ± 0.88	21.60 ± 3.37
BMI, kg/m^2	28.72 ± 0.12	28.22 ± 0.29
Macaroni and cheese		
n	10,291	406
Age, y	47.09 ± 0.53	40.69 ± 1.31*
Male sex, %	49.73 ± 0.59	40.79 ± 2.40*
Ethnicity, %		
Hispanic	14.22 ± 1.88	7.00 ± 1.41*
Non-Hispanic white	67.46 ± 2.54	67.10 ± 4.50
Non-Hispanic black	11.22 ± 1.25	22.00 ± 4.25*
PIR, %		
≤1.3	24.14 ± 1.27	34.22 ± 4.38*
>1.3 to <1.85	10.21 ± 0.53	12.17 ± 2.17
≥1.85	65.65 ± 1.59	53.62 ± 5.49*
Physical activity, %		
Sedentary	22.01 ± 0.98	16.52 ± 2.53*
Moderate	39.30 ± 0.74	41.38 ± 3.96
Vigorous	38.69 ± 1.34	42.10 ± 5.10
Current smoking, %	20.81 ± 0.89	27.45 ± 3.34
BMI, kg/m^2	28.64 ± 0.12	29.46 ± 0.45
Pasta, noodles, and cooked grains (except for nonpasta grains)		
n	10,465	232
Age, y	46.89 ± 0.53	45.49 ± 1.45
Male sex, %	49.50 ± 0.62	45.22 ± 3.84
Ethnicity, %		
Hispanic	14.19 ± 1.85	4.21 ± 1.14*
Non-Hispanic white	67.43 ± 2.58	68.15 ± 3.90
Non-Hispanic black	11.76 ± 1.33	6.15 ± 1.35*

(Continued)

TABLE 1 (*Continued*)

Variable	Nonconsumers	Consumers
PIR, %		
≤1.3	24.64 ± 1.33	20.16 ± 3.49
>1.3 to <1.85	10.32 ± 0.56	8.71 ± 2.39
≥1.85	65.04 ± 1.64	71.13 ± 4.09
Physical activity, %		
Sedentary	21.80 ± 0.94	22.29 ± 4.83
Moderate	39.27 ± 0.74	43.79 ± 4.34
Vigorous	38.93 ± 1.36	33.92 ± 5.23
Smoking current, %	21.27 ± 0.84	12.31 ± 2.79*
BMI, kg/m^2	28.68 ± 0.11	28.29 ± 1.13

[1] Values are means ± SEs unless otherwise indicated; n = 10,697. Data are from NHANES 2009–2012. *$P < 0.05$ as determined by regression analyses comparing consumers and nonconsumers. PIR, poverty-income ratio.
[2] "All pasta" includes all 3 types of pasta.

In addition, SAS Proc Cluster was used to categorize dietary patterns of pasta consumers on the basis of food group intakes as defined by the USDA Food Patterns Equivalent Database (24). Food group intakes were standardized to z scores before cluster analyses. Nonconsumers were classified as cluster 0. The identified food group intakes associated with clusters were deemed

TABLE 2 Energy and selected nutrient intakes associated with pasta consumption[1]

Variable	Nonconsumers	Consumers
All pasta		
n	9210	1487
Energy, kcal	2144 ± 12	2314 ± 37*
Total SFAs, g	26.1 ± 0.3	27.4 ± 0.7
Sodium, mg	3583 ± 22	3738 ± 67
Dietary fiber, g	17.3 ± 0.2	19.2 ± 0.3*
Calcium, mg	1004 ± 9	1013 ± 25
Potassium, mg	2777 ± 18	2826 ± 68
Vitamin D (D_2 + D_3), μg	4.9 ± 0.1	4.7 ± 0.2
Pasta mixed dishes (excludes macaroni and cheese)		
n	9820	877
Energy, kcal	2154 ± 11	2323 ± 42*
Total SFAs, g	26.3 ± 0.3	26.7 ± 0.8
Sodium, mg	3589 ± 19	3775 ± 58*
Dietary fiber, g	17.3 ± 0.2	19.7 ± 0.4*
Calcium, mg	1005 ± 8	1009 ± 29
Potassium, mg	2771 ± 18	2920 ± 65*
Vitamin D (D_2 + D_3), μg	5.0 ± 0.1	4.3 ± 0.2*
Macaroni and cheese		
n	10,291	406
Energy, kcal	2159 ± 12	2426 ± 54*
Total SFAs, g	26.1 ± 0.3	31.6 ± 1.1*
Sodium, mg	3600 ± 17	3748 ± 117
Dietary fiber, g	17.6 ± 0.2	17.4 ± 0.6
Calcium, mg	1002 ± 8	1077 ± 45
Potassium, mg	2789 ± 19	2654 ± 118
Vitamin D (D_2 + D_3), μg	4.9 ± 0.1	5.7 ± 0.4
Pasta, noodles, and cooked grains (excluding cooked grains)		
n	10,465	232
Energy, kcal	2170 ± 11	2134 ± 70
Total SFAs, g	26.4 ± 0.3	24.2 ± 1.4
Sodium, mg	3604 ± 16	3663 ± 138
Dietary fiber, g	17.5 ± 0.2	19.8 ± 0.9*
Calcium, mg	1007 ± 7	933 ± 50
Potassium, mg	2785 ± 19	2726 ± 98
Vitamin D (D_2 + D_3), μg	4.9 ± 0.1	4.6 ± 0.5

[1] Values are least-square means ± SEs unless otherwise indicated; n = 10,697 adults aged ≥19 y. Data are from NHANES 2009–2012. *$P < 0.05$ as determined by regression analyses comparing consumers and nonconsumers adjusted for age, sex, race/ethnicity, poverty-income ratio, physical activity level, current smoking status, and alcohol analyses; analyses of nutrients also adjusted for energy intake.

TABLE 3 HEI-2010 scores associated with pasta consumption[1]

Variable	Nonconsumers	Consumers
All pasta		
n	9210	1487
HEI-2010		
Total score	50.96 ± 0.34	49.90 ± 0.63
Component 1 (total vegetables)	3.06 ± 0.03	3.07 ± 0.05
Component 2 (greens and beans)	1.32 ± 0.03	1.21 ± 0.08
Component 3 (total fruit)	2.19 ± 0.04	2.11 ± 0.09
Component 4 (whole fruit)	2.14 ± 0.04	2.09 ± 0.12
Component 5 (whole grains)	2.68 ± 0.07	2.38 ± 0.13*
Component 6 (dairy)	5.20 ± 0.06	5.24 ± 0.15
Component 7 (total protein foods)	4.27 ± 0.02	3.81 ± 0.06*
Component 8 (seafood and plant protein)	2.10 ± 0.04	1.95 ± 0.08
Component 9 (FA ratio)	5.16 ± 0.07	5.10 ± 0.12
Component 10 (sodium)	4.19 ± 0.06	4.52 ± 0.12*
Component 11 (refined grains)	6.35 ± 0.06	5.16 ± 0.14*
Component 12 (SOFAAS calories)	12.32 ± 0.15	13.26 ± 0.28*
Pasta mixed dishes (excludes macaroni and cheese)		
n	9820	877
HEI-2010		
Total score	50.89 ± 0.34	49.91 ± 0.83
Component 1 (total vegetables)	3.03 ± 0.03	3.33 ± 0.07*
Component 2 (greens and beans)	1.32 ± 0.04	1.10 ± 0.09*
Component 3 (total fruit)	2.18 ± 0.04	2.16 ± 0.10
Component 4 (whole fruit)	2.14 ± 0.04	2.04 ± 0.14
Component 5 (whole grains)	2.67 ± 0.07	2.32 ± 0.15*
Component 6 (dairy)	5.20 ± 0.06	5.24 ± 0.20
Component 7 (total protein foods)	4.26 ± 0.02	3.61 ± 0.08*
Component 8 (seafood and plant protein)	2.11 ± 0.04	1.79 ± 0.10*
Component 9 (FA ratio)	5.14 ± 0.07	5.20 ± 0.18
Component 10 (sodium)	4.22 ± 0.06	4.38 ± 0.16
Component 11 (refined grains)	6.30 ± 0.07	4.86 ± 0.16*
Component 12 (SOFAAS calories)	12.32 ± 0.16	13.89 ± 0.33*
Macaroni and cheese		
n	10,291	406
HEI-2010		
Total score	50.95 ± 0.33	46.93 ± 0.99*
Component 1 (total vegetables)	3.08 ± 0.03	2.37 ± 0.12*
Component 2 (greens and beans)	1.30 ± 0.04	1.27 ± 0.13
Component 3 (total fruit)	2.19 ± 0.04	1.81 ± 0.13*
Component 4 (whole fruit)	2.14 ± 0.04	1.91 ± 0.14
Component 5 (whole grains)	2.66 ± 0.07	2.02 ± 0.19*
Component 6 (dairy)	5.18 ± 0.06	5.80 ± 0.25*
Component 7 (total protein foods)	4.21 ± 0.02	4.01 ± 0.10
Component 8 (seafood and plant protein)	2.08 ± 0.04	2.12 ± 0.10
Component 9 (FA ratio)	5.17 ± 0.07	4.52 ± 0.20*
Component 10 (sodium)	4.20 ± 0.06	5.18 ± 0.25*
Component 11 (refined grains)	6.20 ± 0.06	5.54 ± 0.23*
Component 12 (SOFAAS calories)	12.54 ± 0.15	10.39 ± 0.43*
Pasta, noodles, and cooked grains (excluding cooked grains)		
n	10,465	232
HEI-2010		
Total score	50.74 ± 0.33	53.58 ± 1.37*
Component 1 (total vegetables)	3.06 ± 0.03	3.11 ± 0.11
Component 2 (greens and beans)	1.29 ± 0.04	1.60 ± 0.33
Component 3 (total fruit)	2.18 ± 0.04	2.28 ± 0.22
Component 4 (whole fruit)	2.12 ± 0.04	2.43 ± 0.29
Component 5 (whole grains)	2.63 ± 0.07	3.03 ± 0.38
Component 6 (dairy)	5.22 ± 0.05	4.32 ± 0.29*
Component 7 (total protein foods)	4.20 ± 0.02	4.24 ± 0.10
Component 8 (seafood and plant protein)	2.07 ± 0.04	2.35 ± 0.20
Component 9 (FA ratio)	5.14 ± 0.06	5.67 ± 0.32

(Continued)

TABLE 3 (*Continued*)

Variable	Nonconsumers	Consumers
Component 10 (sodium)	4.25 ± 0.05	3.92 ± 0.27
Component 11 (refined grains)	6.19 ± 0.06	5.51 ± 0.26*
Component 12 (SOFAAS calories)	12.39 ± 0.15	15.14 ± 0.57*

[1] Values are least-square means ± SEs unless otherwise indicated; *n* = 10,697 adults ≥19 y. Data are from NHANES 2009–2012. *$P < 0.05$ as determined by regression analyses comparing consumers and nonconsumers adjusted for age, sex, race/ethnicity, poverty-income ratio, physical activity level, current smoking status, and alcohol intake. HEI-2010, Healthy Eating Index–2010; SOFAAS, solid fats, alcohol, and added sugars.

meaningful if individual food group categories were ≥40% different from those of nonconsumers (which was approximately twice the average difference of a key food group, i.e., fruit intake). HEI-2010 scores by cluster groups were compared by using regression analyses and *t* tests. For all analyses, $P < 0.05$ was considered significant.

Results

A total of 1487 (14.7%) adults consumed pasta on the day 1 recall. Overall, pasta consumers were more likely to be female and younger and less likely to be Hispanic (**Table 1**). Consumers of "pasta mixed dishes" (*n* = 877; 8.9%) were more likely to be female and non-Hispanic white and less likely to be Hispanic than nonconsumers, whereas consumers of "macaroni and cheese" (*n* = 406; 3.7%) were more likely to be female, younger, non-Hispanic black, and have an income ≤1.3 PIR and less likely to be Hispanic and sedentary compared with nonconsumers (Table 1). Those who consumed "pasta, noodles" (*n* = 232; 2.4%), were less likely to be Hispanic, non-Hispanic black, or current smokers (Table 1).

In fully adjusted models, energy intake was higher (difference ± SE: 170 ± 41 kcal/d) in pasta consumers than in nonconsumers (**Table 2**) and was also higher in consumers of "pasta mixed dishes" (169 ± 44 kcal/d) and "macaroni and cheese" (267 ± 56 kcal/d) but not "pasta, noodles" than in nonconsumers. Total SFAs were only higher (5.5 ± 1.1 g/d) in consumers of "macaroni and cheese" compared with nonconsumers. Mean dietary fiber intake was higher (1.9 ± 0.3 g/d) among all pasta consumers than in nonconsumers. Similarly, those who consumed "pasta mixed dishes" (2.3 ± 0.4 g/d) and those who ate "pasta, noodles" (2.3 ± 0.9 g/d) had higher fiber intakes than nonconsumers of these pasta groups. Relatively few differences in intakes of calcium, potassium, sodium, and vitamin D were observed regardless of pasta consumption group. However, mean potassium and sodium intakes were significantly higher (149 ± 60 and 187 ± 69 mg/d, respectively) and vitamin D intake was significantly lower (−0.7 ± 0.2 μg/d) in consumers of "pasta mixed dishes" compared with nonconsumers.

Overall, there was no significant difference in diet quality (HEI-2010 scores: 49.9 ± 0.6 compared with 51.0 ± 0.3) between pasta consumers and nonconsumers (**Table 3**). No overall differences in HEI-2010 scores (49.9 ± 0.8 compared with 50.9 ± 0.3) were seen in the "pasta mixed dishes" pasta group compared with nonconsumers. Consumers of "macaroni and cheese" had a significantly lower mean HEI-2010 score (46.9 ± 1.0 compared with 51.0 ± 0.3) compared with nonconsumers, which was mainly driven by differences in women (47.9 ± 0.3 compared with 52.3 ± 0.4; $P = 0.001$). Consumers of "pasta, noodles" had a higher total mean HEI-2010 score (53.6 ± 0.3 compared with 50.7 ± 1.4) than did nonconsumers. The HEI subcomponents that accounted for the lower HEI-2010 total score in "macaroni and cheese" consumers were SOFAAS calories (−2.1 points), total vegetables (−0.7 points), refined grains (−0.7 points), whole grains (−0.7 points), FA ratio (−0.7 points), and total fruit (−0.4 points), which were partially offset by improvements in sodium (+1.0 point) and dairy (+0.6 points) subcomponents. The HEI subcomponent that accounted for the higher HEI-2010 total score in "pasta, noodles" consumers was SOFAAS calories (+2.8 points), which was partially offset by lower scores for dairy (−0.9 points) and refined-grain (−0.7 points) subcomponents.

Dietary patterns identified 3 distinct pasta consumption groups (**Table 4**). By using differences of ≥40% of that of nonconsumers (cluster 0), cluster 1 (*n* = 811) represented ~8% of the total

TABLE 4 Food group intake associated with cluster analyses of pasta consumers[1]

			Food group intakes								
Cluster	*n*	Pop. pct.	Fruit, cup eq	Vegetables, cup eq	Meat, oz eq	Poultry, oz eq	Fish, oz eq	Other protein, oz eq	Dairy, cup eq	Refined grain, oz eq	Whole grain, oz eq
0	9210	85.30	1.02	1.60	1.72	1.51	0.68	2.46	1.67	5.59	0.92
1	811	8.02	0.53[2]	1.69	2.38	1.53	0.20[2]	1.97	1.89	7.97	0.38[2]
2	419	4.12	1.68[3]	1.21	0.79[2]	0.71[2]	0.25[2]	1.03[2]	1.11	5.00	0.85
3	257	2.55	1.48[3]	2.36[3]	0.73[2]	1.20	1.90[3]	4.15[3]	2.40[3]	6.48	2.27[3]

[1] *n* = 10,697 adults aged ≥19 y. Data are from NHANES 2009–2012. Cluster analysis was performed among pasta consumers (nonconsumers were defined as cluster 0); clusters were developed with standardized *z* scores of food group intakes. cup eq, cup equivalents; oz eq, ounce equivalents; Pop. pct., population percentage (sample weighted population percentage of adults in each cluster).
[2] ≥40% lower than cluster 0 group (nonconsumers).
[3] ≥40% higher than cluster 0 group (nonconsumers).

TABLE 5 HEI-2010 scores associated with clusters[1]

HEI-2010	Cluster 0	Cluster 1	Cluster 2	Cluster 3
Total score	50.99 ± 0.31[a]	43.80 ± 0.58[b]	53.83 ± 0.90[c]	61.60 ± 1.04[d]
Component 1 (total vegetables)	3.06 ± 0.03	2.96 ± 0.08	3.12 ± 0.11	3.21 ± 0.13
Component 2 (greens and beans)	1.32 ± 0.03[a,c]	1.06 ± 0.09[b]	1.05 ± 0.12[b]	1.81 ± 0.26[c]
Component 3 (total fruit)	2.20 ± 0.03[a]	1.28 ± 0.09[b]	3.33 ± 0.12[c]	2.55 ± 0.18[d]
Component 4 (whole fruit)	2.15 ± 0.04[a]	1.38 ± 0.10[b]	2.96 ± 0.23[c]	2.67 ± 0.23[c]
Component 5 (whole grains)	2.68 ± 0.08[a]	1.10 ± 0.10[b]	3.42 ± 0.25[c]	4.84 ± 0.30[d]
Component 6 (dairy)	5.19 ± 0.07	5.31 ± 0.18	5.04 ± 0.21	5.58 ± 0.33
Component 7 (total protein foods)	4.27 ± 0.02[a]	3.97 ± 0.08[b]	3.15 ± 0.15[c]	4.24 ± 0.09[a]
Component 8 (seafood and plant protein)	2.10 ± 0.04[a]	1.49 ± 0.08[b]	1.70 ± 0.15[c]	3.81 ± 0.15[d]
Component 9 (FA ratio)	5.16 ± 0.07[a]	4.66 ± 0.13[b]	5.17 ± 0.30[a,b]	6.24 ± 0.27[c]
Component 10 (sodium)	4.19 ± 0.06[a]	4.22 ± 0.14[a]	5.00 ± 0.30[b]	4.63 ± 0.26[a,b]
Component 11 (refined grains)	6.33 ± 0.07[a]	4.74 ± 0.20[b]	4.88 ± 0.22[c]	7.31 ± 0.29[d]
Component 12 (SOFAAS calories)	12.35 ± 0.15[a]	11.62 ± 0.35[a]	15.01 ± 0.45[b]	14.71 ± 0.32[b]

[1] Values are means ± SEs; n = 10,697 adults aged ≥19 y. Data are from NHANES 2009–2012. Cluster analysis was performed among pasta consumers (nonconsumers were defined as cluster 0); clusters were developed with standardized z scores of food group intakes. Means without a common superscript letter differ, $P < 0.05$ (from regression analyses comparing clusters). HEI-2010, Healthy Eating Index–2010; SOFAAS, solid fat, alcohol, and added sugars.

population and can be described as having lower intakes of fruit, fish, and whole grains and higher intakes of refined grains than pasta nonconsumers. Cluster 2 (n = 419) represented ~4% of the total population and can be described as having higher intakes of fruit and other (nonanimal) protein and lower intakes of meat, poultry, and fish, whereas cluster 3 (n = 257) represented ~2.5% of the total population and can be described as having higher intakes of fruit, vegetables, fish, and other (nonanimal) protein and less meat than pasta nonconsumers. The total HEI-2010 score was higher in cluster 2 and cluster 3 (2.8 and 10.6 points, respectively) than in nonconsumers (**Table 5**). Cluster 1 HEI-2010 scores were lower (−7.2 points) than in nonconsumers.

Discussion

This is one of the few epidemiologic studies, to our knowledge, that are national in scope that investigated the association between types and patterns of pasta consumption with nutrient intakes and diet quality. Our findings suggest that when considering all types of pasta (i.e., grouped together), consumption was not associated with diet quality. However, specific types of pasta were associated with changes in HEI-2010 score. The consumption of "pasta, noodles" was associated with a slightly improved diet quality, whereas the consumption of "macaroni and cheese" was associated with lower diet quality. Only "pasta, noodles" was not associated with higher daily calories, whereas "pasta mixed dishes" and "pasta, noodles" were associated with increased dietary fiber intake. "Pasta mixed dishes" was also associated with higher intakes of potassium and sodium. Cluster analyses showed that, among pasta consumers, there can be quite divergent dietary patterns. In this study, cluster 1 had the lowest HEI-2010 score (−7.2 points compared with nonconsumers), whereas cluster 3 had the highest HEI-2010 score (10.6 points higher than nonconsumers); thus, the difference between these 2 patterns was almost 18 points and cluster 3 showed an improvement of ~40% compared with cluster 1 HEI-2010 scores. The cluster 3 pattern, with more fruit, vegetables, fish, and whole grains and less meat, is very similar to the Healthy Mediterranean Style and the Dietary Approaches to Stop Hypertension (DASH) eating pattern as described in the 2015–2020 DGA (1); and as such, these improvements in diet quality makes sense. Unfortunately, only ~2.5% of the adult population consumed the cluster 3–type pattern. A concerted effort from health professionals and food manufacturers to help consumers better combine healthier foods and food forms with their favorite pasta dishes is needed. Simultaneously, given that almost 8% of the adult population consumes pasta in ways that are associated with a reduction in diet quality, efforts should be undertaken to find ways to educate consumers that there are better ways to enjoy pasta (like that in cluster 3). Consideration should also be given to develop "macaroni and cheese" recipes that are more consistent with current dietary recommendations, especially by reducing saturated fat. In addition, the development of lower sodium versions of "pasta mixed dishes," while retaining sources of potassium, would also be helpful.

This study has limitations inherent in all observational research. Data for energy and nutrient intakes, including food group intakes used to determine diet quality, were obtained by using 24-h dietary recalls, which rely on self-report and may not always represent typical intake. Because we used the first day of dietary recalls, our results indicate what may occur on any given day. Although validated procedures were used to collect the data, recalled information may have inaccuracies and biases from misreporting, memory lapses, and other potential measurement errors that occur in epidemiologic research involving large data sets (25). In addition, because the current evidence is observational, a causal link between intake of pasta and improvements in diet quality and nutrient intakes cannot be established. We were also not able to analyze whether there were differences due to whole-grain compared with non–whole-grain pasta due to very limited reports of whole-grain pasta consumption. Numerous covariates were used to adjust the data in an attempt to remove potential confounding, but there could still be residual confounding. Cluster analysis also has some disadvantages, because it groups individuals who may identify with multiple dietary patterns (26).

Nevertheless, the results from this large, nationally representative study suggest that the type of pasta consumed and other foods consumed with pasta can affect diet quality and intakes of key nutrients of public health concern. The consumption of pastas and noodles was associated with a small increase in diet quality and fiber intake, whereas the consumption of "macaroni and cheese" was associated with a lower diet quality and higher saturated fat intake. Cluster analyses indicated that there are quite divergent dietary patterns among American pasta consumers and one pattern, closely aligned with the Healthy Mediterranean Style eating pattern, can lead to large improvements in diet quality. This work highlights the need to meaningfully separate major food groups and subgroups before making associations with diet quality and nutrient intakes.

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