Original Investigation

Association Between Apple Consumption and Physician Visits
Appealing the Conventional Wisdom That an Apple a Day Keeps the Doctor Away

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IMPORTANCE Fruit consumption is believed to have beneficial health effects, and some claim, "An apple a day keeps the doctor away."

OBJECTIVE To examine the relationship between eating an apple a day and keeping the doctor away.

DESIGN, SETTING, AND PARTICIPANTS A cross-sectional study of a nationally representative sample of the noninstitutionalized US adult population. A total of 8728 adults 18 years and older from the 2007-2008 and 2009-2010 National Health and Nutrition Examination Survey completed a 24-hour dietary recall questionnaire and reported that the quantity of food they ate was reflective of their usual daily diet.

EXPOSURES Daily apple eaters (consuming the equivalent of at least 1 small apple daily, or 149 g of raw apple) vs non–apple eaters, based on the reported quantity of whole apple consumed during the 24-hour dietary recall period.

MAIN OUTCOMES AND MEASURES The primary outcome measure was success at "keeping the doctor away," measured as no more than 1 visit (self-reported) to a physician during the past year; secondary outcomes included successful avoidance of other health care services (ie, no overnight hospital stays, visits to a mental health professional, or prescription medications).

RESULTS Of 8399 eligible study participants who completed the dietary recall questionnaire, we identified 753 adult apple eaters (9.0%)—those who typically consume at least 1 small apple per day. Compared with the 7646 non–apple eaters (91.0%), apple eaters had higher educational attainment, were more likely to be from a racial or ethnic minority, and were less likely to smoke ($P < .001$ for each comparison). Apple eaters were more likely, in the crude analysis, to keep the doctor (and prescription medications) away: 39.0% of apple eaters avoided physician visits vs 33.9% of non–apple eaters ($P = .03$). After adjusting for sociodemographic and health-related characteristics, however, the association was no longer statistically significant (OR, 1.19; 95% CI, 0.93-1.53; $P = .15$). In the adjusted analysis, apple eaters also remained marginally more successful at avoiding prescription medications (odds ratio, 1.27; 95% CI, 1.00-1.63). There were no differences seen in overnight hospital stay or mental health visits.

CONCLUSIONS AND RELEVANCE Evidence does not support that an apple a day keeps the doctor away; however, the small fraction of US adults who eat an apple a day do appear to use fewer prescription medications.

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The aphorism, "An apple a day keeps the doctor away," originated in Wales, first appearing in a publication in 1866 in a different rhyming format: "Eat an apple on going to bed and you'll keep the doctor from earning his bread."[1] The saying reappeared in 1913 in its current form.[2,3] Medical practice in the 19th and 20th centuries was crude, and the public sensibly sought to keep physicians (and other health practitioners) away—a sentiment that may not be out of place in the 21st century.[4-7] Through the ages, the apple has come to symbolize health and healthy habits, and has been used by government and private health organizations to symbolize lifestyle choices that lead to health and wellness.[8,9]

Promoted by the lay media and powerful special interest groups, including the US Apple Association,[10] the beneficial effects of apple consumption have been variably attributed to fiber, essential vitamins and minerals, and flavonoids (particularly quercetin), a group of molecular compounds thought to be beneficial in the prevention of cancer and other health conditions.[11] Although evidence is mixed,[12-15] apple consumption has been previously associated with positive health effects as far reaching as weight loss,[16] prevention of neurologic degradation,[17] cancer suppression,[18-22] reduction in asthma symptoms,[23,24] and improved cardiovascular health.[15,25-29]

All of this, however, raises the question of whether an apple a day actually keeps the doctor away—that is, is apple consumption associated with reduced health care use? Prior studies showing improved health related to apple eating may not necessarily translate into lower health care use,[30] a goal sought by policy makers and, doubtless, many individual Americans. To our knowledge, the association between daily apple consumption and use of health care services has never been rigorously examined. Although some may jest,[31] considering the relatively low cost of apples (currently $1.13 per pound of Red Delicious apples[32]), a prescription for apple consumption could potentially reduce national health care spending if the aphorism holds true.

We used nationally representative data from the National Health and Nutrition Examination Survey (NHANES) to examine the association between daily apple consumption and self-reported avoidance of physicians.

Methods

We used publicly available deidentified data from the NHANES to examine the relationship between the regular consumption of an apple per day and the avoidance of health care services. The NHANES is a continuous, cross-sectional, multistage probability interview survey of the civilian noninstitutionalized US population that provides nationally representative estimates of health measures, including detailed information on diet. For this study, we used 2007-2008 and 2009-2010 NHANES survey data from the demographics, in-person dietary questionnaire, examination, and health questionnaire files. This study was granted an exemption from institutional board review by Dartmouth College's Committee for the Protection of Human Subjects.

Study Sample

We analyzed data from all adults 18 years and older who participated in the NHANES survey from 2007 to 2010. During this time, a total of 12 755 adults participated, and the overall unweighted response rate for the entire survey was 75.4% and 77.3% for the 2007-2008 and 2009-2010 surveys, respectively. All NHANES study participants are eligible to participate in the 24-hour dietary recall questionnaire, which collects comprehensive information on everything the participant consumed in the preceding 24 hours, including the type of food and amount.[33] In addition, the NHANES asks participants whether the amount of food reported in the 24-hour recall period is reflective of the study participant's usual diet; only those who responded in the affirmative were included in our study. We also excluded participants with incomplete dietary data, yielding a sample size of 8728.

Outcome Measures

Identification of Apple Eaters in the NHANES Dietary Data

For each food item listed in the 24-hour dietary recall period, the NHANES reports a United States Department of Agriculture's food code and the amount (in grams) of that food consumed. We linked each food code to the US Environmental Protection Agency's Food Commodity Intake Database,[34] allowing us to estimate the total grams of raw apple contained in 100 g of the corresponding food. Summing these amounts for each food item consumed, we calculated the total grams of raw apple consumed by each study participant during the 24-hour dietary recall period (eAppendix in the Supplement).

We categorized study participants as either apple eaters or non-apple eaters using a cutoff point of 149 g/d, which corresponds to eating at least 1 small apple (7.0 cm in diameter), according to the United States Department of Agriculture's National Nutrient Database for Standard Reference.[35] In subanalyses to evaluate a potential dose-response relationship by apple size, we compared the effect of daily consumption of 1 small vs 1 medium (182 g, or approximately 7.6 cm in diameter) vs 1 large (223 g, or 8.3 cm in diameter) apple compared with no apples (ie, less than 1 small apple).

Because previous studies examining the potential health effects of apple consumption have used various forms of apple (eg, whole apple, apple juice, and applesauce),[18,25,26] we also performed a sensitivity analysis based on consumption of raw vs processed apple compared with no apples (eAppendix in the Supplement). The analysis presented excludes the 329 study participants whose apple consumption was derived entirely from apple juice and applesauce. Therefore, our final study sample consisted of 8399 adults.

Avoidance of Health Care Services

To examine whether an apple a day keeps the doctor (and other health care services) away, we examined self-reported use of selected health care services according to apple-eater status. During the in-person interview, the NHANES asks how many times in the past year the study participants saw "a doctor or other health professional" about their health at any location (excluding hospitalizations), offering 6 categories of response ranging from none to 13 or more. Since it has been de-

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Table. Characteristics of US Adults 18 Years or Older According to Apple vs Non-Apple Eater Status[a]

Characteristic	Persons, %[b]		P Value[d]
	Apple Eater (n = 753)[c]	Non-Apple Eater (n = 7646)	
Americans, No. (in millions)	19.3	207.2	
Sociodemographic Characteristics			
Mean age, y	47.8	46.6	.20
Sex			
Male	49.1	49.2	.98
Female	50.9	50.8	
Race or ethnicity			
Non-Hispanic white	65.7	73.3	<.001
Non-Hispanic black	7.0	9.6	
Mexican American	12.5	7.4	
Other, multiple races	14.8	9.7	
Educational attainment			
≤High school	37.3	42.6	<.001
Some college	26.1	29.9	
≥College	36.6	27.5	
Marital status			
Married or living with partner	66.4	65.4	.31
Divorced, separated, or widowed	15.4	18.2	
Never married	18.2	16.4	
Annual family income, $			
<35 000	33.8	35.5	.74
35 000-74 999	31.2	31.7	
≥75 000	35.0	32.9	
Health-Related Characteristics			
Body mass index[e]			
Reference range (<25.0)	34.1	32.0	.10
Overweight (≥25.0 to <30.0)	36.4	33.6	
Obese (≥30.0)	29.5	34.6	
Self-reported health status			
Excellent, very good, or good	85.3	83.2	.36
Fair or poor	14.7	16.8	
Smoking status			
None	64.3	53.8	<.001
Current	13.5	20.7	
Former	22.3	25.6	
Health insurance			
Private	51.9	50.8	.47
Public	28.5	30.5	
Uninsured	19.6	18.7	

[a] All summary statistics, which are weighted using complex survey design, represent national estimates. Sample is restricted to study participants who reported the quantity of food in the 24-h dietary recall period as being representative of their usual diet.

[b] Values are presented as percentage of persons unless otherwise indicated.

[c] Apple eating was defined as consuming the equivalent of at least 1 small apple (149 g of raw apple) during the 24-hour dietary recall period.

[d] *t* Test used to compare means and χ^2 test used to compare proportions.

[e] Calculated as weight in kilograms divided by height in meters squared.

cades since standard health maintenance for US adults evolved to include 1 annual visit to a physician,[36] we operationalized our primary outcome measure as successful avoidance of more than 1 physician visit in the past year—that is, we dichotomized the responses as 0 or 1 visit (kept the doctor away) vs any other response (did not). We also examined self-reported avoidance of other health care services in the past year, defined as no overnight hospital stays (vs any stays); no visits to mental health care professionals, including those in psychiatry, psychology, and social work (vs any visits); and no (vs any) prescription medications taken in the past month.

Covariates

We collected data on sociodemographic characteristics (age, sex, race or ethnicity, educational attainment, marital status, and annual family income), body mass index, self-reported health status, smoking status, and health insurance. We classified race and ethnicity as non-Hispanic white, non-Hispanic black, Mexican American, and other, multiple races.

Statistical Analysis

To account for the NHANES sampling methods, we used complex survey design methods in Stata, version 13.1 (StataCorp),

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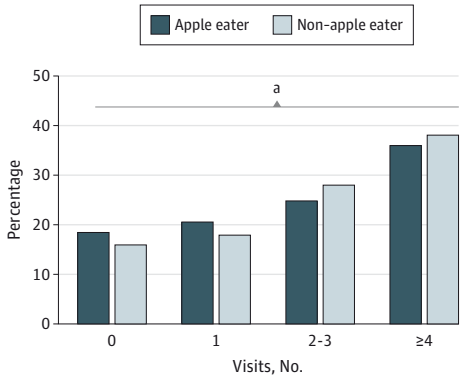
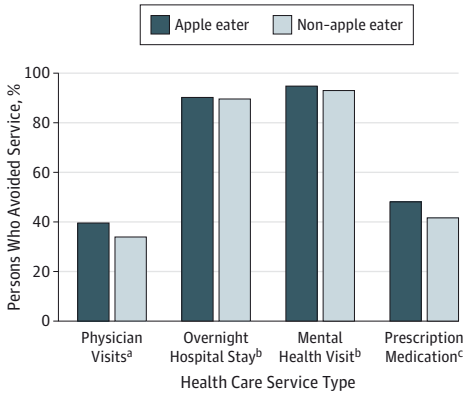
Figure 1. Self-reported Number of Visits to a Physician Within the Previous Year Among US Adult Apple Eaters vs Non–Apple Eaters



χ^2 Test was used in comparison of proportions.

[a] $P = .03$.

Figure 2. Percentage of US Adult Apple Eaters vs Non–Apple Eaters Who Did Not Use Each Specific Health Care Service in the Past Year



χ^2 Test was used in comparison of proportions.

[a] Persons who avoided more than 1 physician visit in the past year ($P = .03$).

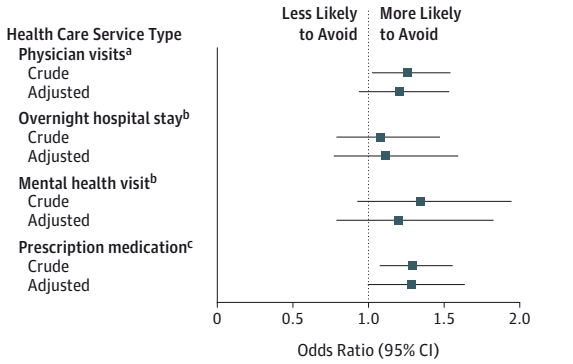
[b] Persons who avoided any use in the past year (overnight hospital stay $P = .64$; mental health visit $P = .11$).

[c] Persons who avoided using a prescription medication in past month ($P = .01$).

for all analyses. These methods account for a study participant's probability of selection and clustering of study participants within primary sampling units. We adjusted the NHANES person-weight variables from the 2007-2008 and 2009-2010 surveys so our sample represented the estimated size of the US adult population in 2010 (234.6 million).[37]

For crude comparisons, we used a *t* test for continuous variables and a χ^2 test for categorical variables; we used logistic regression to model the relationship between eating an apple a day and successfully avoiding health care. Our primary dependent variable was avoiding more than 1 visit to a physician in the previous year. Secondary dependent variables included avoidance of an overnight hospital stay, a visit to a mental health professional, and prescription medication use. Our primary independent variable was daily consumption of the equivalent of at least 1 small whole apple. Our adjusted

Figure 3. Crude and Adjusted Odds Ratios for the Association Between Daily Apple Consumption and Avoidance of Health Care Services



Adjusted models include covariates for age, sex, race or ethnicity, educational attainment, body mass index, smoking status, and health insurance type.

[a] Persons who avoided more than 1 physician visit in the past year.

[b] Persons who avoided any use in the past year.

[c] Persons who avoided using a prescription medication in past month.

models included age (continuous), sex, race or ethnicity (non-Hispanic white vs non-Hispanic black; Mexican American; or other, or multiple races), educational attainment (high school or less vs some college or college or more), body mass index (within the normal range vs overweight, or obese), smoking status (nonsmoker vs current or former smoker), and health insurance type (private vs public or uninsured). For all analyses, we used complete case analysis and set the significance at $P = .05$ (2-sided).

Results

Characteristics of Apple Eaters

An estimated 19.3 million US adults (SE, 1.6) are apple eaters who consume the equivalent of approximately 26.9 million small apples daily, weighing 8.8 million pounds (**Table**). We estimate that 207.2 million adults are non-apple eaters (eating less than 1 small apple daily).

Compared with non-apple eaters, apple eaters were more likely to be from racial or ethnic minorities (14.8% vs 9.7%; $P < .001$). The Table also demonstrates that apple eaters had higher educational attainment and were less likely to smoke.

Apple Eating and Avoiding Health Care Services

Figure 1 shows the distribution of the number of physician visits in the previous year among apple eaters vs non-apple eaters. In unadjusted analyses, apple eaters were more likely to keep the doctor away (39.0% vs 33.9%; odds ratio [OR], 1.25; 95% CI, 1.03-1.53; $P = .03$) (Figures 1, **2**, and **3**). Daily apple eaters were also more likely to successfully avoid prescription medication use (47.7% vs 41.8%; OR, 1.29; 95% CI, 1.07-1.55). There was no difference between apple eaters and non-apple eaters in the likelihood of avoiding an overnight hospital stay or a visit to a mental health professional.

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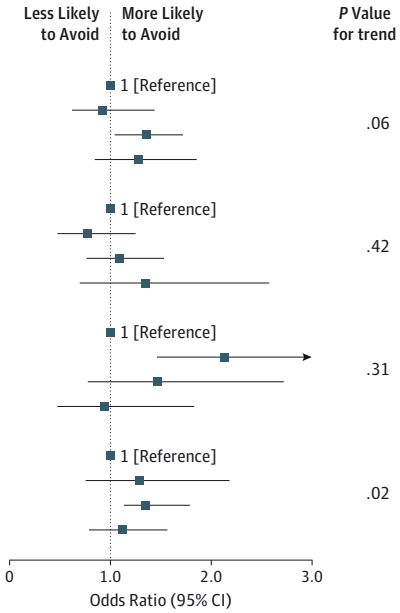
Figure 4. Crude Odds Ratios for the Association Between Dose Response of Daily Apple Consumption and Avoidance of Health Care Services

Health Care Service Type	Persons, No.	Persons Who Avoided Service, No. (%)
Physician visits[a]		
No apple	7641	2566 (33.6)
Small apple	135	41 (30.4)
Medium apple	438	172 (39.3)
Large apple	180	71 (39.4)
Overnight hospital stay[b]		
No apple	7646	6642 (86.9)
Small apple	135	112 (83.0)
Medium apple	438	387 (88.4)
Large apple	180	162 (90.0)
Mental health visit[b]		
No apple	7646	7107 (93.0)
Small apple	135	131 (97.0)
Medium apple	438	412 (94.1)
Large apple	180	165 (91.7)
Prescription medication[c]		
No apple	7646	3144 (41.1)
Small apple	135	65 (48.2)
Medium apple	438	216 (49.3)
Large apple	180	83 (46.1)



Apple eating according to consuming no apples (<149 g) or a small (149-181 g of raw apple), medium (182-222 g), or large (≥223 g) apple per day. *P* values are for the trend across apple categories.

[a] Persons who avoided more than 1 physician visit in the past year.

[b] Persons who avoided any use in the past year.

[c] Persons who avoided using a prescription medication in past month.

Adjustment for sociodemographic and health-related characteristics attenuated the observed associations. The relationship between apple eating and keeping the doctor away was no longer statistically significant after adjustment (OR, 1.19; 95% CI, 0.93-1.53; *P* = .15) (Figure 3). Although mildly attenuated, the association between apple eating and avoidance of prescription medications remained marginally significant after adjustment: apple eaters were somewhat more likely to avoid prescription medication use than non-apple eaters (OR, 1.27; 95% CI, 1.00-1.63).

In our evaluation of a potential dose-response relationship between daily apple intake and success in avoiding health care services, **Figure 4** shows no relationship between apple "dose" and the likelihood of avoiding health care services except for avoidance of prescription medications (*P* = .02). Similarly, we did not observe a threshold effect, although such an effect is hinted at in the case of avoidance of physician visits by eaters of a medium or large apple a day (for which the *P* value for the trend across apple categories is marginal).

Discussion

To our knowledge, this is the first study to thoroughly examine whether an apple a day keeps the doctor away. Our findings may imperil the veracity of this time-worn (but not time-tested) adage. We estimate that in the United States, the equivalent of 26.9 million small apples are eaten daily by nearly 20 million adult apple eaters. While the direction of the associations we observed supports the superiority of apple eaters over non-apple eaters at avoiding the use of health care services, these differences largely lacked statistical significance. Our findings suggest that the promotion of apple consumption may have limited benefit in reducing national health care spending. In the age of evidence-based assertions, however, there may be merit to saying, "An apple a day keeps the pharmacist away."

Prescription medication costs represent approximately 30% of out-of-pocket US health care spending.[38] If the observed association between apple consumption and reduced use of prescription medication were causal, the promotion of apple consumption could, at least in theory, help contain costs associated with prescription medication use.

In a back-of-the-envelope calculation, based on a mean medical prescription cost among US adults of $82.75 in 2010,[39,40] we estimate the difference in annual prescription medication cost per capita between apple eaters ($1697) and non-apple eaters ($1925) to be $228 (95% CI, −$6 to $462). If all 234.6 million US adults were apple eaters, and if apples protect against prescription medication use, national prescription costs would be considerably lower (by approximately $47.2 billion). Based on the cost per pound of Red Delicious apples,[32] 1 small apple daily for each of the estimated 207.2 million adult non-apple eaters would cost approximately $28.0 billion—a potential net savings of up to $19.2 billion. Although impressive, this estimate does not account for the costs associated with potential adverse events associated with apple consumption such as outbreaks of infectious diseases.[41,42]

Our study has several important limitations. First, owing to the cross-sectional study design, we are unable to assess cause and effect in any observed relationships between daily apple consumption and successful avoidance of health care service use. We anticipate, however, that reverse causality is highly unlikely (ie, that individuals who take no prescription medications are impelled to eat apples).

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Second, although we account in our analyses for a variety of characteristics, including healthy and unhealthy behaviors, we cannot dismiss the possibility of residual confounding in any associations observed between apple consumption and successful avoidance of health care services. Apple eaters were, in fact, measurably different from non-apple eaters (Table) and would be expected to differ in other, unmeasured ways. Specifically, individuals who eat apples may be more health conscious and otherwise healthier, which could entirely explain the associations we observed. On the other hand, individuals who are less healthy may, in subscribing to the "apple a day" adage, be more likely to consume apples, in which case we may have seriously underestimated the true salutary effect of apple consumption on health care use. Measurement of the true effect of apple eating would require prospective analyses or an experimental design. In the future, consideration could be given to studies based on natural experiments (eg, crop failure) or experimental designs (eg, an apple lottery) to more closely examine the relationship.

Finally, our reliance on self-reported estimates of apple consumption may raise concerns. Estimating usual diet is clearly a challenge, and different methods entail specific tradeoffs. While the NHANES 24-hour dietary recall offers detailed data (allowing us to identify all forms of apple consumption), it provides only a snapshot of an individual's dietary pattern. Evidence suggests that, at least for fruit and vegetable consumption, a single 24-hour recall is comparable with other methods such as food frequency questionnaires and repeated 24-hour dietary recalls.[43] Although we cannot rule out inaccurate reporting of either apple eating or health care use owing to social desirability, the likelihood of having introduced a bias away from the null appears quite low.

Conclusions

As the practice of medicine continues to advance in the 21st century, we believe it is important to examine what we can learn from the past. While the empirical evaluation of medical proverbs may allow us to profit from the wisdom of our predecessors, we were surprised to find a paucity of prior investigations of popular aphorisms. Our investigation has allowed us to update the well-known proverb to clarify that, if anything, apple eating may help keep the pharmacist away. Were this borne out, it certainly could have health policy implications. Perhaps not surprisingly, many widely accepted proverbs promote healthy lifestyle choices. Rigorously evaluating the clues handed down in these aphorisms—to wit, "Early to bed and early to rise, makes a man healthy, wealthy, and wise"—may provide important answers for improving population health and reducing health care expenditures in the future.

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Acquisition, analysis, or interpretation of data: All authors.
Drafting of the manuscript: All authors.
Critical revision of the manuscript for important intellectual content: All authors.
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Editor's Note

The Prescription Is Laughter

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Although we take seriously the statement, "An apple a day keeps the doctor away"[1] (and the importance of a good parachute), these articles launch our first April Fool's issue. At least once per year, and more is likely better (but needs to be tested), laughter is the best medicine. We look forward to continued editorial chuckles as you send us scientifically rigorous and humorous content that will educate and entertain us all, in time for our next April Fool's issue.

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Conflict of Interest Disclosures: None reported.

1. Davis MA, Bynum JPW, Sirovich BE. Association between apple consumption and physician visits: appealing the conventional wisdom that an apple a day keeps the doctor away [published online March 30, 2015]. *JAMA Intern Med*. doi:10.1001/jamainternmed.2014.5466.

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