DASH-Style Diet Associates with Reduced Risk for Kidney Stones

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ABSTRACT

The impact of the Dietary Approaches to Stop Hypertension (DASH) diet on kidney stone formation is unknown. We prospectively examined the relation between a DASH-style diet and incident kidney stones in the Health Professionals Follow-up Study ($n = 45,821$ men; 18 yr of follow-up), Nurses' Health Study I ($n = 94,108$ older women; 18 yr of follow-up), and Nurses' Health Study II ($n = 101,837$ younger women; 14 yr of follow-up). We constructed a DASH score based on eight components: high intake of fruits, vegetables, nuts and legumes, low-fat dairy products, and whole grains and low intake of sodium, sweetened beverages, and red and processed meats. We used Cox hazards regression to adjust for factors that included age, BMI, and fluid intake. Over a combined 50 yr of follow-up, we documented 5645 incident kidney stones. Participants with higher DASH scores had higher intakes of calcium, potassium, magnesium, oxalate, and vitamin C and had lower intakes of sodium. For participants in the highest compared with the lowest quintile of DASH score, the multivariate relative risks for kidney stones were 0.55 (95% CI, 0.46 to 0.65) for men, 0.58 (95% CI, 0.49 to 0.68) for older women, and 0.60 (95% CI, 0.52 to 0.70) for younger women. Higher DASH scores were associated with reduced risk even in participants with lower calcium intake. Exclusion of participants with hypertension did not change the results. In conclusion, consumption of a DASH-style diet is associated with a marked decrease in kidney stone risk.

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Diet plays a major role in the development of kidney stones, and dietary changes likely have contributed to the substantial increase in nephrolithiasis over the past several decades.[1,2] A wide variety of dietary factors either promote or inhibit the formation of calcium oxalate kidney stones,[1,2] the most common type of stone.[3]

Despite previously observed associations between individual dietary factors and kidney stone risk,[2] relatively few studies have examined the impact of overall diet or dietary patterns on risk. The identification of an effective stone prevention diet is difficult partly because most diets are isocaloric: if an individual reduces the intake of certain foods, he or she will increase the intake of other foods to maintain constant energy intake.[4] As a result, consuming less of one dietary factor (such as animal protein[5]) to decrease stone risk may lead to the consumption of other factors (such as sucrose or fructose[6]) that increase risk.

The Dietary Approaches to Stop Hypertension (DASH) diet, which is high in fruits and vegetables, moderate in low-fat dairy products, and low in animal protein represents a novel potential means of kidney stone prevention. The consumption of fruits and vegetables increases urinary citrate,[7] an impor-

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tant inhibitor of calcium stone formation, and a diet with normal to high calcium content but low in animal protein and sodium decreases the risk of calcium oxalate stone recurrence by 51%.[8] The DASH diet also lowers BP,[9] which is particularly appealing given the high rates of prevalent and incident hypertension in stone formers.[10–14] Because the DASH diet would be expected to contain higher amounts of oxalate and vitamin C, both of which may increase calcium kidney stone risk,[15,16] the impact of the DASH diet on stone risk is currently unknown.

To examine the relation between a DASH-style diet and the risk of incident kidney stones, we conducted prospective studies in three large cohorts: the Health Professionals Follow-up Study (HPFS), the Nurses' Health Study I (NHS I), and the Nurses' Health Study II (NHS II). Previously, we identified associations between individual dietary factors and stone risk in each of these study populations.[5,6,15–18] For the first time, we now report the impact of a specific dietary pattern on risk.

RESULTS

Over a combined 50 yr of follow-up, we documented 5645 new symptomatic kidney stones in the three cohorts. In HPFS (men), NHS I (older women), and NHS II (younger women), there were 1717, 1675, and 2253 incident kidney stones, respectively.

Age-adjusted baseline characteristics for men, older women, and younger women by quintile of DASH score are displayed in Tables 1 through 3. Participants in the highest quintile of DASH score had lower body mass index (BMI) than participants in the lowest quintile. Women with higher DASH scores had a lower prevalence of hypertension at baseline. Men and older women in the highest quintile of DASH score had a higher prevalence of diabetes at baseline than their counterparts in the lowest quintile. In all three cohorts, participants in the highest quintile of DASH score had higher intakes of calcium (both dietary and supplemental), fluid, oxalate, potassium, magnesium, and vitamin C than participants in the lowest quintile. Animal protein intake was similar across quintiles of DASH score.

Higher DASH score was associated with a reduced risk of incident kidney stones in both age-adjusted and multivariate regression models (Table 4). After adjusting for age, BMI, total energy intake, use of thiazide diuretics, fluid intake, caffeine, alcohol use, history of hypertension, and history of diabetes, the relative risk for men in the highest compared with lowest quintile of DASH score was 0.55 (95% confidence interval [CI], 0.46 to 0.65; P for trend <0.001), for older women was 0.58 (95% CI, 0.49 to 0.68; P for trend <0.001), and for younger women was 0.60 (95% CI, 0.52 to 0.70; P for trend <0.001).

Because sodium was not measured well with the food-frequency questionnaire (FFQ) used to assess diet, we also constructed a modified DASH score excluding sodium intake. After multivariate adjustment, the relative risk for men in the highest compared with lowest quintile of modified DASH score was 0.52 (95% CI, 0.44 to 0.62; P for trend <0.001), for older women was 0.53 (95% CI, 0.44 to 0.63; P for trend <0.001), and for younger women was 0.59 (95% CI, 0.51 to 0.68; P for trend <0.001).

Because a DASH-style diet may affect the development of hypertension or other chronic diseases associated with kidney stones, we performed analyses restricted to study participants without hypertension or diabetes. Exclusion of participants with hypertension or diabetes at baseline or during follow-up did not change the results. The relations between DASH score and stone risk did not vary by age or BMI. In analyses restricted to participants with dietary calcium less than the cohort specific median, higher DASH scores also were associated with reduced risk. Additional adjustment for supplemental calcium and supplemental vitamin C intakes did not change the results.

Table 1. Age-adjusted baseline characteristics and dietary intake of men (Health Professionals Follow-up Study) in 1986 according to quintiles of DASH score[a]

HPFS	DASH Score Quintiles		
	Quintile 1	Quintile 3	Quintile 5
BMI (kg/m^2)	25.2	25.0	24.3
History of hypertension (%)	21.0	21.0	22.3
History of diabetes (%)	1.9	3.0	3.9
Thiazide use (%)	8.9	9.7	8.6
Intakes			
Dietary calcium (mg/d)	647	815	934
Supplemental calcium (mg/d)	61	89	155
Fluid (l/d)	1.9	2.0	2.0
Oxalate (mg/d)	153	201	254
Potassium (mg/d)	2870	3450	4063
Magnesium (mg/d)	291	355	424
Vitamin C (mg/d)	293	427	593
Animal protein (g/d)	68	68	66
Components of DASH score			
Fruit (servings/d)	1.1	2.2	3.8
Vegetables (servings/d)	1.7	2.7	4.1
Nuts (servings/d)	0.5	0.9	1.4
Sodium (mg/d)[b]	3765	3239	2777
Low-fat dairy (servings/d)	0.3	1.0	1.6
Red and processed meats (servings/d)[b]	1.3	1.0	0.6
Whole grains (servings/d)	0.5	1.4	2.6
Sweetened beverages (servings/d)[b]	0.6	0.3	0.2

[a]Values are means unless otherwise indicated. Nutrient intakes are energy adjusted.
[b]In constructing the DASH score, higher intakes received lower scores.

DISCUSSION

In this large prospective study of three distinct cohorts, consumption of a DASH-style diet high in fruits and vegetables, moderate in low-fat dairy products, and low in animal protein

Table 2. Age-adjusted baseline characteristics and dietary intake of older women (Nurses' Health Study I) in 1986 according to quintiles of DASH score[a]

NHS I	DASH Score Quintiles		
	Quintile 1	Quintile 3	Quintile 5
BMI (kg/m^2)	25.5	25.3	24.8
History of hypertension (%)	28.4	27.8	27.5
History of diabetes (%)	2.9	3.5	3.8
Thiazide use (%)	14.0	13.8	13.0
Intakes			
Dietary calcium (mg/d)	589	727	845
Supplemental calcium (mg/d)	275	365	429
Fluid (l/d)	1.8	2.0	2.2
Oxalate (mg/d)	130	165	208
Potassium (mg/d)	2620	3057	3529
Magnesium (mg/d)	250	298	355
Vitamin C (mg/d)	254	341	447
Animal protein (g/d)	53	55	56
Components of DASH score			
Fruit (servings/d)	1.4	2.5	3.9
Vegetables (servings/d)	2.4	3.7	5.5
Nuts (servings/d)	0.5	0.7	1.1
Sodium (mg/d)[b]	3307	2835	2395
Low-fat dairy (servings/d)	0.4	1.0	1.8
Red and processed meats (servings/d)[b]	1.1	0.9	0.6
Whole grains (servings/d)	0.5	1.1	2.0
Sweetened beverages (servings/d)[b]	0.4	0.2	0.1

[a]Values are means unless otherwise indicated. Nutrient intakes are energy adjusted.
[b]In constructing the DASH score, higher intakes received lower scores.

Table 3. Age-adjusted baseline characteristics and dietary intake of younger women (Nurses' Health Study II) in 1991 according to quintiles of DASH score[a]

NHS II	DASH Score Quintiles		
	Quintile 1	Quintile 3	Quintile 5
BMI (kg/m^2)	25.2	24.6	24.0
History of hypertension (%)	7.3	6.2	5.5
History of diabetes (%)	0.6	0.7	0.6
Thiazide use (%)	1.9	1.7	1.6
Intakes			
Dietary calcium (mg/d)	725	904	1031
Supplemental calcium (mg/d)	93	129	173
Fluid (l/d)	1.9	2.1	2.4
Oxalate (mg/d)	134	169	219
Potassium (mg/d)	2539	2953	3366
Magnesium (mg/d)	259	318	378
Vitamin C (mg/d)	188	259	337
Animal protein (g/d)	63	65	64
Components of DASH score			
Fruit (servings/d)	0.8	1.8	3.2
Vegetables (servings/d)	1.6	2.7	4.3
Nuts (servings/d)	0.3	0.6	1.0
Sodium (mg/d)[b]	2221	2157	2070
Low-fat dairy (servings/d)	0.6	1.3	2.0
Red and processed meats (servings/d)[b]	1.0	0.8	0.5
Whole grains (servings/d)	0.5	1.1	2.1
Sweetened beverages (servings/d)[b]	0.7	0.4	0.3

[a]Values are means unless otherwise indicated. Nutrient intakes are energy adjusted.
[b]In constructing the DASH score, higher intakes received lower scores.

(but with a substantial amount of plant protein from legumes and nuts) was associated with a marked decrease in the risk of incident kidney stones. This relation was independent of age, body size, hypertension, diabetes, thiazide use, and intakes of total calories, fluid, caffeine, and alcohol.

The consistent association between consumption of a DASH-style diet and lower kidney stone risk in all three cohorts is remarkable considering the substantial differences we previously observed in individual dietary factors and risk between men (HPFS), older women (NHS I), and younger women (NHS II). For example, animal protein intake was associated with a higher risk of kidney stone formation in men[5] but not women.[17,18] Potassium intake was strongly associated with a lower risk of stone formation in men and older women[5,17] but not in younger women.[18] Magnesium intake was associated with lower stone risk in men[16] but not women,[17,18] and phytate was associated with a lower risk of incident kidney stones in younger women[18] but not men.[16]

Several features may account for the uniform impact of a DASH-style diet on stone risk despite the disparate effects of many individual nutrients. First, the DASH diet is rich in calcium, and higher levels of dietary calcium were associated with a reduced risk of kidney stone formation in these cohorts.[5,16–18] However, we observed associations between higher DASH score and reduced stone risk even in study participants with low calcium intake. Thus, it is unlikely that calcium alone mediates the impact of DASH on risk. Second, fruits and vegetables contain a wide array of nutrients that impact stone risk. Although higher levels of potassium in the DASH-style diet may not reduce the risk of kidney stones in younger women, the DASH-style diet also contains large amounts of phytate, a factor in plant matter strongly associated with reduced stone formation in NHS II.[18] The adverse effects of vitamin C on stone risk in men may be offset by the beneficial effects of higher magnesium intake in this cohort.[16] Finally, it is possible the DASH-style diet contains unknown factors affecting stone risk.

The higher oxalate content of the DASH-style diet (because of higher intakes of fruits, vegetables, and nuts) may increase urinary oxalate, which is a major risk factor for calcium oxalate nephrolithiasis.[19,20] However, consumption of fruits and vegetables also increases urinary citrate, an important inhibitor of calcium stones. The elimination of fruits and vegetables from the diet of 12 healthy adults resulted in lower urinary oxalate but also decreased urinary citrate by 44%.[7] Overall, fruit and

Table 4. Quintiles of DASH score and the relative risk of incident kidney stones in men (Health Professionals Follow-up Study), older women (Nurses' Health Study I), and younger women (Nurses' Health Study II)[a]

	DASH Score Quintiles					
	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	*P* for Trend
HPFS						
Median DASH score	16	21	24	27	31	
Cases of new stones	445	416	370	260	226	
Person-years	113,406	123,848	127,562	110,087	112,924	
Age-adjusted RR	1.0	0.89	0.79	0.66	0.57	<0.001
95% CI	(Ref)	(0.78 to 1.02)	(0.68 to 0.90)	(0.56 to 0.77)	(0.49 to 0.68)	
Multivariate RR[b]	1.0	0.89	0.77	0.64	0.55	<0.001
95% CI	(Ref)	(0.77 to 1.01)	(0.67 to 0.89)	(0.54 to 0.74)	(0.46 to 0.65)	
NHS I						
Median DASH score	17	21	24	27	31	
Cases of new stones	452	372	354	259	238	
Person-years	263,851	248,556	279,617	244,572	252,017	
Age-adjusted RR	1.0	0.89	0.76	0.64	0.58	<0.001
95% CI	(Ref)	(0.77 to 1.02)	(0.66 to 0.87)	(0.55 to 0.74)	(0.49 to 0.67)	
Multivariate RR[b]	1.0	0.89	0.76	0.64	0.58	<0.001
95% CI	(Ref)	(0.77 to 1.02)	(0.65 to 0.87)	(0.54 to 0.74)	(0.49 to 0.68)	
NHS II						
Median DASH score	17	21	24	27	31	
Cases of new stones	581	547	411	414	300	
Person-years	229,342	244,892	221,988	233,327	217,330	
Age-adjusted RR	1.0	0.88	0.73	0.71	0.55	<0.001
95% CI	(Ref)	(0.79 to 0.99)	(0.65 to 0.83)	(0.62 to 0.80)	(0.48 to 0.63)	
Multivariate RR[b]	1.0	0.92	0.77	0.75	0.60	<0.001
95% CI	(Ref)	(0.81 to 1.03)	(0.68 to 0.88)	(0.66 to 0.86)	(0.52 to 0.70)	

[a]For illustrative purposes, median DASH scores in HPFS, NHS I, and NHS II are from 1990, 1990, and 1991. However, updated period-specific DASH scores were used in the prospective analyses.
[b]Multivariate model includes age, body mass index, total energy intake, use of thiazide diuretics (yes or no), fluid intake (quintiles), caffeine (quintiles), alcohol use (seven categories), history of hypertension, and history of diabetes.

vegetable restriction increased the urinary relative supersaturation for calcium oxalate by 30%.[7] In addition, we previously reported that higher dietary oxalate was associated with only a modest increase in the risk of kidney stones in men and older women and was not associated with risk in younger women.[15] Thus, it is possible that the higher oxalate in DASH did not substantially impact kidney stone risk. The higher calcium content of the DASH-style diet also may minimize any adverse effect of higher oxalate intake. Previous data suggested that orally administered calcium may bind oxalate in the intestinal tract, thereby reducing oxalate absorption and urinary excretion.[21–23]

The impact of a DASH-style diet on the urinary excretion of calcium, a major risk factor for calcium kidney stone formation, is unclear. Higher calcium intake would be expected to increase urinary calcium, whereas lower sodium, lower animal protein, and higher intake of potassium-rich foods would be expected to decrease it.[2] In the initial trial evaluating the effects of the DASH diet on BP, 24-h urinary calcium on DASH was slightly higher (9 mg/d) than on the control diet.[9] However, the original DASH diet did not restrict sodium intake, and subsequent studies of the DASH diet combined with lower sodium intakes did not report urinary calcium.[24]

Although the majority of incident kidney stones in this study likely were calcium oxalate, a DASH-style diet also may lower the risk of other stone types. By decreasing uric acid production and increasing urinary pH, reducing consumption of animal flesh may decrease the risk of uric acid stones. Higher intake of fruits and vegetables also may raise urine pH and reduce the risk of uric acid crystal formation. Because an increase in urinary pH can increase the risk of calcium phosphate crystal formation, the impact of a DASH-style diet on calcium phosphate kidney stone risk is unclear.

Unique advantages of the DASH diet as a means of kidney stone prevention include beneficial effects on BP[9,24] and cardiovascular risk,[25] all the more important given the link between nephrolithiasis and higher rates of hypertension and other risk factors for coronary heart disease (including diabetes mellitus and larger body size).[10–14,26–28] The DASH diet reduces LDL-cholesterol levels,[29] is promoted by the National Heart, Lung, and Blood Institute for the prevention and treatment of hypertension,[30] and is included as an example of a healthy eating pattern in the 2005 Dietary Guidelines for Americans.[31] Modifications to the original DASH diet, including combining DASH with lower intakes of sodium[24] or reducing the carbohydrate content of DASH with either plant pro-

tein or unsaturated fat (as in the Optimal Macronutrient Intake Trial to Prevent Heart Disease),[32] would be expected to increase (or at least not decrease) the effectiveness of the original DASH diet as a means of stone prevention. The DASH-style diet we analyzed in this study included a low sodium component and emphasized lower carbohydrate intake in the form of lower sweetened beverage consumption.

There are several limitations to this study. First, we did not have stone composition reports from all stone formers and did not determine whether a high DASH score preferentially reduced the risk of certain stone types. Second, we did not examine the impact of DASH score on the urinary excretion of lithogenic factors, including 24-h urine calcium. Third, sodium was not measured well with the FFQ. Thus, it is possible that the impact of higher DASH score on reduced stone risk was greater than we report. Finally, the generalizability of our study may be limited. Only a small proportion of our study population is nonwhite, and we do not have data on stone formation in men <40 yr of age.

In conclusion, consumption of a DASH-style diet was independently associated with a marked decrease in the risk of incident kidney stone formation in three large cohorts. In contrast to our previous studies of individual dietary factors and kidney stone risk in these populations, the impact of a DASH-style diet was similar in men and women, in older and younger individuals, and in participants with both low and high BMI. Although we think it reasonable for calcium oxalate stone formers with high levels of urinary oxalate to avoid intake of some individual foods very high in oxalate (such as spinach and almonds), our data do not support the common practice of dietary oxalate restriction in calcium stone formers, particularly if such advice results in lower intake of fruits, vegetables, and whole grains. Because of the adverse side effect profile of many current medical therapies for nephrolithiasis,[33] a randomized trial is needed to determine the efficacy of a DASH-style diet compared with medical intervention for the secondary prevention of calcium oxalate kidney stones.

CONCISE METHODS

Study Population

HPFS

In 1986, 51,529 male dentists, optometrists, osteopaths, pharmacists, podiatrists, and veterinarians between the ages of 40 and 75 yr enrolled in HPFS by completing and returning an initial questionnaire that provided detailed information on diet, medical history, and medications. This cohort, like NHS I and NHS II, is followed by biennial mailed questionnaires, which include inquiries about newly diagnosed diseases such as kidney stones. We limited the analysis to men who completed at least one dietary questionnaire and excluded participants with a history of kidney stones before 1986. A total of 45,821 men remained in the study group.

NHS I

In 1976, 121,700 female registered nurses between the ages of 30 and 55 yr enrolled in NHS I by completing and returning an initial questionnaire. Because we first asked NHS I participants about their lifetime history of kidney stones in 1992, the current analysis was limited to women who answered questionnaires in 1992 or later. We started follow-up for this study in 1986, when complete dietary information was available, and limited the analysis to women who completed at least one dietary questionnaire. After excluding participants with kidney stones before 1986, our study population included 94,108 women.

NHS II

In 1989, 116,671 female registered nurses between the age of 25 and 42 yr enrolled in NHS II by completing and returning an initial questionnaire. Dietary information was first collected from this cohort in 1991. We limited the analysis to women who completed at least one dietary questionnaire and excluded participants with a history of kidney stones before 1991. A total of 101,837 women remained in the study group.

Person-time follow-up for HPFS, NHS I, and NHS II exceeded 90%.

Assessment of Diet

To assess dietary intake, we used a semiquantitative FFQ that asked about the average use of >130 individual foods and 22 beverages during the previous year. The FFQ also included an open-ended section for food items not specified on the questionnaire. The baseline dietary questionnaires were completed in 1986 (HPFS), 1986 (NHS I), and 1991 (NHS II) and were updated every 4 yr.

Intake of individual dietary factors was computed from the reported frequency of consumption of each specified unit of food and, with the exception of oxalate, from United States Department of Agriculture data on the content of the relevant nutrient in specified portions. The oxalate content of the majority of foods on the FFQ, as well as frequently consumed write-in foods, was measured by capillary electrophoresis in the laboratory of Dr. Ross Holmes.[15,34] The intake of supplements (such as calcium and vitamin C) in multivitamins or isolated form was determined by the brand, type, and frequency of reported use.

Considerable effort has been expended to confirm the validity and reliability of the dietary questionnaire in these cohorts. For example, 127 HPFS participants weighed and recorded all foodstuffs consumed over two 1-wk periods (between 6 and 8 mo apart). The values for individual foods and various nutrients from the food diaries were compared with the values obtained on the questionnaire, and the results were highly correlated.[35,36] Correlations were 0.88 for skim milk, 0.86 for yogurt, 0.95 for bananas, 0.76 for oranges, 0.59 for green peppers, 0.71 for tomatoes, 0.77 for bacon, 0.63 for hamburger, and 0.84 for sugar-sweetened cola.[35] The correlation between total fluid intake as measured by the FFQ and 24-h urine volume was 0.59.[37] In a similar study, dietary intake assessed by the FFQ was compared with four 7-d food records kept by a sample of 194 NHS I participants who weighed and measured everything they ate or drank. The values for individual foods and various nutrients from the food diaries were

compared with the values obtained on the questionnaire, and the results were highly correlated.[38,39] The degree of reproducibility for the FFQ was not modified by obesity or other personal characteristics.

We used the FFQ to measure the dietary components of our DASH score, which we constructed according to food and nutrients emphasized or minimized in the DASH diet. We focused on eight components: high intake of fruits, vegetables, nuts and legumes, low-fat dairy products, and whole grains and low intake of sodium, sweetened beverages, and red and processed meats.[25] The first four components were directly targeted in the DASH diet, which also included lower consumption of red and processed meats and greater consumption of whole grains.[40]

We calculated a participant's DASH score for each FFQ. For each of the components, we classified participants into quintiles according to their intake ranking. The component score for fruits, vegetables, nuts and legumes, low-fat dairy products, and whole grains was the participant's quintile ranking (*i.e.,* quintile 1 was assigned one point and quintile 5 was assigned five points). For sodium, red and processed meats, and sweetened beverages, low intake was desired: the lowest quintile was given a score of five points and the highest quintile a score of one point. We summed up the component scores to obtain an overall DASH score ranging from 8 to 40. Because sodium was not measured well with the FFQ, scoring by quintiles was least prone to misclassification.

Assessment of Nondietary Covariates

For each cohort, information on age, weight, and height was obtained on the baseline questionnaire, and age and weight were updated every 2 yr. Self-reported weight has been validated in HPFS and NHS I.[41] BMI was calculated as the weight in kilograms divided by the square of height in meters. Information on hypertension and diabetes mellitus was obtained from biennial questionnaires. The validity of these self-reported diseases has been documented.[42–44] Updated information on the use of thiazide diuretics also was obtained from biennial questionnaires.

Assessment of Incident Kidney Stones

The primary outcome was an incident kidney stone accompanied by pain or hematuria. Any study participant who reported a new kidney stone on the biennial questionnaire was sent an additional questionnaire to determine the date of occurrence and the symptoms from the stone. In HPFS, we obtained medical records from 582 men who reported a kidney stone, and the diagnosis was confirmed in 95%. There were 148 records that contained a stone composition report and 127 men (86%) had a stone that contained ≥50% calcium oxalate. In NHS I, we obtained medical records from 194 women who reported a kidney stone, and 96% of the records confirmed the diagnosis. There were 78 records that contained a stone composition report, and 60 women (77%) had a stone that contained ≥50% calcium oxalate. In NHS II, we obtained medical records from 858 women who reported a kidney stone and 98% of the records confirmed the diagnosis. There were 243 records that contained a stone composition report, and 191 women (79%) had a stone that contained ≥50% calcium oxalate.

Statistical Analysis

The study design was prospective; information on diet was collected before the diagnosis of the kidney stone. The relative risk was used as the measure of association between quintiles of DASH score and incident kidney stones. The lowest quintile of the DASH score served as the referent group. The Mantel extension test was used to evaluate linear trends across categories of the DASH score.

Dietary exposures were updated every 4 yr. We allocated person-months of follow-up according to exposure status at the start of each follow-up period. If complete information on diet was missing at the start of a time period, the participant was excluded for that time period. For HPFS, person-months of follow-up were counted from the date of the return of the 1986 questionnaire to the date of a kidney stone or death or to January 31, 2004. For NHS I, person-months of follow-up were counted from the date of the return of the 1986 questionnaire to the date of a kidney stone or death or to May 31, 2004, whichever came first. For NHS II, person-months of follow-up were counted from the date of the return of the 1991 questionnaire to the date of a kidney stone or death or to May 31, 2005.

We used Cox proportional hazards regression to estimate the relative risk for incident kidney stones in multivariate analyses. Variables included in the multivariate models were age (continuous), BMI (six categories), total energy intake (quintiles), use of thiazide diuretics (yes or no), fluid intake (quintiles), caffeine (quintiles), alcohol use (seven categories), history of hypertension, and history of diabetes.

We calculated 95% CIs for all relative risks. All *P* values are two tailed. Data were analyzed by using SAS software, version 9.1 (SAS Institute, Cary, NC). The research protocol for this study was reviewed and approved by the institutional review board of Brigham and Women's Hospital.

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DISCLOSURES

None.

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