Association between milk and dairy product intake and the risk of dental caries in children and adolescents: NHANES 2011-2016

doi: 10.6133/apjcn.202104/PP.0001
Published online: April 2021

Running title: Different types of dairy intake and caries

Jingjing Wang MD, Genquan Jin MD, Kunfang Gu MD, Jing Sun MD, Ronghui Zhang MD, Xiubo Jiang MD

Department of Epidemiology and Health Statistics, the School of Public Health of Qingdao University, Qingdao, Shandong Province, China

Authors' email addresses and contributions:
Jingjing Wang: wjjcn92@126.com
Genquan Jin: 2558500583@qq.com
Kunfang Gu: 2458449172@qq.com
Jing Sun: sunjing1011@163.com
Ronghui Zhang: ZhangRH9634@163.com
Xiubo Jiang: jiangxiubo2005@126.com

J.W: Conceptualization. K.G and G.J: Methodology. J.W, J.S and R.Z: Data curation. J.W: Writing-Original draft preparation. X.J: Writing-Reviewing and Editing. All authors provided critical revisions of the manuscript and approved the final manuscript.

Corresponding Author: Prof Xiubo Jiang, Department of Epidemiology and Health Statistics, the School of Public Health of Qingdao University, 308 Ningxia Road, 266071, Qingdao, Shandong Province, China. Tel: +8653282991712. Fax: +8653283801449. Email: jiangxiubo2005@126.com; jiangxiubo@qdu.edu.cn

ABSTRACT

Background and Objectives: To date, few studies have comprehensively explored the association between milk and dairy product intake and dental caries. Therefore, this study aimed to simultaneously assess the associations between whole milk, low-fat milk, skim milk, yogurt, milk desserts, cheese, creams, and total fluid milk intake and the risk of dental caries in children and adolescents. **Methods and Study Design:** Data were from the National Health and Nutrition Examination Survey (NHANES) 2011-2016. Two 24-hour dietary recall interviews measured dietary milk and dairy product intake. Primary teeth caries was diagnosed by the dfs (decayed or filled primary tooth surfaces) index, and permanent teeth caries was diagnosed by the DMFS (decayed, missing, or filled permanent tooth surfaces) index. We used logistic regression to explore the associations between milk and dairy product intake and the risk of dental caries. **Results:** A total of 6885 individuals aged 2-17 years were included in this study. In the fully adjusted model, the odds ratios (95% confidence intervals) of dental caries were 0.66 (0.47-0.93) for intake ≥ 122.50 g/day of yogurt and 0.82 (0.69-0.98) for intake < 22.58 g/day of cheese, as compared with non-consumers. **Conclusions:** Our study indicates that high yogurt and low cheese intake is associated with a decreased risk of dental caries among American children and adolescents. These findings may be applied to update and supplement the evidence that informs public health policies on milk and dairy products and the prevention of dental caries.

Key Words: dental caries, yogurt, cheese, children, adolescents

INTRODUCTION

Oral health is a key indicator of well-being, overall health and quality of life. Data from the Global Burden of Disease Study 2017 indicated that oral diseases affected 3.47 billion people worldwide, with untreated caries being among the most prevalent non-communicable diseases assessed. It is estimated that across the world, 2.3 billion people suffer from dental caries in permanent teeth and 532 million children suffer from dental caries in primary teeth.[1] Dental caries is a heavy financial burden to individuals, families and societies.[2] The global economic burden of dental diseases reached USD 544.41 billion in 2015, and untreated caries contributed to 12% of global productivity losses.[3] Further, dental caries also has adverse effects on children's and adolescents' physical and psychological health and learning ability (e.g., toothache, difficulty eating and difficulty sleeping).[4-6]

As teeth are in contact with various foods every day, the types and properties of foods play a vital role in the development and occurrence of dental caries. Milk and dairy products are rich in nutrients, including minerals (i.e., calcium, phosphorus), proteins (i.e., casein, whey protein) and lipids (i.e., essential and nonessential fatty acids).[7,8] *In vitro* studies have demonstrated that calcium, phosphorus, and casein in milk play a role in inhibiting the formation of dental caries.[9,10] Studies have also found that casein phosphopeptides in the salivary pellicle inhibit bacterial attachment to the tooth.[11] Moreover, casein phosphopeptides extracted from yogurt and cheese may also inhibit dental enamel demineralization and promote the remineralization of tooth enamel.[12,13]

There is limited research on the associations between different types of milk and dairy products and dental caries.[14-18] Previous studies of Italian schoolchildren aged 6-11 years[14] and African American children aged 3-5 years suggested that milk intake was negatively associated with dental caries.[15] In Sweden, frequent cheese intake had a caries-protective effect in four-year-old children.[16] A cross-sectional study of three-year-old Japanese found that high yogurt intake was associated with a lower prevalence of dental caries.[17] Further, in a prospective study of the Danish population, frequent intake of milk and dairy products was associated with the development of fewer dental caries.[18]

Thus, we used data from the National Health and Nutrition Examination Survey (NHANES) 2011-2016 to assess the associations between milk (i.e., whole milk, low-fat milk, skim milk and total fluid milk) and dairy products (i.e., yogurt, cheese, creams and milk desserts) and the risk of dental caries in American children and adolescents (aged 2-17 years). The findings of this study may be applied to update and supplement the evidence that informs public health policies on milk and dairy products and the prevention of dental caries.

MATERIALS AND METHODS

Data source and study sample

NHANES is conducted by the National Center for Health Statistics (NCHS). Data are collected in two-year cycles using a multistage probabilistic sampling design to select a stratified random sample that is representative of the civilian non-institutionalized United States (U.S.) population. The survey's purpose is to evaluate the health and nutritional status of American children and adults.

This study used data from NHANES 2011-2012, 2013-2014, 2015-2016, which included a total of 29,902 individuals; of these, 9,956 were children and adolescents (aged 2-17 years). We excluded individuals with unreliable 24-hour recall data (n=2974) and no dental

examination (n=97). Thus, data from 6,885 children and adolescents were included in this study (Figure 1).

Dental caries

During the NHANES dental caries assessment, dental examiners used a surface reflecting mirror and No. 23 explorer to assess the surface condition of participants' (aged > 1 year) teeth. The third molars and wisdom teeth were omitted from the exam. According to the NHANES examination protocol, all dental examiners received professional training and displayed a high level of reliability and data quality in tooth count and dentition.[19] The key outcome variable for the primary dentition (2 to 8 years old) was the presence or absence of coronal dental caries (yes/no) by dfs (decayed or filled primary tooth surfaces) index. The key outcome variable for the permanent dentition (6 to 17 years old) was the presence or absence of coronal dental caries (yes/no) by DMFS (decayed, missing, or filled permanent tooth surfaces) index.[20]

Dietary milk and milk product intake

Two 24-hour dietary recall interviews measured dietary milk and dairy product intake. The first interview was conducted in-person in the Mobile Examination Center (MEC), and the second interview was conducted by telephone 3-10 days later. Dietary and nutrient intakes were coded and calculated by the U.S. Department of Agriculture (USDA) and the Food and Nutrient Database for Dietary Studies (FNDDS) (http://www.ars.usda.gov/ba/bhnrc/fsrg). According to the food codes provided by USDA, milk and dairy products include whole milk, low-fat milk, skim milk, yogurt, milk desserts, cheese, creams, and total fluid milk. Since most participants did not consume any single type of milk or dairy products, we used the non-consumers (intake =0) as a reference group (group 1). Then the consumers (intake >0) were segmented into group 2 (intake <50th percentile), and group 3 (intake ≥50th percentile). Finally, we divided the dietary intake of whole milk, low-fat milk, skim milk, yogurt, milk desserts, cheese, creams, and total fluid milk into three groups (group 1: =0, group 2: <50th percentile, group 3: ≥50th percentile).

Covariates

Trained NHANES investigators obtained demographic information from an adult that resided in the household of the sampled children/adolescents. These data included age (2-5, 6-11, 12-17 years old),[21] gender (men, women), race/ethnicity (Mexican American, Other Hispanic,

Non-Hispanic White, Non-Hispanic Black, and Other Race), educational level of the head of household (less than high school, high school graduate, some college or AA degree, college graduate or higher), period since last dental visit (<1 years, 1-2 years, >2 years ago or never),[20] annual household income (<$20,000, ≥$20,000) and total daily energy intake (continuous).

Statistical analysis

Analyses were performed by using Stata 12.0 (Stata Corporation, College Station, TX, USA) and weighted to obtain representative estimates. We used the Kolmogorov-Smirnov normality test to assess the normality of continuous variables. Normal distributions were described using means (standard deviations), and non-normal distributions were described using medians (quartile ranges). We used the Mann-Whitney U test to compare averages of non-normal continuous variables, and the chi-square test to compare the percentages of categorical variables, between the caries and non-caries groups. We used a binary logistic regression model to evaluate the association between whole milk, low-fat milk, skim milk, yogurt, milk desserts, cheese, creams, total fluid milk, and dental caries. Model 1 was adjusted for age and gender, and Model 2 was further adjusted for race/ethnicity, educational level of the head of household, period since last dental visit, annual household income, and total daily energy intake. Lastly, we performed stratified analyses to determine whether the association between milk and dairy product intake and the risk of dental caries differed by age and gender. Additionally, we performed a linear trend test by entering the median of each milk and dairy product intake group as a continuous variable in model 2.[22] We considered p value <0.05 to be statistically significant (two-sided).

RESULTS

Table 1 displays the baseline characteristics of participants by dental caries. A total of 6885 participants were included in this study. The overall prevalence of dental caries was 48.24%, among which the prevalence of dental caries in men was 48.33% and was 48.14% in women. The prevalence of dental caries in children and adolescents aged 2-5, 6-11, and 12-17 years were 24.22%, 56.22%, 56.82%, respectively. Compared with participants without dental caries, participants with dental caries tended to be older, have greater energy intake, and have a lower educational level and a lower income of the head of household. The percentage of dental caries in Mexican Americans was higher than that in other races. Recent dental visits were associated with more caries.

Table 2 presents the weighted odds ratios (ORs) and 95% confidence intervals (CIs) of the associations between the intake of milk and dairy products and dental caries. According to binary logistic regression analyses, high yogurt intake (≥122.50 g/day) and low cheese intake (<22.58 g/day) were significantly associated with decreased risk of dental caries, as compared with the reference group (intake =0); the ORs (95% CIs) were 0.49 (0.36-0.66) and 0.78 (0.65-0.94), respectively. These associations remained after adjusting for age and gender (Model 1). After further adjusting for race/ethnicity, educational level of the head of household, period since last dental visit, annual household income and total daily energy intake (Model 2), the OR (95% CI) of dental caries for high yogurt intake was 0.66 (0.47-0.93), and for low cheese intake was 0.82 (0.69-0.98). There were no statistically significant associations between the intake of whole milk, low-fat milk, skim milk, milk desserts, and total fluid milk and the risk of dental caries in any of the models (i.e., crude, model 1, and model 2).

The associations between milk and dairy product intake and the risk of dental caries in gender-stratified analyses are shown in Table 3. Among men, higher yogurt intake was associated with reduced risk of dental caries in the crude model (OR=0.49, 95% CI=0.33-0.73) and model 1 (OR=0.60, 95% CI=0.39-0.92). There were no statistically significant differences between the intake of other milk and dairy products and dental caries. Among women, high yogurt and low cheese intake were inversely associated with dental caries in the crude model, model 1 and model 2. There were no statistically significant associations between the intake of whole milk, low-fat milk, skim milk, milk desserts, and total fluid milk and the risk of dental caries.

The association between milk and dairy product intake and the risk of dental caries in age-stratified analyses are shown in Table 4. Analyses of participants aged 2-5 (n=1763) showed no statistically significant associations between the intake of milk and milk products and dental caries after adjusting for gender, race/ethnicity, educational level of the head of household, period since last dental visit, annual household income, and total daily energy intake. In children aged 6-11 (n=2718), a negative association was found between high yogurt intake and dental caries after adjusting for relevant covariates. Finally, among participants aged 12-17 (n=2404), low intake of skim milk, high intake of yogurt, and low intake of total fluid milk were associated with decreased risk of dental caries, after adjusting for relevant covariates; the ORs (95% CIs) were 0.43 (0.19-1.00), 0.50 (0.28-0.88), and 0.74 (0.55-0.98), respectively.

DISCUSSION

In this study, we explored the associations between whole milk, low-fat milk, skim milk, yogurt, cheese, milk desserts, creams, and total fluid milk dietary intake and the risk of dental caries among a nationally representative sample of American children and adolescents (2-17 years old). We found that high yogurt intake (≥50th percentile) and low cheese intake (<50th percentile) were significantly associated with decreased risk of dental caries. These associations remained stable after adjusting for potential confounders.

Dental caries is the most common health disease, and a serious public health problem in the US. We found that the prevalence of dental caries among American children and adolescents was 48.24% and that there was no statistically significant difference between men and women. However, the prevalence of dental caries among children aged 2-5 years was far lower than participants aged 6-17 years. The reason may be that dental caries, as a multifactorial chronic cumulative disease, requires time to become clinically evident.[23] Moreover, as children age, their dietary habits, hygiene practices and oral microbiome change.[24-27]

Our findings pertaining to milk and dairy product intake are consistent with some studies. A prospective study of Danish children and adolescents found that a high intake of milk and dairy products was associated with the development of fewer dental caries in the future.[18] Wu et al. found that drinking yogurt was a protective factor for dental caries among Chinese children aged 7-12 years.[28] In contrast to previous studies, we did not find an association between yogurt intake and dental caries among children aged 2-5 years, nor between cheese intake and dental caries in any age group. Tanaka K et al found that high consumption of yogurt may reduce the prevalence of dental caries among Japanese children aged 3 years,[17] and Petti S et al. also reported the presence of this negative association among Italian children aged 3 to 5 years.[29] Further, Ohlund et al reported a negative relation between cheese intake and dental caries in Swedish children aged 4 years,[16] and Llena et al found this negative association among Spanish children aged 6-10 years.[30]

Dental caries causes the breakdown of dental hard tissue through acids that are generated by the bacterial fermentation of dietary carbohydrates. However, the mechanisms that underlie the association between high yogurt and low cheese intake and decreased risk of dental caries are unclear. Yogurt and cheese are nutrient-rich and are produced by the fermentation of milk. The casein phosphopeptides extracted from yogurt and cheese might play a critical role in caries prevention by preventing demineralization and enhancing remineralization of enamel caries.[12,13,31] Moreover, epidemiologic studies have reported that people with higher levels of calcium and phosphate in plaques have a correspondingly lower

risk of caries.[32-34] Ravishankar et al. found that the ingestion of cheese and yogurt without added sugar can increase the concentration of calcium and phosphorus in dental plaque and the plaque pH.[35] Furthermore, cheese can stimulate salivary flow and rapidly return plaque pH toward neutrality.[34]

This study had several strengths. First, according to the food codes provided by the USDA, we performed a detailed classification of milk and milk products, to further understand the contribution of different types of milk and dairy products to the occurrence and development of dental caries. Second, we conducted stratified analyses based on age and gender to explore the association between milk and milk product intake and dental caries in three age groups and by gender. Third, to control for potential confounders, we adjusted analyses for demographic factors, educational level of head of the household, period since last dental visit, annual household income, and total daily energy intake.

This study also has several limitations. First, since we measured average milk and milk product intake with two 24-hour dietary recalls, the accuracy of the data depended on the memory of participants or proxies, which was susceptible to recall bias. Second, although we adjusted for several potential confounders, we could not control for unmeasured confounding. Third, since this is a cross-sectional study, it is difficult to determine causality.

Conclusion

Our study indicates that high yogurt intake and low cheese intake are associated with a lower risk of dental caries among American children and adolescents. Additionally, we found that high yogurt intake and low cheese intake were inversely associated with dental caries among women only. High yogurt intake was also negatively associated with dental caries among children aged 6-11, low skim milk intake, high yogurt intake and low total fluid milk intake were negatively associated with dental caries among children aged 12-17. More large-scale prospective studies are needed to confirm these findings.

ACKNOWLEDGEMENTS

This research uses data from the National Health and Nutrition Examination Survey (NHANES). NHANES was developed and sponsored by the Centers for Disease Control and Prevention (CDC). The data were collected and managed by the staff of NHANES. We thank all participants who contributed to NHANES.

AUTHOR DISCLOSURE

The authors declare that they have no conflict of interest.

This research did not receive any specific grant from funding agencies in the public, commercial, or non-profit sectors.

REFERENCES

1. GBD 2017 Disease and Injury Incidence and Prevalence Collaborators. Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet. 2018;392(10159):1789-858. doi: 10.1016/s0140-6736(18)32279-7.
2. Petersen PE, Bourgeois D, Ogawa H, Estupinan-Day S, Ndiaye C. The global burden of oral diseases and risks to oral health. Bull World Health Organ. 2005;83:661-9. doi: /S0042-96862005000900011.
3. Righolt AJ, Jevdjevic M, Marcenes W, Listl S. Global-, regional-, and country-level economic impacts of dental diseases in 2015. J Dent Res. 2018;97:501-7. doi: 10.1177/0022034517750572.
4. Souza JGS, Souza SE, Noronha MDS, Ferreira EFE, Martins A. Impact of untreated dental caries on the daily activities of children. J Public Health Dent. 2018;78:197-202. doi: 10.1111/jphd.12259.
5. Mota-Veloso I, Soares ME, Alencar BM, Marques LS, Ramos-Jorge ML, Ramos-Jorge J. Impact of untreated dental caries and its clinical consequences on the oral health-related quality of life of schoolchildren aged 8-10 years. Qual Life Res. 2016;25:193-9. doi: 10.1007/s11136-015-1059-7.
6. Haag DG, Peres KG, Balasubramanian M, Brennan DS. Oral conditions and health-related quality of life: A systematic review. J Dent Res. 2017;96:864-74. doi: 10.1177/0022034517709737.
7. Woodward M, Rugg-Gunn AJ. Chapter 8: Milk, yoghurts and dental caries. Monogr Oral Sci. 2020;28:77-90. doi: 10.1159/000455374.
8. Dror DK, Allen LH. Dairy product intake in children and adolescents in developed countries: trends, nutritional contribution, and a review of association with health outcomes. Nutr Rev. 2014;72:68-81. doi: 10.1111/nure.12078.
9. Grenby TH, Andrews AT, Mistry M, Williams RJ. Dental caries-protective agents in milk and milk products: investigations in vitro. J Dent. 2001;29:83-92. doi: 10.1016/s0300-5712(00)00061-0.
10. Shetty V, Hegde AM, Nandan S, Shetty S. Caries protective agents in human milk and bovine milk: an in vitro study. J Clin Pediatr Dent. 2011;35:389-92. doi: 10.17796/jcpd.35.4.r1668v3l38mh8404.
11. Schupbach P, Neeser JR, Golliard M, Rouvet M, Guggenheim B. Incorporation of caseinoglycomacropeptide and caseinophosphopeptide into the salivary pellicle inhibits adherence of mutans streptococci. J Dent Res. 1996;75:1779-88. doi: 10.1177/00220345960750101101.
12. Ferrazzano GF, Cantile T, Quarto M, Ingenito A, Chianese L, Addeo F. Protective effect of yogurt extract on dental enamel demineralization in vitro. Aust Dent J. 2008;53:314-9. doi: 10.1111/j.1834-7819.2008.00072.x.
13. Kashket S, DePaola DP. Cheese consumption and the development and progression of dental caries. Nutr Rev. 2002;60:97-103. doi: 10.1301/00296640260085822.

14. Petti S, Simonetti R, Simonetti D'Arca A. The effect of milk and sucrose consumption on caries in 6-to-11-year-old Italian schoolchildren. Eur J Epidemiol. 1997;13:659-64. doi: 10.1023/a:1007343904877.
15. Kolker JL, Yuan Y, Burt BA, Sandretto AM, Sohn W, Lang SW, Ismail AI. Dental caries and dietary patterns in low-income African American children. Pediatr Dent. 2007;29:457-64. doi:
16. Ohlund I, Holgerson PL, Backman B, Lind T, Hernell O, Johansson I. Diet intake and caries prevalence in four-year-old children living in a low-prevalence country. Caries Res. 2007;41:26-33. doi: 10.1159/000096102.
17. Tanaka K, Miyake Y, Sasaki S. Intake of dairy products and the prevalence of dental caries in young children. J Dent. 2010;38:579-83. doi: 10.1016/j.jdent.2010.04.009.
18. Lempert SM, Christensen LB, Froberg K, Raymond K, Heitmann BL. Association between dairy intake and caries among children and adolescents: results from the Danish EYHS follow-up study. Caries Res. 2015;49:251-8. doi: 10.1159/000375505.
19. Dye BA, Afful J, Thornton-Evans G, Iafolla T. Overview and quality assurance for the oral health component of the National Health and Nutrition Examination Survey (NHANES), 2011-2014. BMC Oral Health. 2019;19:95. doi: 10.1186/s12903-019-0777-6.
20. Slade GD, Grider WB, Maas WR, Sanders AE. Water Fluoridation and Dental Caries in U.S. Children and Adolescents. J Dent Res. 2018;97:1122-8. doi: 10.1177/0022034518774331.
21. Slade GD, Sanders AE. Two decades of persisting income-disparities in dental caries among U.S. children and adolescents. J Public Health Dent. 2018;78:187-91. doi: 10.1111/jphd.12261.
22. Park SY, Freedman ND, Haiman CA, Le Marchand L, Wilkens LR, Setiawan VW. Association of coffee consumption with total and cause-specific mortality among nonwhite populations. Ann Intern Med. 2017;167:228-35. doi: 10.7326/m16-2472.
23. Cabral M, Mota ELA, Cangussu MCT, Vianna MIP, Floriano FR. Risk factors for caries-free time: longitudinal study in early childhood. Rev Saude Publica. 2017;51:118. doi: 10.11606/s1518-8787.2017051006558.
24. Jain M, Namdev R, Bodh M, Dutta S, Singhal P, Kumar A. Social and behavioral determinants for early childhood caries among preschool children in India. J Dent Res Dent Clin Dent Prospects. 2015;9:115-20. doi: 10.15171/joddd.2014.023.
25. Dzidic M, Collado MC, Abrahamsson T, Artacho A, Stensson M, Jenmalm MC, Mira A. Oral microbiome development during childhood: an ecological succession influenced by postnatal factors and associated with tooth decay. Isme j. 2018;12:2292-306. doi: 10.1038/s41396-018-0204-z.
26. Masumo RM, Ndekero TS, Carneiro LC. Prevalence of dental caries in deciduous teeth and oral health related quality of life among preschool children aged 4-6 years in Kisarawe, Tanzania. BMC Oral Health. 2020;20:46. doi: 10.1186/s12903-020-1032-x.
27. Fry Vennerod FF, Nicklaus S, Lien N, Almli VL. The development of basic taste sensitivity and preferences in children. Appetite. 2018;127:130-7. doi: 10.1016/j.appet.2018.04.027.

28. Wu L, Chang R, Mu Y, Deng X, Wu F, Zhang S, Zhou D. Association between obesity and dental caries in Chinese children. Caries Res. 2013;47:171-6. doi: 10.1159/000344017.
29. Petti S, Cairella G, Tarsitani G. Rampant early childhood dental decay: an example from Italy. J Public Health Dent. 2000;60:159-66. doi: 10.1111/j.1752-7325.2000.tb03322.x.
30. Llena C, Forner L. Dietary habits in a child population in relation to caries experience. Caries Res. 2008;42:387-93. doi: 10.1159/000154784.
31. Varghese L, Varughese JM, Varghese NO. Inhibitory effect of yogurt extract on dental enamel demineralisation - an in vitro study. Oral Health Prev Dent. 2013;11:369-74. doi: 10.3290/j.ohpd.a30604.
32. Ashley FP, Wilson RF. Dental plaque and caries. A 3-year longitudinal study in children. Br Dent J. 1977;142:85-91. doi: 10.1038/sj.bdj.4803870.
33. Schamschula RG, Bunzel M, Agus HM, Adkins BL, Barmes DE, Charlton G. Plaque minerals and caries experience: associations and interrelationships. J Dent Res. 1978;57:427-32. doi: 10.1177/00220345780570030101.
34. Wilson RF, Ashley FP. The relationship between the biochemical composition of dental plaque from both approximal and free smooth surfaces of teeth and subsequent 3-year caries increment in adolescents. Arch Oral Biol. 1990;35:933-7. doi: 10.1016/0003-9969(90)90011-x.
35. Ravishankar TL, Yadav V, Tangade PS, Tirth A, Chaitra TR. Effect of consuming different dairy products on calcium, phosphorus and pH levels of human dental plaque: a comparative study. Eur Arch Paediatr Dent. 2012;13:144-8. doi: 10.1007/bf03262861.

Table 1. Characteristics of children and adolescents by dental caries NHANES 2011–2016 (N=6885)

	Non-caries	Caries	*p* value
Number of participants (%)	3564 (51.76)	3321 (48.24)	
Age (%)			<0.001†
2-5 years	1336 (75.78)	427 (24.22)	
6-11 years	1190 (43.78)	1528 (56.22)	
12-17 years	1038 (43.18)	1366 (56.82)	
Gender (%)			0.876†
Men	1793 (51.67)	1677 (48.33)	
Women	1771 (51.86)	1644 (48.14)	
Race/ethnicity (%)			<0.001†
Mexican American	567 (39.27)	877 (60.73)	
Other Hispanic	398 (51.35)	377 (48.65)	
Non-Hispanic White	1069 (59.55)	726 (40.45)	
Non-Hispanic Black	922 (51.94)	853 (48.06)	
Other Race	608 (55.47)	488 (44.53)	
Education of household referent (%)			<0.001†
Less than high school	645 (39.07)	1006 (60.93)	
High school graduate	700 (47.85)	763 (52.15)	
Some college or AA degree	1088 (55.09)	887 (44.91)	
College graduate or above	1037 (64.89)	561 (35.11)	
Period since last dental visit (%)			<0.001†
Within 1 years	2632 (48.63)	2780 (51.37)	
1–2 years	246 (48.43)	262 (51.57)	
More than 2 years or never	673 (71.29)	271 (28.71)	
Household income (%)			<0.001†
<$20,000	695 (46.30)	806 (53.70)	
≥$20,000	2761 (53.75)	2378 (46.27)	
Total energy intake (kcal/day)	1673 (735.60)	1781 (810.50)	<0.001‡

Data are the number of subjects (percentage) or medians (interquartile ranges).
†Chi-square test was used to compare the percentage between participants with and without caries.
‡Mann-Whitney U test was used to compare the mean values between participants with and without caries.

Table 2. Weighted odds ratios (ORs) with 95 percent confidence intervals (CIs) for dental caries across milk and dairy products intake

Milk and dairy products	Case/Participants	Crude†	Model 1†	Model 2†	*p* for trend
		OR (95% CI)	OR (95% CI)	OR (95% CI)	
Whole milk (g/day)					0.266
=0	3589/6885	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	
<244.00	1303/6885	0.90 (0.73-1.11)	1.08 (0.87-1.35)	0.98 (0.80-1.21)	
≥244.00	1993/6885	0.85 (0.72-1.01)	0.98 (0.82-1.18)	0.92 (0.79-1.07)	
Low fat milk (g/day)					0.618
=0	3004/6885	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	
<244.00	1441/6885	0.92 (0.75-1.11)	1.06 (0.85-1.33)	0.97 (0.76-1.24)	
≥244.00	2440/6885	0.95 (0.78-1.16)	1.02 (0.83-1.27)	0.95 (0.77-1.17)	
Skim milk (g/day)					0.395
=0	6491/6885	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	
<245.00	179/6885	0.62(0.37-1.03)	0.60 (0.34-1.04)	0.69 (0.40-1.18)	
≥245.00	215/6885	0.65 (0.40-1.12)	0.63 (0.38-1.04)	0.86 (0.52-1.437)	
Yogurt (g/day)					0.011
=0	5731/6885	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	
<122.50	495/6885	0.55 (0.38-0.78) **	0.72 (0.49-1.04)	0.84 (0.55-1.28)	
≥122.50	659/6885	0.49 (0.36-0.66) **	0.58 (0.42-0.80) **	0.66 (0.47-0.93) *	
Cheese (g/day)					0.906
=0	3207/6885	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	
<22.58	1839/6885	0.78 (0.65-0.94) **	0.82 (0.68-0.99) *	0.82 (0.69-0.98) *	
≥22.58	1839/6885	0.91 (0.72-1.15)	0.90 (0.70-1.17)	0.98 (0.76-1.28)	
Cream (g/day)					0.116
=0	6342/6885	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	
<15.50	264/6885	0.83 (0.58-1.19)	0.81 (0.53-1.24)	0.74 (0.50-1.08)	
≥15.50	279/6885	1.34 (0.91-1.98)	1.17 (0.80-1.72)	1.17 (0.77-1.78)	
Desserts (g/day)					0.685
=0	4856/6885	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	
<106.38	1016/6885	0.87(0.68-1.12)	0.97 (0.73-1.27)	1.03 (0.78-1.36)	
≥106.38	1013/6885	1.17 (0.93-1.46)	0.98 (0.78-1.24)	1.04 (0.83-1.32)	
Total milk (g/day)					0.736
=0	1725/6885	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	
<259.25	2532/6885	0.92 (0.78-1.08)	1.10 (0.92-1.30)	0.97 (0.81-1.16)	
≥259.25	2628/6885	0.83 (0.68-1.03)	1.01 (0.81-1.26)	0.96 (0.76-1.21)	

†Calculated using binary logistic regression.
Model 1 adjusted for age and gender.
Model 2 adjusted for age and gender, race/ethnicity, educational level of the head of household, period since last dental visit, annual household income, and total energy intake.
*p<0.05, **p<0.01.

Table 3. Weighted odds ratios (ORs) with 95 percent confidence intervals (CIs) for dental caries across milk and dairy products intake, stratified by gender

Milk and dairy products	Men			Women		
	Crude[†]	Model 1[†]	Model 2[†]	Crude[†]	Model 1[†]	Model 2[†]
Whole milk (g/day)						
=0	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
<244.00	0.77 (0.53-0.12)	0.88 (0.60-1.29)	0.75 (0.51-1.08)	1.03 (0.81-1.31)	1.32 (1.01-1.72) *	1.25 (0.95-1.65)
≥244.00	0.90 (0.69-1.17)	0.98 (0.75-1.28)	0.88 (0.69-1.31)	0.77 (0.62-0.96) *	0.98 (0.78-1.22)	0.94 (0.76-1.56)
Low fat milk (g/day)						
=0	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
<244.00	1.00 (0.74-1.36)	1.09 (0.76-1.55)	0.91 (0.64-1.31)	0.85 (0.68-1.07)	1.04 (0.81-1.33)	1.02 (0.77-1.34)
≥244.00	1.06 (0.84-1.34)	1.06 (0.83-1.34)	0.95 (0.74 -1.22)	0.84 (0.63-1.13)	1.00 (0.72-1.38)	0.95 (0.70-1.28)
Skim milk (g/day)						
=0	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
<245.00	0.57 (0.25-1.29)	0.51 (0.21-1.22)	0.61 (0.28-1.33)	0.66 (0.33-1.32)	0.67 (0.32-1.42)	0.79 (0.38-1.66)
≥245.00	0.61 (0.33-1.34)	0.59 (0.32-1.10)	0.83 (0.46-1.49)	0.72 (0.32-1.65)	0.67 (0.29-1.53)	0.91 (0.38-2.19)
Yogurt (g/day)						
=0	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
<122.50	0.49 (0.32-0.75) **	0.57 (0.36-0.92) *	0.65 (0.40-1.06)	0.60 (0.40-0.91) *	0.86 (0.56-1.32)	1.04 (0.63-1.74)
≥122.50	0.49 (0.33-0.73) **	0.60 (0.39-0.92) *	0.71 (0.45-1.12)	0.48 (0.33-0.71) **	0.56 (0.36-0.86) **	0.60 (0.38-0.94) *
Cheese (g/day)						
=0	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
<22.58	0.91 (0.69-1.21)	1.03 (0.77-1.37)	1.06 (0.79-1.41)	0.67 (0.51-0.87) **	0.65 (0.49-0.88) **	0.65 (0.48-0.87) **
≥22.58	1.01 (0.75-1.33)	1.02 (0.75-1.38)	1.17 (0.88-1.55)	0.82 (0.62-1.08)	0.79 (0.58-1.09)	0.83 (0.59-1.16)
Cream (g/day)						
=0	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
<15.50	0.70 (0.39-1.25)	0.72 (0.35-1.49)	0.65 (0.34-1.23)	0.96 (0.61-1.51)	0.89 (0.55-1.44)	0.79 (0.51-1.20)
≥15.50	1.10 (0.64-1.89)	0.94 (0.55-1.61)	0.90 (0.50-1.63)	1.54 (0.86-2.76)	1.34 (0.74-2.42)	1.40 (0.75-2.60)
Desserts (g/day)						
=0	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
<106.38	0.93 (0.69-1.27)	1.13 (0.81-1.56)	1.18 (0.83-1.68)	0.83 (0.58-1.18)	0.84 (0.57-1.25)	0.91 (0.63-1.33)
≥106.38	1.08 (0.78-1.48)	0.90 (0.65-1.26)	0.95 (0.65-1.41)	1.27 (0.92-1.76)	1.07 (0.77-1.49)	1.12 (0.81-1.54)
Total milk (g/day)						
=0	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
<259.25	1.05 (0.79-1.39)	1.16 (0.86-1.56)	1.00 (0.75-1.34)	0.81 (0.66-0.99) *	1.05 (0.85-1.30)	0.95 (0.77-1.19)
≥259.25	0.94 (0.71-1.24)	1.05 (0.79-1.39)	0.99 (0.74-1.32)	0.74 (0.54-1.02)	0.98 (0.71-1.37)	0.94 (0.66-1.35)

[†]Calculated using binary logistic regression.
Model 1 adjusted for age.
Model 2 adjusted for age, race/ethnicity, educational level of the head of household, period since last dental visit, annual household income, and total energy intake.
*p<0.05, **p<0.01.

Table 4. Weighted odds ratios (ORs) with 95 percent confidence intervals (CIs) for dental caries across milk and dairy products intake, stratified by age

	2-5 years			6-11 years		
	Crude†	Model 1†	Model 2†	Crude†	Model 1†	Model 2†
Whole milk						
=0	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
<244.00	1.09 (0.76-1.57)	1.10 (0.76-1.58)	0.99 (0.67-1.47)	1.31 (0.88-1. 95)	1.31 (0.88-1.95)	1.14 (0.77-1.69)
≥244.00	0.80 (0.51-1.23)	0.80 (0.52-1.23)	0.75 (0.50-1.13)	1.17 (0.86-1.58)	1.16 (0.86-1.56)	1.01 (0.74-1.39)
Low fat milk						
=0	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
<244.00	1.45 (0.99-2.14)	1.48 (1.00-2.19)	1.33 (0.91-1.96)	1.12 (0.83-1.52)	1.12 (0.83-1.52)	0.98 (0.70-1.37)
≥244.00	0.85 (0.60-1.20)	0.85 (0.60-1.21)	0.83 (0.58-1.17)	1.22 (0.90-1.67)	1.22 (0.89-1.66)	1.04 (0.73-1.48)
Skim milk						
=0	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
<245.00	0.62 (0.26-1.49)	0.64 (0.27-1.53)	0.80 (0.37-1.70)	0.72 (0.37-1.41)	0.73 (0.37-1.43)	0.87 (0.46-1.62)
≥245.00	0.40 (0.10-1.55)	0.40 (0.10-1.53)	0.66 (0.16-2.70)	0.46 (0.22-0.98) *	0.46 (0.22-0.98) *	0.61 (0.29-1.29)
Yogurt						
=0	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
<122.50	0.59 (0.35-1.00) *	0.60 (0.35-1.02)	0.76 (0.43-1.35)	0.74 (0.45-1.23)	0.75 (0.37-1.43)	0.88 (0.49-1.57)
≥122.50	0.88 (0.51-1.51)	0.88 (0.51-1.51)	1.20 (0.69-2.11)	0.52 (0.33-0.82) **	0.52 (0.33-0.82) **	0.55 (0.34-0.91) *
Cheese						
=0	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
<22.58	0.89 (0.65-1.22)	0.88 (0.64-1.20)	0.88 (0.64-1.21)	0.83 (0.62-1.10)	0.83 (0.62-1.11)	0.84 (0.63-1.13)
≥22.58	0.87 (0.59-1.28)	0.87 (0.59-1.27)	1.01 (0.68-1.50)	0.98 (0.71-1.34)	0.98 (0.71-1.35)	1..10 (0.78-1.55)
Cream						
=0	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
<15.50	0.78 (0.30-2.04)	0.77 (0.30-2.00)	0.80 (0.34-1.86)	0.80 (0.50-1.29)	0.81 (0.50-1.31)	0.71 (0.45-1.13)
≥15.50	1.55 (0.58-4.14)	1.59 (0.59-4.32)	1.61 (0.52-4.98)	1.12 (0.69-1.83)	1.13 (0.69-1.84)	1.22 (0.73-2.06)
Desserts						
=0	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
<106.38	1.28 (0.87-1.88)	1.27 (0.86-1.86)	1.31 (0.85-2.00)	0.87 (0.61-1.25)	0.88 (0.61-1.25)	0.98 (0.69-1.38)
≥106.38	1.10 (0.59-2.06)	1.10 (0.59-2.05)	0.94 (0.57-1.58)	0.84 (0.61-1.15)	0.84 (0.61-1.16)	0.92 (0.68-1.26)
Total milk						
=0	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
<259.25	1.05 (0.72-1.52)	1.07 (0.73-1.57)	0.82 (0.54-1.23)	1.54 (1.16-2.05) **	1.54 (1.15-2.05) **	1.29 (0.95-1.75)
≥259.25	1.07 (0.38-1.31)	0.72 (0.39-1.33)	0.62 (0.33-1.16)	1.29 (0.94-1.77)	1.28 (0.93-1.76)	1.11 (0.79-1.57)

†Calculated using binary logistic regression.
Model 1 adjusted for gender.
Model 2 adjusted for gender, race/ethnicity, educational level of the head of household, period since last dental visit, annual household income, and total energy intake.
*p<0.05, **p<0.01.

Table 4. Weighted odds ratios (ORs) with 95 percent confidence intervals (CIs) for dental caries across milk and dairy products intake, stratified by age

	12-17 years		
	Crude[†]	Model 1[†]	Model 2[†]
Whole milk			
=0	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
<244.00	0.84 (0.59-1.19)	0.84 (0.59-1.19)	0.78 (0.55-1.10)
≥244.00	0.92 (0.67-1.27)	0.93 (0.68-1.26)	0.91 (0.69-1.19)
Low fat milk			
=0	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
<244.00	0.82 (0.55-1.23)	0.82 (0.55-1.23)	0.78 (0.52-1.18)
≥244.00	0.95 (0.67-1.34)	0.95 (0.68-1.34)	0.95 (0.68-1.33)
Skim milk			
=0	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
<245.00	0.42 (0.18-0.99) *	0.42 (0.178-1.00) *	0.43 (0.19-1.00) *
≥245.00	0.90 (0.42-1.92)	0.90 (0.42-1.91)	1.19 (0.55-2.61)
Yogurt			
=0	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
<122.50	0.85 (0.28-2.59)	0.85 (0.28-2.57)	1.04 (0.32-3.38)
≥122.50	0.45 (0.25-0.81) **	0.45 (0.25-0.81) **	0.50 (0.28-0.88) *
Cheese			
=0	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
<22.58	0.79 (0.54-1.15)	0.79 (0.54-1.14)	0.81 (0.57-1.53)
≥22.58	0.84 (0.57-1.25)	0.84 (0.57-1.25)	0.91 (0.61-1.35)
Cream			
=0	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
<15.50	0.84 (0.47-1.49)	0.83 (0.46-1.50)	0.77 (0.45-1.31)
≥15.50	1.12 (0.55-2.31)	1.12 (0.55-2.26)	1.01 (0.47-2.19)
Desserts			
=0	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
<106.38	0.88 (0.54-1.42)	0.87 (0.54-1.40)	0.93 (0.58-1.50)
≥106.38	1.15 (0.81-1.62)	1.15 (0.81-1.62)	1.24 (0.88-1.76)
Total milk			
=0	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
<259.25	0.80 (0.61-1.05)	0.80 (0.61-1.05)	0.74 (0.55-0.98) *
≥259.25	1.00 (0.71-1.39)	1.00 (0.72-1.40)	1.02 (0.73-1.44)

[†]Calculated using binary logistic regression.
Model 1 adjusted for gender.
Model 2 adjusted for gender, race/ethnicity, educational level of the head of household, period since last dental visit, annual household income, and total energy intake.
*p<0.05, **p<0.01.

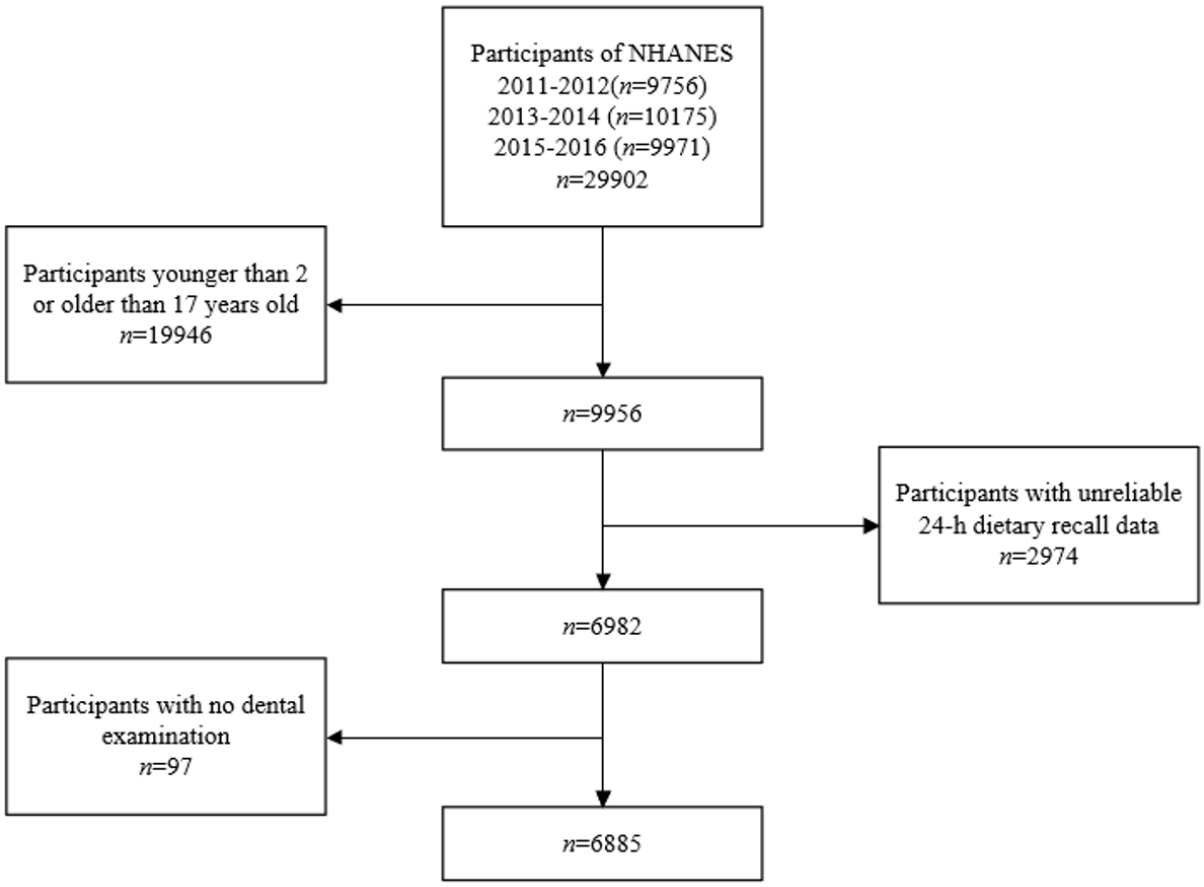

Figure 1. Flow chart of the screening process for the selection of eligible participants.