



DASH (Dietary Approaches to Stop Hypertension) Diet and Risk of Subsequent Kidney Disease

Casey M. Rebholz, PhD, MS, MPH,^{1,2} Deidra C. Crews, MD, ScM,^{1,3}
Morgan E. Grams, MD, PhD, MHS,^{1,2,3} Lyn M. Steffen, PhD, MPH, RD,⁴
Andrew S. Levey, MD,⁵ Edgar R. Miller III, MD, PhD,^{1,6}
Lawrence J. Appel, MD, MPH,^{1,2,6} and Josef Coresh, MD, PhD, MHS^{1,2,6}

Background: There are established guidelines for recommended dietary intake for hypertension treatment and cardiovascular disease prevention. Evidence is lacking for effective dietary patterns for kidney disease prevention.

Study Design: Prospective cohort study.

Setting & Participants: Atherosclerosis Risk in Communities (ARIC) Study participants with baseline estimated glomerular filtration rate (eGFR) ≥ 60 mL/min/1.73 m² (N = 14,882).

Predictor: The Dietary Approaches to Stop Hypertension (DASH) diet score was calculated based on self-reported dietary intake of red and processed meat, sweetened beverages, sodium, fruits, vegetables, whole grains, nuts and legumes, and low-fat dairy products, averaged over 2 visits.

Outcomes: Cases were ascertained based on the development of eGFRs < 60 mL/min/1.73 m² accompanied by $\geq 25\%$ eGFR decline from baseline, an *International Classification of Diseases, Ninth/Tenth Revision* code for a kidney disease–related hospitalization or death, or end-stage renal disease from baseline through 2012.

Results: 3,720 participants developed kidney disease during a median follow-up of 23 years. Participants with a DASH diet score in the lowest tertile were 16% more likely to develop kidney disease than those with the highest score tertile (HR, 1.16; 95% CI, 1.07–1.26; *P* for trend < 0.001), after adjusting for sociodemographics, smoking status, physical activity, total caloric intake, baseline eGFR, overweight/obese status, diabetes status, hypertension status, systolic blood pressure, and antihypertensive medication use. Of the individual components of the DASH diet score, high red and processed meat intake was adversely associated with kidney disease and high nuts, legumes, and low-fat dairy products intake was associated with reduced risk for kidney disease.

Limitations: Potential measurement error due to self-reported dietary intake and lack of data for albuminuria.

Conclusions: Consuming a DASH-style diet was associated with lower risk for kidney disease independent of demographic characteristics, established kidney risk factors, and baseline kidney function. Healthful dietary patterns such as the DASH diet may be beneficial for kidney disease prevention.

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Editorial, p. 828

The Dietary Approaches to Stop Hypertension (DASH) diet, a dietary pattern that is high in fruits, vegetables, and low-fat dairy products, substantially decreases blood pressure.¹ The

addition of sodium reduction to the DASH diet further lowers blood pressure and reduces the risk for hypertension, type 2 diabetes, cardiovascular disease, stroke, and mortality.^{1–6} The DASH diet has been recommended by multiple clinical guidelines for health promotion and disease prevention.^{7–11}

From the ¹Welch Center for Prevention, Epidemiology, and Clinical Research; ²Department of Epidemiology, Johns Hopkins Bloomberg School of Public Health; ³Division of Nephrology, Department of Medicine, Johns Hopkins School of Medicine, Baltimore, MD; ⁴Division of Epidemiology & Community Health, University of Minnesota School of Public Health, Minneapolis, MN; ⁵William B. Schwartz Division of Nephrology, Department of Medicine, Tufts Medical Center, Boston, MA; and ⁶Division of General Internal Medicine, Department of Medicine, Johns Hopkins School of Medicine, Baltimore, MD.

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Address correspondence to Casey M. Rebholz, PhD, MS, MPH, Johns Hopkins Bloomberg School of Public Health, Department of Epidemiology, Welch Center for Prevention, Epidemiology, and Clinical Research, 2024 E Monument St, Ste 2-600, Baltimore, MD 21287. E-mail: crebhol1@jhu.edu

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Although treatment of traditional cardiovascular risk factors such as hypertension and diabetes is the primary approach to prevent kidney disease, evidence for dietary approaches to prevent kidney disease is lacking. Current clinical guidelines focus primarily on dietary restriction of protein and sodium to prevent kidney disease progression, but the evidence supporting this suggestion is weak (graded as level 2B).¹² A comprehensive approach, such as that prescribed in the DASH diet, may be more meaningful given that nutrients are likely have additive or synergistic effects.¹³ Furthermore, dietary patterns rather than nutrient restriction may be easier to implement given the success of the DASH diet for the prevention and treatment of other chronic conditions.¹⁴

Previous research has demonstrated a significant association between the DASH diet and kidney function reduction in older white women.^{15,16} The objective of this study was to assess the longitudinal relationship between consuming a DASH-style diet with sodium reduction and subsequent risk for kidney disease in a more diverse general population sample, including African American and white men and women. Elucidating this relationship could inform the use of dietary modification as a preventative strategy for kidney disease.

METHODS

Study Population and Design

We conducted a prospective analysis of the Atherosclerosis Risk in Communities (ARIC) Study.¹⁷ The ARIC Study is a community-based observational study of 15,792 middle-aged (45–64 years) predominantly African American and white men and women. Study participants were enrolled in 1987 to 1989 from 4 US communities: Forsyth County, NC; Jackson, MS; suburbs of Minneapolis, MN; and Washington County, MD. Follow-up study visits occurred in 1990 to 1992 (study visit 2), 1993 to 1995 (study visit 3), 1996 to 1998 (study visit 4), and 2011 to 2013 (study visit 5). The institutional review board (IRB) at each site approved the study protocol and study participants provided informed consent at each study visit (IRB #H.34.99.07.02.A1). After excluding participants with missing dietary intake data ($n = 18$), implausibly low caloric intake (<600 kcal for men and <500 kcal for women; $n = 149$), and implausibly high caloric intake ($>4,200$ kcal for men and $>3,600$ kcal for women; $n = 152$), those with baseline estimated glomerular filtration rates (eGFRs) < 60 mL/min/1.73 m² or end-stage renal disease identified by linkage to the US Renal Data System (USRDS) registry ($n = 356$), those who were neither African American nor white ($n = 48$), and those with missing covariates ($n = 187$), our analytic sample size was 14,882 (Fig S1, available as online supplementary material).¹⁸

Measurement of Dietary Intake

Usual dietary intake was assessed at study visits 1 (baseline, 1987–1989) and 3 (1993–1995) using a semiquantitative 66-item food frequency questionnaire, modified from the Willett questionnaire.^{19–21} The questionnaire was administered in person by a trained interviewer with visual representations of portions

(glasses and measuring cups of different sizes). Participants reported how often on average they consumed each food item of a particular portion size in the preceding year. Nutrient intake was calculated by multiplying self-reported frequency of consumption and portion size by the nutritional content of each food item from US Department of Agriculture data sources. The reliability of these diet data was previously assessed in a randomly selected subset of participants from all 4 sites who repeated the food frequency questionnaire at a follow-up visit (study visit 2, 1990–1992; $n = 419$).¹⁹ For the analysis, we incorporated the 2 measurements of dietary intake (baseline and visit 3) by using the cumulative average diet, which improves estimation of usual dietary intake relative to a single measurement.²² That is, for those who developed kidney disease or were censored between baseline and visit 3, baseline dietary intake data are used. Otherwise, for those who developed kidney disease or were censored after visit 3, the mean of values from baseline and visit 3 is used.

Definition of DASH Diet Score

We assessed the degree to which study participants followed a DASH-style diet with reduced sodium using 2 previously developed indexes.^{4,16,23,24} Study participants were not advised to follow a DASH diet, DASH diet results had not been published by the time of dietary assessment, and study participants did not receive dietary counseling. The primary analysis used a score based primarily on food items: low intake of (1) red and processed meat, (2) sweetened beverages, and (3) sodium, as well as high intake of (4) fruits, (5) vegetables, (6) whole grains, (7) nuts and legumes, and (8) low-fat dairy (Table S1).⁴ Each component was scored from 1 to 5 based on ranked distribution in quintiles, which is ideally suited to this analysis because the food frequency questionnaire is designed to rank individuals on dietary intake rather than quantify absolute nutrient intake levels.

In sensitivity analyses, we used an alternative score based on 9 nutrients: low intake of (1) saturated fat, (2) total fat, (3) cholesterol, and (4) sodium and high intake of (5) protein, (6) fiber, (7) magnesium, (8) calcium, and (9) potassium (Table S2).^{16,23,24} For the purposes of our study, the food item–based score and the nutrient-based score were both analyzed as tertiles. Higher score signifies that a participant's dietary pattern more closely resembles a DASH-style diet. Mean levels of DASH diet scores and individual components of the DASH diet scores for the overall study population and by case status are presented in Table S3.

Ascertainment of Kidney Disease

Blood creatinine was measured using the modified kinetic Jaffé method, standardized to the National Institute of Standards and Technology standard, and calibrated to account for laboratory drift.^{25,26} Kidney function was assessed using the 2009 CKD-EPI (Chronic Kidney Disease Epidemiology Collaboration) creatinine equation for eGFR.²⁷ Measurement of urine albumin-creatinine ratio was not available in this study and thus was not included in the composite outcome variable.

Kidney disease cases were ascertained by meeting at least one of the following criteria: (1) eGFR < 60 mL/min/1.73 m² accompanied by $\geq 25\%$ eGFR decline at any follow-up study visit relative to baseline, (2) kidney disease–related hospitalization or death based on *International Classification of Diseases, Ninth/Tenth Revision* codes identified through active surveillance and linkage to the National Death Index, or (3) end-stage renal disease (dialysis or transplantation) identified by linkage to the USRDS registry between baseline (study visit 1, 1987–1989) and December 31, 2012. This outcome was designed to mitigate potential selection bias by disease status and allow for more complete outcome ascertainment during periods between study visits. As a

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