Meat Consumption among Black and White Men and Risk of Prostate Cancer in the Cancer Prevention Study II Nutrition Cohort

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Abstract

Previous epidemiologic studies have suggested that intake of red meat may be associated with increased risk of prostate cancer. Few studies, however, have examined these associations by race. We examined intake of red meat, processed meat, and poultry in relation to incident prostate cancer among Black and White men in the Cancer Prevention Study II Nutrition Cohort. Participants in the study completed a detailed questionnaire on diet, medical history, and lifestyle in 1992 to 1993. After excluding men with a history of cancer and incomplete dietary information, 692 Black and 64,856 White men were included in the cohort. During follow-up through August 31, 2001, we documented 85 and 5,028 cases of incident prostate cancer among Black and White men, respectively. Cox proportional hazards models were used to estimate rate ratios (RR) and 95% confidence intervals (95% CI). No measure of meat consumption was associated with risk of prostate cancer among White men. Among Black men, total red meat intake (processed plus unprocessed red meat) was associated with higher risk of prostate cancer (RR, 2.0; 95% CI, 1.0-4.2 for highest versus lowest quartile; P_{trend} = 0.05); this increase in risk was mainly due to risk associated with consumption of cooked processed meats (sausages, bacon, and hot dogs; RR, 2.7; 95% CI, 1.3-5.3 for highest versus lowest quartile; P_{trend} = 0.008). This study suggests that high consumption of cooked processed meats may contribute to prostate cancer risk among Black men in the United States. (Cancer Epidemiol Biomarkers Prev 2006; 15(2):211–6)

Introduction

Prostate cancer is the most frequently diagnosed cancer in males in the United States and the second most common cause of cancer death (1). In the United States, incidence rates among Black men are 60% higher than among White men (1). Other than race, age, and family history, no other risk factors have been associated consistently with prostate cancer.

Consumption of meat, particularly red meat, has been proposed as a possible modifiable risk factor for prostate cancer (2, 3), although results from epidemiologic studies are mixed. Few studies have examined the association between meat consumption and prostate cancer risk among Black men. Two (4, 5) of three U.S. studies (4-6) that have presented results for both Black and White men showed increased risk with increasing meat consumption in Blacks but not Whites.

Potential biological mechanisms for an association between red meat consumption and prostate cancer incidence have been hypothesized to involve fat, nitrites/nitrates, or heterocyclic amines formed during cooking at high temperatures (2, 7).

We examined the association between unprocessed red meat, processed meats (separating lunch meats and cooked processed meats), and poultry intake among White and Black men in relation to prostate cancer incidence in the Cancer Prevention Study II Nutrition Cohort.

Materials and Methods

Study Population. Men in this study were selected from among the 86,404 male participants in the Cancer Prevention Study II Nutrition Cohort (hereafter called the Nutrition Cohort), a prospective study of cancer incidence and mortality among 184,190 U.S. men and women (8). The Nutrition Cohort is a subgroup of the ~1.2 million participants in the Cancer Prevention Study II, a prospective mortality study established by the American Cancer Society in 1982 (9). Members of the Cancer Prevention Study II mortality cohort who resided in 21 states with population-based state cancer registries and were 50 to 74 years of age in 1992 were invited to participate in the Nutrition Cohort by completing a mailed questionnaire. The recruitment and characteristics of Nutrition Cohort participants are described in detail elsewhere (8). All aspects of the Cancer Prevention Study II Nutrition Cohort study are approved by the Emory University Institutional Review Board.

At enrollment in 1992, participants completed a self-administered mailed questionnaire that included demographic, medical, behavioral, environmental, occupational, and dietary factors. Follow-up questionnaires were sent to cohort members in 1997, 1999, and in 2001, to update exposure information and to ascertain newly diagnosed cancers. The response rate among living participants for each of the follow-up questionnaires (after multiple mailings) was at least 90%. For the present study, the follow-up period ended on August 31, 2001.

We excluded from this analysis 3,489 men who were lost to follow-up (i.e., they were alive at the time of the first follow-up questionnaire in 1997 but did not return the 1997 follow-up questionnaire or any subsequent questionnaire). We also excluded men who reported any prevalent cancer (except nonmelanoma skin cancer) at baseline (n = 9,001) and those whose self-report of prostate cancer from the 1997 questionnaire could not be verified (n = 217). Men whose self-report of prostate cancer on the 1999 or 2001 questionnaire could not be confirmed (n = 426) and men with stage A_1 prostate cancer (n = 52) contributed person-time to the analysis up to the date of the last questionnaire on which they reported no history of

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prostate cancer or date of their prostate cancer diagnosis and were never considered to be cases. Stage A_1 prostate cancer was not included as prostate cancer because these lesions tend to be relatively innocuous and frequently detected incidentally at surgery for benign prostatic hyperplasia. We excluded men with extreme values of energy intake (<600 or >4,500 kcal) and those with missing or uninterpretable data for meat or other dietary intake in 1992 (≥10% items blank; n = 7,230). We also excluded 877 men of races other than White or Black due to small numbers. After these exclusions, the analytic cohort consisted of 65,590 men, of whom 693 were Black and 64,897 were White.

Identification of Cases of Prostate Cancer. We included a total of 85 and 5,028 incident primary prostate cancer cases, respectively, among Black and White men that occurred in the interval between enrollment in 1992 and August 31, 2001. Most incident cases of prostate cancer (n = 4,961) were initially identified through a self-report of cancer on any of the questionnaires and subsequently verified by medical records (n = 4,015) or by linkage with state cancer registries (n = 946). A previous pilot study linking cohort members to state cancer registries indicated that the ability of our respondents to accurately report a past diagnosis of cancer is high (sensitivity = 0.93; ref. 10). An additional 92 cases were ascertained as deaths due to prostate through linkage with National Death Index (11) among participants who did not report prostate cancer in any of the previous questionnaires. For these cases, the death certificate listed prostate cancer as the primary cause of death between the date of enrollment and December 31, 2000. Additional clinical information was obtained for 63 of these 92 deaths through subsequent linkage with state cancer registries. Finally, 60 men who did not self-report prostate cancer in any of the questionnaires were identified as having a primary prostate cancer during the process of verifying a different cancer through linkage with a state cancer registry. Fifty-five of them had a different cancer listed as the primary cause of death in the death certificate; the other five prostate cancer cases had self-reported a colon cancer, melanoma, or lymphoma.

We defined metastatic prostate cancer as cases verified by medical records with stage D, cases classified by the state cancer state registry as distant stage, and all prostate cancer deaths. Analysis of metastatic cases was restricted to White men (n = 225) because of the small number of metastatic prostate cancer cases among Black men (n = 13).

Meat Intake Assessment. Dietary intake in 1992 was assessed using a 68-item modified brief food-frequency questionnaire by Block et al. (12); nutrient values and consumption frequencies were estimated using the Dietary Analysis System version 3.8a (13). Cohort participants were asked to report their average intake of each food and beverage over the past year, including usual serving size (small, medium, or large) and frequency of intake. The latter ranged from never or less than once per month to 2+ times per day for foods and to 6+ times per day for beverages. The consumption of each meat item was expressed in grams per week from the food-frequency questionnaire using the Diet Analysis System version 3.8a (13). Unprocessed red meat included hamburgers, beef, beef stew, liver, and pork; poultry included fried chicken, and chicken or turkey. Processed meat was further categorized as cooked processed meat (bacon, sausage, and hot dogs) or lunch meats (ham, bologna, salami, and other lunch meats). The analyses considered intake of total red meat (processed plus unprocessed red meat), unprocessed red meat, processed meat, and poultry, computed by summing across all items that contribute to each group. For all men, categories of each type of meat were defined according to the quartile distribution of consumption among Black men; the lowest intake quartile in Black men served as the reference category for all analyses. Participants were also asked ''When you eat red meat such as beef, pork, or lamb, how well done is it cooked?'' with the following possible responses: well-done, medium well-done, medium rare, rare, and don't eat red meat.

The food-frequency questionnaire was validated among 441 Nutrition Cohort participants who completed four 24-hour dietary recall interviews and a repeat food-frequency questionnaire (14). The correlation coefficient in men for red meat between the food-frequency questionnaire and dietary recall interview was 0.55 and that between the food-frequency questionnaire and repeat food-frequency questionnaire was 0.81.

Statistical Analysis. We used Cox proportional hazards modeling (15) to examine the association between different measures of meat intake and incident prostate cancer separately among White and Black men while adjusting for other potential confounding factors. P values for linear trend were estimated by modeling food intake in grams per week using the median value within categories. Follow-up time since enrollment in 1992 served as the time-axis. All Cox models were stratified on single year of age at enrollment and were adjusted for total energy intake in quintiles. Confounders included in the multivariate models were as follows: education (less than high school, high school graduate, some college, college graduate, graduate school, and missing), family history of prostate cancer in a brother and/or father (yes/no), and body mass index (kg/m^2; <25, 25-<30, ≥30, and missing). In addition, personal history of diabetes, which has been previously associated with lower risk of prostate cancer in this cohort (16), was included in all multivariate models as a time-dependent variable. History of recent prostate-specific antigen (PSA) testing (yes/no/missing) was modeled as a time-dependent variable, updated with information from each follow-up questionnaire. Because history of PSA testing was first collected on the 1997 questionnaire, only follow-up after 1997 could be adjusted for history of PSA testing. Total vegetable intake, fruit intake, and dairy intake were also examined as potential confounders but we did not adjust for these factors in the final models because such adjustment had negligible effects on our results (data not shown).

Heterogeneity of trends for the association between the different measures of meat intake and risk of prostate cancer by race was assessed using the likelihood ratio test for heterogeneity of trends (17). Effect modification of the prostate cancer hazard ratio associated with meat consumption variables (unprocessed red meat, processed meat consumption, and poultry) by body mass index, having had a PSA test, family history of prostate cancer, and history of diabetes (yes/no) was evaluated using the likelihood ratio test comparing models with and without interaction terms.

Results

Meat consumption patterns varied by race; on average, Black men reported a higher median intake of processed meat than White men (129 versus 92 g/wk, respectively), lower median intake of unprocessed meat (244 versus 311 g/wk, respectively), and higher median intake of poultry (164 versus 144 g/wk). Bacon and sausage accounted for much of the difference in consumption of processed meats between Black and White men. Median intake of bacon and sausage were 14 and 29 g/wk, respectively, among Black men, and 5 and 8 g/wk among White men.

Selected characteristics of men included in the study in relation to consumption of unprocessed red meat, processed meat, and poultry in 1992 are shown in Table 1. Black and White men in the highest category of processed or unprocessed red meat intake were younger, less educated, had higher body mass index, and were more likely to report diabetes and a diet

Table 1. Age-adjusted percentages and medians of selected characteristics by categories of meat intake and by race (Cancer Prevention Study II Nutrition Cohort, 1992-2001)

	Blacks						Whites					
	Processed meat		Unprocessed red meat		Poultry		Processed meat		Unprocessed red meat		Poultry	
	Q1	Q4	Q1	Q4	Q1	Q4	Q1	Q4	Q1	Q4	Q1	Q4
Age group (y)												
<55	4.7	6.4	4.7	9.4	3.5	10.5	4.0	4.2	3.1	5.2	3.2	6.7
55-64	52.6	50.9	54.4	51.5	48.8	53.2	50.4	54.3	46.3	57.1	46.9	59.0
65-74	39.8	40.9	38.5	36.3	42.9	34.5	40.2	37.9	44.2	34.2	44.1	30.8
>75	2.9	1.8	2.4	2.9	4.7	1.8	5.5	3.6	6.5	3.6	5.8	3.5
Education level												
<High school	8.0	16.2	7.0	14.3	12.5	12.5	5.5	12.1	4.9	9.8	8.6	7.1
High school graduate	13.7	20.7	15.3	20.2	19.3	13.2	14.8	25.6	13.6	22.7	21.2	16.5
Some college	27.5	20.6	25.3	25.8	25.9	23.8	23.2	27.9	23.0	27.1	26.8	24.6
College graduate	17.3	14.4	18.3	13.2	7.6	18.8	23.8	17.6	23.9	20.0	20.3	23.3
Graduate school	31.4	25.2	32.4	25.0	32.4	30.2	32.1	16.1	34.2	19.8	22.5	27.9
Body mass index (kg/m^2)												
<25	31.5	25.5	30.6	29.6	31.0	25.0	43.2	29.5	47.8	28.4	36.8	34.9
25-<30	54.7	47.4	50.6	41.2	49.4	50.1	46.1	49.4	42.8	51.3	48.9	47.9
≥30	11.5	24.9	16.5	26.2	17.8	23.2	9.6	19.5	8.1	19.0	13.0	16.0
Family history of prostate cancer												
No	81.1	82.1	79.4	84.2	85.8	79.3	88.3	87.9	88.4	87.4	88.2	87.4
Yes	18.9	17.9	20.6	15.8	14.2	20.7	11.7	12.1	11.6	12.6	11.8	12.6
History of diabetes												
No	82.9	67.1	78.7	66.7	82.3	71.4	88.1	82.0	88.3	83.9	86.7	84.5
Yes	17.1	32.9	21.3	33.3	17.7	28.6	11.9	18.0	11.7	16.1	13.3	15.5
History of PSA testing*												
No	20.8	25.6	20.1	27.6	29.5	20.2	14.7	20.8	13.7	19.7	18.1	16.1
Yes	79.2	74.4	79.9	72.4	70.5	79.8	85.3	79.2	86.3	80.3	81.9	83.9
Total calorie intake (kcal/d)												
Median	1,281	2,006	1,281	2,083	1,353	1,844	1,480	2,195	1,351	2,121	1,542	1,979
Processed meat intake (g/wk)												
Median	27	347	52	196	108	121	21	349	21	151	88	84
Unprocessed red meat intake (g/wk)												
Median	119	357	73	579	190	284	200	461	79	602	271	332
Poultry intake (g/wk)												
Median	188	177	151	216	56	400	144	144	144	156	59	366

NOTE: Percentages were adjusted to the age distribution of the entire study population and may not sum to 100 due to missing data.
*Ever reported PSA testing during study follow-up, excluding testing reported after prostate cancer diagnosis.

high in calories. Both White and Black men in the highest category of poultry intake were more educated and more likely to report diabetes and a diet high in total caloric intake than men in the lowest category of poultry consumption. Men in the lowest category of unprocessed red meat or processed meat intake and highest category of poultry were more likely to report ever having been tested for PSA. Overall, having received a PSA test during the study follow-up period was reported by 78% of Black and 83% of White men.

As shown in Table 2, total red meat (processed plus unprocessed red meat) consumption was associated with higher incidence of prostate cancer among Black men [rate ratio (RR), 2.0; 95% confidence interval (95% CI), 1.0-4.2, for highest versus lowest category]. However, among White men, no association was seen between total red meat consumption and either the overall incidence of prostate cancer (RR, 1.0; 95% CI, 0.9-1.0) or metastatic (RR, 0.8; 95% CI, 0.5-1.3) prostate cancer.

We further examined the relation between individual meat items and prostate cancer risk by race. Black men in the highest category of processed meat consumption had higher risk of total incident prostate cancer than those in the lowest quartile (RR, 2.4; 95% CI, 1.2-4.9; P_{trend} = 0.008). This increased risk of prostate cancer among Black men was associated solely with consumption of cooked processed meat (bacon, hot dogs, and sausages; RR, 2.7; 95% CI, 1.3-5.3 for the highest versus lowest category; P_{trend} = 0.008) and not with consumption of lunchmeats (ham, bologna, salami, and others). Consumption of any unprocessed red meat was also associated with higher risk of total prostate cancer among Black men, but no significant trend was observed with increasing intake. Among White men, processed or unprocessed red meat consumption was not associated with risk of total incident prostate cancer; no association was seen when octiles of intake for White men were used to create more extreme comparisons (data not shown).

The risk of metastatic prostate cancer was associated with consumption of cooked processed meats (P_{trend} = 0.04) among White men in analyses adjusted only for age, but this association was attenuated by further adjustment (Table 2). No other measure of meat intake was associated with risk of metastatic prostate cancer.

No association was observed between poultry consumption and risk of total prostate cancer among Black men or with total or metastatic prostate cancer among White men. Risk estimates for all meat measurements did not change when unprocessed red meat, cooked processed meat, lunch meat, and poultry were included simultaneously in the regression model with the other confounding variables.

Reported preference for red meat doneness was not associated with risk of prostate cancer among White or Black men (data not shown). We also examined combinations of preference for meat doneness and quantity of meat consumed, although these analyses could be done only among Whites due to the small number of Black men in the cohort. Men who preferred well done meat and were in the top quintile of total red meat consumption were not at increased risk of prostate cancer compared with men who preferred rare meat and were in the lowest quintile of total red meat consumption. We also found no association in a similar analysis of combinations of preference for meat doneness and quartiles of cooked processed meat.

Table 2. RR and 95% CI values for prostate cancer incidence associated with meat intake (Cancer Prevention Study II Nutrition Cohort 1992-2001)

	All prostate cancer						Metastatic prostate cancer		
	Blacks			Whites			Whites		
	No. cases	RR (95% CI)*	RR (95% CI)†	No. cases	RR (95% CI)*	RR (95% CI)†	No. cases	RR (95% CI)*	RR (95% CI)†
Total processed plus unprocessed red meat (g/wk)‡									
0-<246	19	1.0 (reference)	1.0 (reference)	1,249	1.0 (reference)	1.0 (reference)	51	1.0 (reference)	1.0 (reference)
246-<408	22	1.1 (0.6-2.1)	1.2 (0.6-2.2)	1,187	1.0 (0.9-1.1)	1.0 (0.9-1.1)	47	1.0 (0.7-1.5)	0.9 (0.6-1.4)
408-<657	17	1.0 (0.5-1.9)	1.2 (0.6-2.6)	1,353	1.0 (0.9-1.0)	1.0 (0.9-1.1)	71	1.3 (0.9-1.9)	1.1 (0.7-1.6)
≥657	27	1.8 (1.0-3.2)	2.0 (1.0-4.2)	1,239	0.9 (0.9-1.0)	1.0 (0.9-1.0)	56	1.1 (0.8-1.7)	0.8 (0.5-1.3)
P_{trend}		0.06	0.05		0.02	0.17		0.34	0.53
				$P_{heterogeneity}$ = 0.05					
Unprocessed red meat (g/wk)									
0-<137	14	1.0 (reference)	1.0 (reference)	872	1.0 (reference)	1.0 (reference)	42	1.0 (reference)	1.0 (reference)
137-<244	30	2.2 (1.2-4.3)	2.3 (1.2-4.5)	1,123	1.1 (1.0-1.2)	1.1 (1.0-1.2)	40	0.8 (0.5-1.3)	0.7 (0.5-1.2)
244-<423	21	1.7 (0.9-3.5)	1.8 (0.9-3.7)	1,476	1.0 (0.9-1.1)	1.0 (0.9-1.1)	74	1.1 (0.8-1.6)	0.9 (0.6-1.4)
≥423	20	1.7 (0.9-3.6)	1.7 (0.8-3.9)	1,557	1.0 (0.9-1.1)	1.0 (0.9-1.1)	69	1.0 (0.7-1.5)	0.8 (0.5-1.2)
P_{trend}		0.39	0.49		0.21	0.68		0.59	0.39
				$P_{heterogeneity}$ = 0.29					
Processed meat (g/wk)§									
0-<59	17	1.0 (reference)	1.0 (reference)	1,872	1.0 (reference)	1.0 (reference)	71	1.0 (reference)	1.0 (reference)
59-<129	20	1.2 (0.6-2.4)	1.3 (0.7-2.5)	1,320	1.0 (1.0-1.1)	1.1 (1.0-1.1)	63	1.4 (1.0-1.9)	1.2 (0.9-1.8)
129-<247	20	1.2 (0.6-2.3)	1.2 (0.6-2.3)	1,071	1.0 (0.9-1.1)	1.0 (0.9-1.1)	54	1.3 (0.9-1.9)	1.2 (0.8-1.7)
≥247	28	2.0 (1.1-3.7)	2.4 (1.2-4.9)	765	1.0 (0.9-1.0)	1.0 (0.9-1.1)	37	1.3 (0.9-2.0)	1.1 (0.7-1.7)
P_{trend}		0.02	0.008		0.18	0.98		0.19	0.87
				$P_{heterogeneity}$ = 0.03					
Cooked processed meat (g/wk)									
0-<38	14	1.0 (reference)	1.0 (reference)	2,187	1.0 (reference)	1.0 (reference)	82	1.0 (reference)	1.0 (reference)
38-<87	22	1.7 (0.8-3.3)	1.8 (0.9-3.5)	1,527	1.1 (1.0-1.1)	1.1 (1.0-1.2)	74	1.4 (1.0-1.9)	1.3 (0.9-1.8)
87-<165	20	1.4 (0.7-2.8)	1.4 (0.7-2.9)	945	1.0 (1.0-1.1)	1.1 (1.0-1.2)	48	1.5 (1.0-2.1)	1.3 (0.9-1.8)
≥165	29	2.4 (1.3-4.7)	2.7 (1.3-5.3)	369	0.9 (0.8-1.1)	1.0 (0.9-1.2)	21	1.5 (0.9-2.4)	1.2 (0.7-2.1)
P_{trend}		0.009	0.008		0.72	0.34		0.04	0.33
				$P_{heterogeneity}$ = 0.02					
Lunchmeat (g/wk)									
None	29	1.0 (reference)	1.0 (reference)	1,226	1.0 (reference)	1.0 (reference)	53	1.0 (reference)	1.0 (reference)
1-<33	16	0.6 (0.3-1.2)	0.7 (0.3-1.3)	1,020	1.1 (1.0-1.2)	1.1 (1.0-1.2)	40	1.0 (0.6-1.4)	0.9 (0.6-1.4)
33-<56	11	0.5 (0.2-1.0)	0.5 (0.2-1.0)	937	1.1 (1.0-1.2)	1.1 (1.0-1.2)	44	1.2 (0.8-1.8)	1.1 (0.8-1.7)
≥56	29	1.0 (0.6-1.7)	1.0 (0.6-1.9)	1,845	1.0 (0.9-1.1)	1.0 (1.0-1.1)	88	1.2 (0.8-1.6)	1.0 (0.7-1.5)
P_{trend}		0.43	0.37		0.47	0.93		0.33	0.83
				$P_{heterogeneity}$ = 0.46					
Poultry (g/wk)									
0-<91	26	1.0 (reference)	1.0 (reference)	1,520	1.0 (reference)	1.0 (reference)	82	1.0 (reference)	1.0 (reference)
91-<164	18	0.7 (0.4-1.3)	0.7 (0.4-1.3)	1,471	1.1 (1.0-1.2)	1.1 (1.0-1.2)	63	0.9 (0.7-1.3)	0.9 (0.6-1.3)
164-<279	21	0.8 (0.5-1.5)	0.7 (0.4-1.3)	1,254	1.1 (1.0-1.1)	1.0 (1.0-1.1)	54	0.9 (0.6-1.3)	0.9 (0.6-1.2)
≥279	20	0.8 (0.4-1.4)	0.7 (0.4-1.3)	783	1.0 (1.0-1.1)	1.0 (0.9-1.1)	26	0.7 (0.5-1.1)	0.7 (0.4-1.1)
P_{trend}		0.59	0.34		0.68	0.97		0.14	0.10
				$P_{heterogeneity}$ = 0.62					

*Adjusted for age at entry.
†Adjusted for age at entry, total calorie intake, BMI, level of education, family history of prostate cancer, history of PSA testing, and history of diabetes.
‡Includes both processed meat and red meat.
§Includes both cooked processed meat and lunchmeat.

None of the associations between prostate cancer risk and any category of meat consumption were significantly different in men who did or did not report PSA testing, nor was effect modification observed with any of the other covariates examined.

Discussion

In this large prospective study, total consumption of red meat was associated with 2-fold increased risk of prostate cancer among Black men. This association was seen for both unprocessed red meat and cooked processed meat (bacon, hot dogs, and sausages) and there was a dose-response relationship with cooked processed meat and prostate cancer in Black men.

The increased risk of prostate cancer associated with total red meat and cooked processed meat intake observed among Black men is consistent with two (4, 5) of three U.S. studies (4-6). In the large case-control study by Hayes et al. (5), increased consumption of meat (processed and red meat combined) was associated with a significantly higher risk of prostate cancer among Black (but not White) men; the association with processed meat was not presented separately. Similarly, red meat intake was significantly associated with increased risk of total and advanced prostate cancer in Black (but not White) men in the Prostate, Lung, Colorectal, and Ovarian Cancer Screening Trial (4).

Among White men in our cohort, no measure of meat consumption was significantly associated with total prostate cancer. However, there was a suggestion of a modest increased risk of metastatic prostate cancer with increasing intake of cooked processed meats, but this relationship was attenuated after adjustment for confounders. The literature regarding red meat consumption and prostate cancer in studies of primarily White men has been inconsistent, reporting null (5, 6, 18-21) or positive (21-27) associations for different types of red meat consumption.

It is unclear why total red meat intake, and specifically cooked processed meat, is associated with increased risk of prostate cancer in Black but not White men in our cohort. First, we cannot rule out the possibility of a chance finding.

Alternatively, if the risk we observed in Black men is real, possible explanations could include higher intakes of carcinogens such as N-nitroso compounds (7, 28) and heterocyclic amines (29-31) due to a preference for more well-cooked meat (32, 33), differences by race in metabolic activation of these carcinogens (34-37), or a combination of both factors.

Nitrosamines and heterocyclic amines are present in higher amounts in fried or grilled meats. The amount of nitrosamines and heterocyclic amines formed during cooking increases with increasing temperature and frying time (7) and varies by type of meat (38, 39). Preference for well-done red meat in our cohort was much higher among Black (50%) than White (21%) men. Similar racial differences have been reported in a U.S. cooking-method preference survey conducted by Food and Drug Administration/U.S. Department of Agriculture Consumer Food Safety Survey (33) as well as in a study on U.S. dietary exposures to heterocyclic amines by race (32); in the later study, estimated intake of heterocyclic amines in Black men was 50% to 100% greater compared with White men. In a study conducted in Los Angeles County (39, 40), levels of heterocyclic amine metabolites in urine were higher in Black men than White men. Because no correlation between meat intake and heterocyclic amine metabolites in urine were observed in that study, the authors concluded that higher urinary excretion levels of heterocyclic amine in Blacks could be due to a dietary preference for meats prepared at high temperatures (40).

Nitrosamines and heterocyclic amines require metabolic activation to bind to DNA and exert their carcinogenic effect. The first step in the metabolic activation pathway involves N-oxidation by P450 enzymes in the liver followed by additional metabolism by *N*-acetyltransferase-2 and sulfotransferases (SULT). The *N*-acetyltransferase-2 enzyme is coded by a single gene displaying two phenotypes, slow and rapid acetylators (41). Similarly, a functional polymorphism in the gene coding for the SULT1A1 enzyme (within the SULTs family) generates a protein with decreased enzyme activity (42). The proportion of people with rapid acetylator phenotype is higher among Black than White men (36) as it is with high SULT1A1 enzyme activity phenotype (34, 37). Both rapid acetylator genotype (43) and SULT1A1 genotype and phenotype (34) have been associated with increased risk of prostate cancer.

In our cohort, although our questionnaire was not designed to adequately capture different cooking methods, when we examined associations between meat intake and prostate cancer only in those White men who reported preferring eating red meat ''well-done,'' we still saw no associations with amount consumed (data not shown). This would suggest that our finding of a higher risk of prostate cancer in Black men that consume more meat may involve differences in metabolic activation of these carcinogens as well as racial differences in cooking practices.

Our study has several limitations. We had no information on meat cooking methods (e.g., baking or broiling) with which to estimate exposure to heterocyclic amines or other carcinogens produced from cooking meat (44, 45). In addition, we had fewer Black than White men in our study, increasing the possibility that the association may reflect chance.

Strengths of our study include the prospective design, the ability to assess the association between different types of meat intake and prostate cancer among Black and White men separately, and our ability to control for known confounders.

In summary, our study supports the hypothesis that greater intake of meat may contribute to the higher prostate cancer risk seen among Black men in United States. The association between cooked processed meats and risk of prostate cancer among Black men should be examined carefully in future analyses.

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