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Food Groups and Renal Cell Carcinoma: Results from a Case-Control Study

SUZANNE M. DOLWICK GRIEB, MSPH; RYAN P. THEIS, MPH; DEBORAH BURR, PhD; DAN BENARDOT, PhD, RD; TARIQ SIDDIQUI, MD; NABIH R. ASAL, PhD

ABSTRACT

Background The role of diet in renal cell carcinoma risk has been inconclusive. This study uses an integrative approach to assess the role of food groups and food items in renal cell carcinoma risk.

Design A case-control study was conducted from 2003-2006.

Subjects/setting Incident cases (n=335) were identified from hospital records and the Florida cancer registry, and population controls (n=337) frequency matched by age (±5 years), sex, and race were identified through random-digit dialing. Eating habits were assessed through the use of the 70-item Block food frequency questionnaire.

Statistical analyses Odds ratios (ORs), 95% confidence intervals (CIs), and tests for trends were calculated using logistic regression, controlled for age, sex, race, income, body mass index, and pack-years of smoking.

Results Decreased renal cell carcinoma risk was observed among the total sample and for men for vegetable consumption (all subjects: OR 0.56, 95% CI 0.35, 0.88; men: OR 0.49, 95% CI 0.25, 0.96) but not for fruit consumption. Tomato consumption decreased renal cell carcinoma risk for the total population and for men (all subjects: OR 0.50, 95% CI 0.31, 0.81; men: OR 0.47, 95% CI 0.24, 0.95). Increased risk of renal cell carcinoma was observed among all subjects and among women with increased consumption of red meat (all subjects: OR 4.43, 95% CI 2.02, 9.75; women: OR 3.04, 95% CI 1.60, 5.79). White bread consumption increased renal cell carcinoma risk among women only (OR 3.05, 95% CI 1.50, 6.20), as did total dairy consumption (OR 2.36, 95% CI 1.21, 4.60).

Conclusions The protective role of vegetables and the increased risk of renal cell carcinoma with meat consumption are supported. The protective role of fruits is not. Novel findings include the increased risk of renal cell carcinoma with white bread and white potato consumption and the decreased risk of renal cell carcinoma with tomato consumption.

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S. M. D. Grieb and R. P. Theis are research assistants, D. Burr is an associate professor, and N. R. Asal is a professor, all with the Department of Epidemiology and Biostatistics, College of Public Health and Health Professionals, and T. Siddiqui is a professor with the Hematology and Oncology Division, Department of Medicine, College of Medicine, University of Florida, Gainesville. D. Benardot is an associate professor with the College of Health and Human Sciences, Georgia State University, Atlanta.

Address correspondence to: Nabih R. Asal, PhD, College of Public Health and Health Professions, University of Florida, PO Box 100231, Room 3110, 101 S Newell Dr, Gainesville, FL 32610-0231. E-mail: asal@phhp.ufl.edu

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In 2002 there were more than 208,000 new cases of kidney cancer worldwide. Of these, almost 140,000 occurred in developed countries, including 36,000 in the United States (1). The American Cancer Society projects that 54,390 new kidney and pelvis cancer cases will be diagnosed in the United States in 2008 (2). Renal cell carcinoma accounts for approximately 85% of all malignant neoplasms of the kidneys in the United States, and has continued to rise in incidence among both men and women during the past three decades (3). Although incident detection of renal cell carcinoma has improved with increased use of imaging procedures, improved detection cannot fully explain these observed trends (4). Furthermore, only 2% of renal cell carcinoma cases can be attributed to genetic predisposition, suggesting that the secular trends are largely environmental in etiology (3). Research regarding risk factors for renal cell carcinoma has often been inconclusive, and to date, the most established risk factors are cigarette smoking and obesity (5,6). These two risk factors are associated with approximately 30% and 20% of all renal cell carcinoma cases, respectively (3).

Diet has also been implicated in the etiology of renal cell carcinoma. In a review of the general causes of cancer, the American Institute for Cancer Research and the

World Cancer Research Fund estimated that 30% to 40% of all cancers can be prevented through consumption of risk-lowering diets, physical activity, and the maintenance of a healthful body weight (7). Diet was not considered for renal cell carcinoma specifically in this report, although other investigations have considered the role of diet and nutrient intake in the development of renal cell carcinoma with inconclusive results (8-15).

Schatzkin and colleagues (16) suggest two alternative conceptual frameworks for analyzing nutritional factors and cancer: a decompositional approach focusing on the specific nutrients that constitute foods, based on the idea that individual nutrients will have different biochemical effects in the body; and an integrative approach focusing on whole foods, food groups, or food patterns, based on the fact that diets involve the consumption of food items containing hundreds of individual nutrients or chemicals that interact with each other.

This article reports findings from a population-based case-control study of renal cell carcinoma in Florida and Georgia and considers the role of diet on renal cell carcinoma risk. Specifically, an integrative approach is used, focusing on the role of food groups and food items on renal cell carcinoma. Dairy, vegetables, fruits, grains, and meat items are considered. It was hypothesized that increased fruit and vegetable consumption would reduce the risk of renal cell carcinoma whereas increased meat consumption, particularly red meat consumption, would increase renal cell carcinoma risk.

METHODS

Study Population

Ethical approval for this study was obtained from the institutional review boards of the University of Florida (IRB-01), the Florida Department of Health, Emory University, and Georgia State University. Incident, histologically confirmed cases of renal cell carcinoma were identified from hospital records in three participating hospitals in North Florida and Georgia and through the Florida Cancer Data System registry. All cases were considered for inclusion if older than age 20 years and if renal cell carcinoma diagnosis occurred between January 1, 2000, and December 31, 2004. This time frame was selected to allow for an adequate sample of cases and controls to be identified, consented, and interviewed given the budget and challenges of identifying cases and controls. Cases were not eligible for inclusion if their cancer was diagnosed in a transplant kidney or if their listed residence was not in Florida or Georgia. Among 459 living, eligible cases who could be contacted, 316 (69%) agreed to participate and were interviewed in person by trained personnel. An additional 19 cases were included from hospitals and privately practicing urologists in North and Central Florida and Georgia. The number of eligible cases who were initially contacted in these additional locations is unknown and a corresponding response rate could not be calculated. In all, the total sample included 335 cases.

A sample of population controls was identified using random-digit dialing methodology (17), frequency-matched to cases by age (±5 years), sex, and race. Frequencies for matching were initially derived from publicly accessible Surveillance, Epidemiology, and End Results (18) data until the Florida Cancer Data System registry was made available. All respondents were considered eligible as controls if they met the study's matching criteria and reported having never been diagnosed with kidney cancer or kidney disease. Among 801 eligible respondents who could be contacted by telephone, 337 (42%) participated as controls.

Measurements

Participating cases and controls were interviewed in person by study personnel. All personnel had a master's degree in public health or were current graduate students studying epidemiology. Each interviewer was trained in epidemiologic interviewing, dietary assessment, and anthropometry and completed an observational period. All interviews with cases and controls were conducted by two personnel under similar conditions. Data were collected using a structured questionnaire thus minimizing the potential for interviewer bias by personnel who were not blinded to the case or control status of subjects. Data collected included demographic information; medical, occupational, and family histories; lifetime use of medications; lifetime consumption of tobacco, coffee, tea, and artificial sweeteners; and lifetime exposure to radiation, pesticides and environmental tobacco smoke. Age, sex, and race were part of the sampling criteria and thus were identified at the time of case and control identification. Age at interview was identified as well as age of diagnosis among cases. All other variables were collected in-person by self-report. Total household income was collected as a range. Education level was collected as the highest grade or year of school attended. An ever-smoker was defined as smoking 100 or more cigarettes in a person's lifetime. Family history of kidney disease was collected for all biological family members. Body mass index (BMI) was calculated by measuring the subject's height in centimeters (without shoes) and weight in kilograms (dressed, but with ancillary items removed) at the time of interview using a digital scale (TANITA BF-350 Body Composition Analyzer/Scale, TANITA Corporation of America, Arlington Heights, IL). Physical activity, thought to be correlated with obesity, was not considered in our study.

Dietary information was collected using a 70-item Block food frequency questionnaire (FFQ), which assesses past nutritional intake for a single 1-year period—generally the year before the interview. The average long-term diet was considered as this is the more important exposure for disease outcomes than intake on a few specific days (19). This FFQ was developed from large national dietary surveys such as the National Health and Nutrition Examination Survey and has been validated against multiple diet records for use in epidemiologic studies (20). The FFQ estimates usual dietary intake, providing a measure of the average daily intake of 70 food items and nutrients, including vitamin and mineral supplements, alcohol consumption (wine, beer, and liquor) and use of cooking oil. The questionnaire is accompanied by a visual aid handout for estimating portion sizes. From this information on specific food items and sizes, average daily consumption of food groups and average daily energy intake were calculated. All control and most case subjects were asked to respond to food frequency and

amount questions for the year before the interview, maximizing the potential for accuracies in recall. However, to avoid misclassification errors, cases were first asked whether their diet had changed significantly since their cancer diagnosis and treatment. Those who indicated a significant change in diet since diagnosis were asked to respond to the FFQ for the year before diagnosis. Recall period was therefore variable between cases and controls on a contingent basis, with all controls indicating dietary patterns no greater than 1 year before the interview, and some cases indicating dietary patterns up to 7 years before the interview. Although this produced the potential for recall bias—in which cases with longer recall periods reported less accurate dietary estimates—this was considered an acceptable risk for the benefit of avoiding misclassification errors. The literature suggests, however, that general diet patterns may be recalled up to approximately 10 years while maintaining acceptable levels of misclassification (19).

Statistical Methodology

Univariate descriptive statistics were computed for demographic variables and risk factors. These are compared for cases vs controls using *t* tests for continuous variables and χ^2 tests for categorical variables.

Separate multivariate, unconditional logistic regression models were fit for the average daily consumption of five main food groups: dairy, vegetables, fruit, grains, and meat and proteins. Each multivariate model included age, sex, race, income, BMI, and pack-years of smoking (defined as defined as smoking one pack per day for 1 year) to control for potential confounders. Estimated effects of risk factors are estimated odds ratios from a model with categorical versions of the risk factor; the second, third, and fourth quartiles are compared to the first or lowest quartile of risk. Tests for trend are also reported from the χ^2 test for the risk factor in the same multivariate model except with the continuous version of the risk factor.

The effects of specific food items were also estimated, using the same multivariate logistic regression modeling method as for the food groups. In this case, consumption of each food item was classified using the following categories: less than once a week (including never), once a week, twice a week, three to four times a week, and five or more times a week. For some food groups, the last two categories were combined because of a lack of adequate cell counts. Thus, where indicated only, some food items were classified as follows: less than once a week (including never), once a week, twice a week, and three or more times a week. The referent group was the lowest frequency (less than once a week). Tests for trend are also reported from the χ^2 test for the risk factor in the same multivariate model except with the continuous version of the risk factor.

All multivariate analyses were performed two times: for the total sample and stratified by sex. For both univariate and multivariate analyses, a *P* value of 0.05 was used as the cutoff for declaring a result statistically significant. All statistical analyses were performed using SPSS (version 14.0, 2005, SPSS Inc, Chicago, IL).

Table 1. Selected demographic characteristics and risk factors for renal cell carcinoma among cases with renal cell carcinoma and matched controls

Characteristic	Cases (%) n	%	Controls (%) n	%	Pearson χ^2	*P* value
Sex					0.22	0.64
Males	181	54	176	52		
Females	154	46	161	48		
Race					0.05	0.85
White	262	78	266	79		
African-American	73	22	71	21		
Age at interview (y)					13.93	0.008
$<$50	27	8.1	59	17.5		
50-59	64	19.1	62	18.4		
60-69	108	32.2	101	30.0		
70-79	95	28.4	81	24.0		
$>$80	41	12.2	34	10.1		
Income					9.00	0.34
$<$$10,000	19	5.9	25	7.5		
$10,000-$<$$15,000	19	5.9	20	6.0		
$15,000-$<$$20,000	19	5.9	28	8.4		
$20,000-$<$$25,000	41	12.7	24	7.2		
$25,000-$<$$35,000	48	14.8	44	13.3		
$35,000-$<$$50,000	59	18.2	54	16.3		
$50,000-$<$$75,000	58	17.9	65	19.6		
$>$$75,000	53	16.4	65	19.6		
Unsure	8	2.5	7	2.1		
Education					3.67	0.16
Less than high school	41	12.3	28	8.3		
High school diploma	184	55.1	183	54.3		
Bachelor's or higher	109	32.6	126	37.4		
Body mass index					9.99	0.04
$>$18.5	1	0.3	6	1.8		
18.5-24.9	50	14.9	70	20.9		
25-29.9	118	35.2	123	36.7		
30-39.9	135	40.3	111	33.1		
$\geq$40	31	9.3	25	7.5		
Smoking					0.06	0.80
Never smoker	130	38.8	134	39.8		
Ever smoker	205	61.2	203	60.2		
Family history of kidney disease					3.31	0.07
No	276	94.8	294	97.7		
Yes	15	5.2	7	2.3		
Total energy intake (kcal/d)					1.32	0.72
$<$1,300	76	22.9	88	26.4		
1,300-1,699	88	26.5	85	25.5		
1,700-2,199	83	25.0	83	24.9		
$>$2,200	85	25.6	77	23.1		

RESULTS

Table 1 shows the distribution of the 335 cases and 337 controls on selected demographic variables and risk factors for renal cell carcinoma. Cases and controls did not differ significantly with respect to sex, race, income, education, ever-smoking, family history of kidney disease, or average daily energy intake. However, controls were

significantly younger than cases (mean age 62 vs 66 years)—a difference that is notably evident among those subjects younger than age 50 years, representing 17.5% of controls and 8.1% of cases. This outcome resulted from initially using Surveillance, Epidemiology, and End Results data for the frequencies for matching. Once the Florida Cancer Data System registry was available it was recognized that the Florida case distribution differed slightly from the national distribution represented in the Surveillance, Epidemiology, and End Results data. BMI at time of interview was significantly higher among cases than controls. Although cases and controls were equally likely to be ever-smokers (defined as 100 or more cigarettes in lifetime), cases had greater lifetime cigarette consumption in pack-years (20.25 and 14.75, respectively; $t=-2.83$, $P=0.005$). Because of these findings, subsequent adjusted models were controlled for BMI and smoking.

Dairy Product and Egg Consumption and Renal Cell Carcinoma

When analyzed as a food group, dairy was not associated with renal cell carcinoma risk in the total study sample. Women were observed to have a significantly increased risk of renal cell carcinoma with total dairy consumption. Results for total dairy intake and specific significant dairy products are presented in Table 2 and Table 3, respectively. A significant direct trend was observed for butter among the total study sample and for low-fat and nonfat milk among women. No significant associations were observed for renal cell carcinoma and consumptions of eggs, cheese, milk (all types), and ice cream or frozen yogurt.

Vegetable and Fruit Consumption and Renal Cell Carcinoma

Daily total consumption of vegetables significantly reduced risk of renal cell carcinoma in the total sample and among men. Daily servings of any fruit (including fruit juices) was not significantly associated with renal cell carcinoma. Significant results for total vegetable and total fruit intake and for specific types of vegetables and fruits are presented in Table 2 and Table 4, respectively. A significant decrease in risk was observed with increased consumption of spinach and other greens and tomatoes among the total study sample and among men. Consumption of white potatoes was associated with increased risk of renal cell carcinoma for both fried potatoes and nonfried potatoes (including boiled, baked, and mashed potatoes and/or potato salads) among the total sample and among women. Increased apple and pear consumption decreased renal cell carcinoma risk among men only. Although a significant direct negative trend was not observed for broccoli consumption and renal cell carcinoma risk, consuming broccoli three or more times a week was associated with decreased risk of renal cell carcinoma compared to persons eating broccoli less than once a week among the total sample. No significant associations were found between renal cell carcinoma risk and consumption of cabbage (including cole slaw), bananas, citrus fruit (including oranges and tangerines but not their juices), carrots or yams, and sweet potatoes.

Grain Consumption and Renal Cell Carcinoma

Overall daily servings of grains was not significantly associated with renal cell carcinoma risk for the total study sample or for men. Significant risk increases were observed for grain consumption among women only. Results for total grain consumption and significant results for specific types of grain products are presented in Table 2 and Table 5, respectively. Increased consumption of white bread or toast (including French or Italian loaf breads) was significantly associated with increased risk of renal cell carcinoma in the total study sample. In stratified analyses this was also observed for women. Positive associations were also found with increased consumption of pastries, cakes, doughnuts, and pies, biscuits and muffins, and rolls (including hamburger buns, English muffins, and bagels). No significant associations were found between renal cell carcinoma risk and consumption of dark breads (such as rye or whole wheat, including toasted) or pasta with tomato sauces (including, for example, spaghetti or lasagna).

Meat Consumption and Renal Cell Carcinoma

Total average daily consumption of proteins (including all meats, beans and eggs) was not significantly associated with renal cell carcinoma. Results for total protein intake and significant results for various types of meats and meat products are presented in Table 2 and Table 6, respectively. A significant increase in risk was observed with increased red meat consumption (including beef steaks, pot roasts, and ground meat) and fried chicken and fish consumption among the total sample and among women. A significant increased risk was also observed for women with increased consumption of bacon and breakfast sausages. Although a significant direct negative trend was not observed for chicken consumption (excluding fried chicken) and renal cell carcinoma risk, consuming chicken three or more times a week was associated with decreased risk in renal cell carcinoma compared to persons eating chicken less than once a week. No significant associations were found between renal cell carcinoma risk and consumption of lunchmeat, pork (including chops, roasts or dinner ham), or fish (excluding fried fish).

DISCUSSION

Results from this population-based case-control study support previous observations that link diet and renal cell carcinoma risk from both case-control and cohort studies. In general, further evidence is provided linking decreased risk of renal cell carcinoma with increased vegetable consumption (8-15,21). Analyzing data from prospective studies, Lee and colleagues (22) found an inverse relationship for total vegetable consumption and renal cell carcinoma among men only (P for trend=0.02). Total vegetable intake was not significantly associated with renal cell carcinoma among women (22). Specifically, decreased risk has been observed for dark green vegetables (9,10,14,15,18,22) and cruciferous vegetables (8,14,15). Our study found these to be significant among men but not for women. A similar study from Denmark employing 351 cases and 340 controls also did not find a significant

Table 2. Adjusted odds ratio (AOR)[a], 95% confidence intervals (CIs), and tests for trend for renal cell carcinoma by consumption frequency of different food groups

Food group	Quartile of Intake				
	1st quartile[b]	2nd quartile	3rd quartile	4th quartile	*P* for trend
Dairy					
Total					
No. cases	96	84	68	84	
No. controls	88	99	70	76	
AOR (95% CI)	1.00	0.83 (0.54,1.28)	0.87 (0.54,1.39)	1.11 (0.70,1.74)	0.32
Men					
No. cases	54	32	42	40	
No. controls	38	37	39	54	
AOR (95% CI)	1.00	0.60 (0.31,1.18)	0.72 (0.38,1.39)	0.56 (0.30,1.07)	0.18
Women					
No. cases	38	32	32	49	
No. controls	48	52	32	28	
AOR (95% CI)	1.00	0.80 (0.42,1.52)	1.19 (0.60,2.34)	2.36 (1.21,4.60)	0.01
Vegetables					
Total					
No. cases	92	94	82	64	
No. controls	76	71	91	95	
AOR (95% CI)	1.00	1.13 (0.72,1.78)	0.80 (0.51,1.25)	0.56 (0.35,0.88)	0.04
Men					
No. cases	51	52	44	34	
No. controls	38	38	42	54	
AOR (95% CI)	1.00	1.15 (0.60,2.19)	0.81 (0.42,1.55)	0.49 (0.25,0.96)	0.04
Women					
No. cases	41	48	31	32	
No. controls	38	37	41	45	
AOR (95% CI)	1.00	1.16 (0.62,2.19)	0.75 (0.39,1.46)	0.66 (0.34,1.25)	0.55
Fruit					
Total					
No. cases	91	84	83	74	
No. controls	84	88	83	78	
AOR (95% CI)	1.00	0.77 (0.50,1.21)	0.83 (0.53,1.30)	0.73 (0.46,1.17)	0.24
Men					
No. cases	51	38	46	46	
No. controls	43	46	43	40	
AOR (95% CI)	1.00	0.54 (0.28,1.03)	0.80 (0.42,1.50)	0.77 (0.40,1.48)	0.62
Women					
No. cases	40	40	36	35	
No. controls	41	39	38	43	
AOR (95% CI)	1.00	1.00 (0.53,1.89)	0.87 (0.45,1.67)	0.71 (0.37,1.39)	0.24
Grains					
Total					
No. cases	73	78	90	91	
No. controls	93	93	78	69	
AOR (95% CI)	1.00	1.07 (0.69,1.67)	1.52 (0.96,2.39)	1.88 (1.17,3.02)	0.16
Men					
No. cases	42	50	43	46	
No. controls	49	42	40	41	
AOR (95% CI)	1.00	1.33 (0.72,2.46)	1.35 (0.72,2.54)	1.44 (0.74,2.81)	0.99
Women					
No. cases	35	37	36	43	
No. controls	43	46	39	33	
AOR (95% CI)	1.00	1.00 (0.53,1.90)	1.15 (0.60,2.22)	1.86 (0.95,3.62)	0.03
Protein[c]					
Total					
No. cases	91	77	86	78	

(continued)

Table 2. Adjusted odds ratio (AOR)[a], 95% confidence intervals (CIs), and tests for trend for renal cell carcinoma by consumption frequency of different food groups (continued)

	Quartile of Intake				
Food group	**1st quartile[b]**	**2nd quartile**	**3rd quartile**	**4th quartile**	***P* for trend**
No. controls	97	82	70	84	
AOR (95% CI)	1.00	1.05 (0.68,1.64)	1.39 (0.88,2.19)	1.00 (0.63,1.61)	0.96
Men					
No. cases	42	50	43	46	
No. controls	49	42	40	41	
AOR (95% CI)	1.00	1.08 (0.58,2.01)	0.82 (0.43,1.55)	0.75 (0.38,1.46)	0.25
Women					
No. cases	35	37	36	43	
No. controls	43	46	39	33	
AOR (95% CI)	1.00	1.11 (0.60,2.08)	1.59 (0.82,3.09)	1.51 (0.78,2.90)	0.18

[a]Estimates from unconditional logistic regression, controlled for age at interview, sex, race, income, body mass index, and pack-years of smoking.
[b]Reference category.
[c]Includes all meats, beans, and eggs.
NOTE: Information from this table is available online at www.adajournal.org as part of a PowerPoint presentation.

Table 3. Adjusted odds ratio (AOR)[a], 95% confidence intervals (CIs), and tests for trend for renal cell carcinoma by consumption frequency of different types of diary products

	Category of Consumption					
Dairy product	**Less than once a week[b]**	**Once a week**	**Twice a week**	**3-4 times a week**	**5 or more times a week**	***P* for trend**
Butter						
Total						
No. cases	200	25	23	28	57	
No. controls	221	28	18	31	34	
AOR (95% CI)	1.00	1.06 (0.58,1.92)	1.46 (0.75,2.82)	1.02 (0.58,1.80)	1.94 (1.19,3.16)	0.03
Men						
No. cases	104	18	12	15	32	
No. controls	117	14	6	15	19	
AOR (95% CI)	1.00	1.66 (0.75,3.70)	2.36 (0.82,6.77)	1.10 (0.49,2.43)	1.80 (0.92,3.50)	0.08
Women						
No. cases	96	7	11	13	25	
No. controls	104	14	12	16	156	
AOR (95% CI)	1.00	0.55 (0.21,1.47)	0.95 (0.39,2.31)	0.91 (0.41,2.05)	1.95 (0.94,4.03)	0.30
Low- and nonfat milk[c]						
Total						
No. cases	79	21	17	32	91	
No. controls	103	18	15	30	82	
AOR (95% CI)	1.00	1.68 (0.81,3.50)	1.31 (0.60,2.86)	1.25 (0.68,2.30)	1.34 (0.86,2.11)	0.13
Men						
No. cases	42	10	11	17	45	
No. controls	46	11	15	17	45	
AOR (95% CI)	1.00	1.32 (0.46, 3.81)	2.11 (0.64, 6.98)	0.90 (0.37, 2.16)	0.99 (0.51,1.92)	0.74
Women						
No. cases	37	11	6	15	46	
No. controls	57	7	10	13	37	
AOR (95% CI)	1.00	2.50 (0.86,7.25)	0.87 (0.29,2.64)	1.70 (0.71,4.06)	1.80 (0.96,3.38)	0.02

[a]Estimates from unconditional logistic regression, controlled for age at interview, sex, race, income, body mass index, and pack-years of smoking.
[b]Reference category.
[c]Excludes whole-milk drinkers.

Table 4. Adjusted odds ratio (AOR)[a], 95% confidence intervals (CIs), and tests for trend for renal cell carcinoma by consumption frequency of different types of vegetables and fruits

	Category of Consumption					
Vegetable or fruit item	**Less than once a week[b]**	**Once a week**	**Twice a week**	**3-4 times a week**	**5 or more times a week**	***P* for trend**
Fried potatoes[c]						
Total						
No. cases	170	72	48	43	—	
No. controls	213	59	27	34		
AOR (95% CI)	1.00	1.65 (1.08,2.52)	2.40 (1.39,4.15)	2.05 (1.19,3.53)	—	<0.001
Men						
No. cases	83	40	30	28		
No. controls	95	39	20	18	—	
AOR (95% CI)	1.00	1.29 (0.73,2.28)	1.85 (0.92,3.72)	2.07 (1.00,4.30)	—	0.01
Women						
No. cases	87	32	18	15	—	
No. controls	118	20	7	16		
AOR (95% CI)	1.00	2.46 (1.29,4.70)	4.20 (1.60,11.05)	2.00 (0.86,4.65)	—	<0.001
White potatoes (excluding fried varieties)						
Total						
No. cases	105	79	74	58	17	
No. controls	151	71	64	33	14	
AOR (95% CI)	1.00	1.63 (1.07,2.50)	1.59 (1.03,2.46)	2.56 (1.51,4.33)	1.57 (0.70,3.50)	0.02
Men[c]						
No. cases	62	43	34	42	—	
No. controls	71	43	35	23		
AOR (95% CI)	1.00	1.08 (0.60,1.95)	1.08 (0.57,2.04)	1.96 (1.00.3.83)	—	0.14
Women[c]						
No. cases	43	36	40	33	—	
No. controls	80	28	29	24		
AOR (95% CI)	1.00	2.71 (1.42,5.20)	2.55 (1.37,4.76)	2.74 (1.40,5.49)	—	0.01
Broccoli[c]						
Total						
No. cases	169	73	58	33	—	
No. controls	150	74	55	54		
AOR (95% CI)	1.00	0.94 (0.62,1.42)	1.00 (0.64,1.56)	0.57 (0.35,0.95)	—	0.10
Men						
No. cases	103	36	29	13	—	
No. controls	86	35	28	23		
AOR (95% CI)	1.00	0.98 (0.54,1.78)	1.10 (0.58,2.07)	0.54 (0.25,1.15)	—	0.45
Women						
No. cases	66	37	29	20	—	
No. controls	64	39	27	31		
AOR (95% CI)	1.00	0.94 (0.53,1.68)	0.99 (0.52,1.88)	0.64 (0.33,1.26)	—	0.24
Spinach and other greens (including collard greens)[c]						
Total						
No. cases	232	48	36	17	—	
No. controls	205	61	40	27		
AOR (95% CI)	1.00	0.71 (0.46,1.11)	0.80 (0.48,1.32)	0.55 (0.29,1.07)	—	0.01
Men						
No. cases	129	26	19	7	—	
No. controls	109	32	19	12		
AOR (95% CI)	1.00	0.76 (0.42,1.40)	0.96 (0.47,1.97)	0.50 (0.18,1.39)	—	0.04
Women						
No. cases	103	22	17	10	—	
No. controls	96	29	21	15		
AOR (95% CI)	1.00	0.71 (0.38,1.36)	0.73 (0.36,1.51)	0.63 (0.27,1.50)	—	0.27

(continued)

Table 4. Adjusted odds ratio (AOR)[a], 95% confidence intervals (CIs), and tests for trend for renal cell carcinoma by consumption frequency of different types of vegetables and fruits (continued)						
	Category of Consumption					
Vegetable or fruit item	**Less than once a week[b]**	**Once a week**	**Twice a week**	**3-4 times a week**	**5 or more times a week**	***P* for trend**
Tomatoes						
Total						
No. cases	87	43	60	85	58	
No. controls	82	34	44	81	92	
AOR (95% CI)	1.00	1.15 (0.65,2.04)	1.22 (0.72,2.07)	0.91 (0.58,1.44)	0.50 (0.31,0.81)	0.02
Men						
No. cases	48	23	28	49	33	
No. controls	36	20	24	46	46	
AOR (95% CI)	1.00	0.90 (0.40,2.03)	0.88 (0.40,1.88)	0.77 (0.40,1.46)	0.47 (0.24,0.95)	0.04
Women						
No. cases	39	20	32	36	25	
No. controls	46	14	20	35	46	
AOR (95% CI)	1.00	1.53 (0.70,3.50)	1.69 (0.81,3.52)	1.08 (0.56,2.08)	0.53 (0.27,1.05)	0.23
Apples and pears						
Total						
No. cases	169	46	50	39	29	
No. controls	153	56	47	38	39	
AOR (95% CI)	1.00	0.70 (0.44,1.13)	0.91 (0.57,1.45)	0.88 (0.52,1.47)	0.63 (0.36,1.09)	0.15
Men						
No. cases	105	19	26	20	11	
No. controls	80	29	25	20	18	
AOR (95% CI)	1.00	0.42 (0.20,0.85)	0.74 (0.38,1.44)	0.69 (0.33,1.43)	0.41 (0.17,0.97)	0.04
Women						
No. cases	64	27	24	19	18	
No. controls	73	27	22	18	21	
AOR (95% CI)	1.00	1.21 (0.63,2.33)	1.09 (0.55,2.17)	1.17 (0.56,2.44)	0.89 (0.43,1.84)	0.98

[a]Estimates from unconditional logistic regression, controlled for age at interview, sex, race, income, body mass index, and pack-years of smoking.
[b]Reference category.
[c]The categories 3-4 times a week and 5 or more times a week were combined due to low numbers in the 5 or more category.
NOTE: Information from this table is available online at www.adajournal.org as part of a PowerPoint presentation.

association among women (12). A larger case-control study in Canada that included >1,000 cases and controls did, and thus future research should continue to examine these items (15). In addition, increased tomato consumption decreased renal cell carcinoma risk in our study, an association not previously observed as far as the authors are aware. Because tomatoes have been found to decrease cancer risk for other forms of cancer (23), its association with renal cell carcinoma is plausible and requires validation through further research.

Although several organizations, including the National Cancer Institute, the American Cancer Society, and the World Cancer Research Fund (23), encourage increased intake of citrus fruit to reduce the risk of cancer in general, fruits were not found to influence renal cell carcinoma risk in this study. Some previous studies have found an association between decreased renal cell carcinoma and increased citrus fruit intake and/or other fruit intake (14,24,25). A case-control study that included more than 2,000 participants found a significant inverse association for renal cell carcinoma risk with citrus fruit consumption among men and women combined (P for trend <0.001) (14). However, these findings have not been confirmed elsewhere (11-13,26). Using data from the Nurses' Health Study and the Health Professionals Follow-up Study cohorts, researchers found an inverse association with total fruit intake and renal cell carcinoma among men (P for trend$=0.02$), but found no association between citrus fruit consumption and renal cell carcinoma among men or women (22). Our study did observe a decreased risk of renal cell carcinoma with increased intake of apples and pears among men. Only a few studies have considered apple and pear intake alone, and associations with renal cell carcinoma were not observed for women (9) or among men and women (13). Men alone were not considered in these studies. Overall, our research suggests that fruit and vegetable consumption are more protective for men. There appears to be a sex difference of renal cell carcinoma because men are twice as likely to develop renal cell carcinoma than women. It is suggested that hormones, such as estrogen and progesterone, could alter the effects of fruit and vegetable intake among women, although research has not been conducted to confirm this (22).

The role of meat, specifically red meat, on risk of cancer in general and renal cell carcinoma in particular has been

Table 5. Adjusted odds ratio (AOR)[a], 95% confidence intervals (CIs), and tests for trend for renal cell carcinoma by consumption frequency of different types of grains

Grain product	Less than once a week[b]	Once a week	Twice a week	3-4 times a week	5 or more times a week	*P* for trend
	Category of Consumption					
White bread						
Total						
No. cases	155	31	39	49	59	
No. controls	186	32	30	35	49	
AOR (95% CI)	1.00	1.32 (0.76,2.31)	1.83 (1.06,3.15)	1.84 (1.11,3.04)	1.55 (0.97,2.47)	0.01
Men						
No. cases	84	16	22	32	27	
No. controls	94	13	16	15	33	
AOR (95% CI)	1.00	1.51 (0.66,3.42)	1.84 (0.87,3.93)	2.52 (1.23,5.19)	0.78 (0.40,1.53)	0.26
Women						
No. cases	71	15	17	17	32	
No. controls	92	19	14	20	16	
AOR (95% CI)	1.00	1.08 (0.50,2.32)	1.88 (0.84,4.20)	1.31 (0.62,2.79)	3.05 (1.50,6.20)	0.01
Pastries, cakes, doughnuts, and pies[c]						
Total						
No. cases	182	45	43	63	—	
No. controls	226	46	22	38		
AOR (95% CI)	1.00	1.29 (0.81,2.06)	2.56 (1.43,4.58)	2.00 (1.26,3.18)	—	$<$0.001
Men						
No. cases	105	23	24	34	—	
No. controls	189	50	19	15		
AOR (95% CI)	1.00	1.03 (0.51,2.09)	1.39 (0.68,2.83)	2.38 (1.17,4.85)	—	0.08
Women						
No. cases	77	27	19	29	—	
No. controls	112	23	3	23		
AOR (95% CI)	1.00	1.64 (0.86,3.13)	8.89 (2.50,31.62)	1.70 (0.91,3.20)	—	$<$0.001
Rolls[d]						
Total						
No. cases	146	65	55	44	23	
No. controls	175	65	37	31	24	
AOR (95% CI)	1.00	1.11 (0.73,1.69)	1.89 (1.15,3.11)	1.70 (1.00,2.91)	1.14 (0.60,2.15)	0.01
Men[c]						
No. cases	73	40	30	38	—	
No. controls	87	32	26	26		
AOR (95% CI)	1.00	1.52 (0.84,2.75)	1.55 (0.80,3.02)	1.79 (0.95,3.38)	—	0.04
Women[c]						
No. cases	73	25	25	29	—	
No. controls	88	33	11	29		
AOR (95% CI)	1.00	0.84 (0.45,1.55)	2.87 (1.28,6.44)	1.19 (0.64,2.20)	—	0.08
Biscuits and muffins[c]						
Total						
No. cases	218	49	27	38	—	
No. controls	249	41	16	25		
AOR (95% CI)	1.00	1.38 (0.86,2.21)	1.81 (0.93,3.52)	1.75 (1.00,3.06)	—	0.01
Men						
No. cases	108	34	19	19	—	
No. controls	125	24	11	11		
AOR (95% CI)	1.00	1.69 (0.91,3.13)	1.80 (0.79,4.09)	1.82 (0.77,4.30)	—	0.09
Women						
No. cases	110	15	8	19	—	
No. controls	124	17	5	14		
AOR (95% CI)	1.00	0.96 (0.45,2.05)	1.79 (0.56,5.74)	1.52 (0.71,3.25)	—	0.10

[a]Estimates from unconditional logistic regression, controlled for age at interview, sex, race, income, body mass index, and pack-years of smoking.

[b]Reference category.

[c]The categories 3-4 times a week and 5 or more times a week were combined due to low numbers in the 5 or more category.

[d]Includes rolls, hamburger buns, English muffins, and bagels.

NOTE: Information from this table is available online at www.adajournal.org as part of a PowerPoint presentation.

Table 6. Adjusted odds ratio (AOR)[a], 95% confidence intervals (CIs), and tests for trend for renal cell carcinoma by consumption frequency of different types of meats

Meat product	Category of Consumption					*P* for trend
	Less than once a week[b]	Once a week	Twice a week	3-4 times a week	5 or more times a week	
Fried chicken and/or fish[c]						
Total						
No. cases	179	89	31	32	—	
No. controls	208	72	24	27		
AOR (95% CI)	1.00	1.53 (1.04,2.25)	1.37 (0.75,2.50)	1.40 (0.75,2.60)	—	0.02
Men						
No. cases	96	44	20	20	—	
No. controls	100	43	12	15		
AOR (95% CI)	1.00	1.11 (0.65,1.91)	1.49 (0.65,3.40)	1.17 (0.51,2.69)	—	0.95
Women						
No. cases	83	45	11	12	—	
No. controls	108	29	12	12		
AOR (95% CI)	1.00	2.26 (1.27,4.02)	1.25 (0.51,3.06)	1.77 (0.69,4.58)	—	0.001
Red meat						
Total						
No. cases	72	81	65	84	27	
No. controls	108	86	66	60	11	
AOR (95% CI)	1.00	1.51 (0.97,2.35)	1.46 (0.91,2.37)	2.22 (1.37,3.58)	4.43 (2.02,9.75)	<0.001
Men[c]						
No. cases	36	42	39	61	—	
No. controls	46	40	43	41		
AOR (95% CI)	1.00	1.49 (0.77,2.89)	1.12 (0.58,2.17)	2.08 (1.08,4.00)	—	0.22
Women[c]						
No. cases	36	39	26	50	—	
No. controls	62	46	23	30		
AOR (95% CI)	1.00	1.48 (0.81,2.73)	2.03 (0.98,4.19)	3.04 (1.60,5.79)	—	<0.001
Bacon and sausage						
Total						
No. cases	155	73	48	35	22	
No. controls	190	57	40	26	18	
AOR (95% CI)	1.00	1.47 (0.96,2.24)	1.40 (0.85,2.29)	1.48 (0.83,2.64)	1.28 (0.63,2.62)	0.37
Men						
No. cases	73	39	33	18	18	
No. controls	90	28	24	14	14	
AOR (95% CI)	1.00	1.42 (0.77,2.64)	1.54 (0.80,2.95)	1.12 (0.49,2.57)	1.02 (0.44,2.39)	0.37
Women[c]						
No. cases	82	34	15	21	—	
No. controls	100	29	16	16		
AOR (95% CI)	1.00	1.51 (0.84,2.74)	1.23 (0.56,2.70)	1.87 (0.88,3.96)	—	0.03
Chicken (excluding fried varieties)[c]						
Total						
No. cases	169	70	56	35	—	
No. controls	138	80	52	61		
AOR (95% CI)	1.00	0.73 (0.49,1.11)	0.97 (0.61,1.54)	0.53 (0.32,0.86)	—	0.12
Men						
No. cases	101	40	25	13	—	
No. controls	82	44	18	26		
AOR (95% CI)	1.00	0.80 (0.46,1.40)	1.22 (0.59,2.52)	0.46 (0.22,0.98)	—	0.19
Men						
No. cases	68	30	31	22	—	
No. controls	56	36	34	35		
AOR (95% CI)	1.00	0.62 (0.33,2.26)	0.74 (0.39,1.38)	0.52 (0.26,1.00)	—	0.28

[a]Estimates from unconditional logistic regression, controlled for age at interview, sex, race, income, body mass index, and pack-years of smoking.
[b]Reference category.
[c]The categories 3-4 times a week and 5 or more times a week were combined due to low numbers in the 5 or more category.
NOTE: Information from this table is available online at www.adajournal.org as part of a PowerPoint presentation.

highly contested (11,15,27). Numerous studies have found significant associations with meat and renal cell carcinoma, although the types of meat and methods of preparation considered have differed. Increased risk of renal cell carcinoma has been found with increased consumption of red meat (8,15,21,28), fried meats (10,25), and sautéed meat (25). In a multicenter case-control study fried meats were found to significantly increase renal cell carcinoma risk as well, with the degree of 'doneness' displaying a significant dose-response (P for trend <0.05). The process of frying meat causes the formation of heterocyclic amines that have been demonstrated to be absorbed rapidly and distributed to the kidneys. Animal experiments suggest that large amounts of this carcinogen are absorbed and may be a factor in the direct association between fried meat consumption and renal cell carcinoma risk (10). While "doneness" was not considered in our study, fried chicken and fish consumption was associated with increased risk of renal cell carcinoma among the total population and among women. In our study red meat was also significantly associated with increased risk of renal cell carcinoma among women. In a large case-control study conducted in Canada, the researchers found a significant association with hamburger among men and women (P for trend$=0.003$) as well as among women who had smoked (P for trend$=0.01$) and/or were overweight (P for trend$=0.01$) (15).

An important finding of this research is the increased risk of renal cell carcinoma observed with increased consumption of white grains and white potatoes, especially among women. Similar results were first described in a recent case-control study in Italy (11), which found a 94% increase in renal cell carcinoma risk for the highest quintile of consumption compared to the lowest (odds ratio 1.94; 95% confidence interval 1.40, 2.71), and observed an overall direct positive trend in renal cell carcinoma risk with increased bread consumption ($P=0.0002$). This association between renal cell carcinoma and consumption of bread and potatoes (observed only in this study) may be related to their high glycemic index ratings. Foods with high glycemic index ratings affect insulin resistance and insulin-like growth factors, which have been implicated in colon, breast, and prostate cancer (29,30).

There are several limitations to this study. This study's lower than expected response rates for both cases (69%) and controls (42%) suggest that selection biases may have been present. It should be noted that differences in education and income, often cited among those factors typically differing as a result of this potential bias (31), were not significantly different between cases and controls. Among cases, the average time from diagnosis to follow-up was 3 years (range 0 to 6 years), leading to potential survivor bias in which excluded deceased cases had significantly different rates of exposure than those included in the sample. Longer rates of follow-up also introduce the potential of exposure misclassification among cases. This was minimized by the use of a structured questionnaire, and personnel were trained to be sensitive to the possibility of such error. A major limitation of the study was the small number of African-American participants. Statistical power was not great enough for considering the African-American sample alone.

CONCLUSIONS

This study reinforces previous findings linking diet and renal cell carcinoma. Specifically, previous findings regarding the protective role of vegetable consumption, particularly dark green and cruciferous vegetables, are supported, as are findings of increased renal cell carcinoma risk with increased meat consumption. No support is provided for associations between fruit and dairy consumption and renal cell carcinoma risk. Novel findings include the potential protective properties of tomato consumption, particularly among men, and increased renal cell carcinoma risk with consumption of white breads and white potatoes, particularly among women. Further research is needed to verify these associations. In addition, further research is warranted regarding diet and renal cell carcinoma risk, including alcohol consumption, as well as other nondietary risk factors, including physical activity, for renal cell carcinoma among various racial groups, because temporal trends in renal cell carcinoma incidence show clear racial disparities (4,18).

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