Dietary Factors and Risks for Prostate Cancer among Blacks and Whites in the United States[1]

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Abstract

Prostate cancer is the most common malignancy in men in the United States, with substantially higher rates among American blacks than whites. We carried out a population-based case-control study in three geographic areas of the United States to evaluate the reasons for the racial disparity in incidence rates. A total of 932 men (449 black men and 483 white men) who had been newly diagnosed with pathologically confirmed prostate cancer and 1201 controls (543 black men and 658 white men) were interviewed in person to elicit information on potential risk factors. This report evaluates the impact of dietary factors, particularly the consumption of animal products and animal fat, on the risk of prostate cancer among blacks and whites in the United States.

Increased consumption (grams/day) of foods high in animal fat was linked to prostate cancer (independent of intake of other calories) among American blacks [by quartile of intake, odds ratio (OR) = 1.0 (referent), 1.5, 2.1, and 2.0; $P_{trend} = 0.007$], but not among American whites [by quartile of intake, OR = 1.0 (referent), 1.6, 1.5, and 1.1; $P_{trend} = 0.90$]. However, risks for advanced prostate cancer were higher with greater intake of foods high in animal fat among blacks [by quartile of intake, OR = 1.0 (referent), 2.2, 4.2, and 3.1; $P_{trend} = 0.006$] and whites [by quartile of intake, OR = 1.0 (referent), 2.2, 2.6, and 2.4; $P_{trend} = 0.02$]. Increased intake of animal fat as a proportion of total caloric intake also showed positive but weaker associations with advanced prostate cancer among blacks ($P_{trend} = 0.13$) and whites ($P_{trend} = 0.08$). No clear associations were found with vitamin A, calcium, or specific lycopene-rich foods.

The study linked greater consumption of fat from animal sources to increased risk for prostate cancer among American blacks and to advanced prostate cancer among American blacks and whites. A reduction of fat from animal sources in the diet could lead to decreased incidence and mortality rates for prostate cancer, particularly among American blacks.

Introduction

In the United States, blacks are diagnosed with prostate cancer about 70% more often than whites (blacks, 234.4 cases/100,000 persons; whites, 135.3 cases/100,000 persons), tend to present more often with advanced disease, and have poorer stage-specific survival. Age-adjusted death rates from prostate cancer are 130% greater among American blacks (55.5 deaths/100,000 persons in 1992) than whites (23.8 deaths/100,000 persons; Ref. 1). Also, autopsy investigations show that latent prostate cancer tends to be more aggressive (2) and multifocal (3) among blacks than whites. The reasons for the ethnic differential in risk are unknown.

Evidence from correlational, case-control, and cohort studies (4–6) suggests that the intake of animal products increases the risk of prostate cancer, possibly due to the impact of dietary fat. Vitamin A, fruit and vegetable intake, and anthropometric factors may also affect the risk for prostate cancer, but findings have not been consistent (6). Although identifying the reasons for the high rates of prostate cancer among American blacks is a high priority (7), cohort investigations have not included large numbers of blacks, and only one other large case-control study with substantial participation by blacks has been completed (8). In a large case-control study of prostate cancer among blacks and whites in the United States, we have evaluated the effects of diet, and particularly animal fat intake, on racial differentials in prostate cancer.

Materials and Methods

Study Design. This case-control study of prostate cancer is one component of a multicenter study of cancers of the esophagus, pancreas, and prostate and multiple myeloma among blacks and whites in the United States. The investigation received Institutional Review Board approval. Study subjects resided in geographic areas covered by the population-based

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cancer registries of the Georgia Center for Cancer Statistics (Fulton and DeKalb counties), the Metropolitan Detroit Cancer Surveillance System (Wayne, Oakland, and Macomb counties), and the New Jersey State Cancer Registry (10 New Jersey counties). A detailed description of the study design was reported previously (9).

Study Eligibility. Cases for this study were men ages 40–79 years who were identified from pathology and outpatient records at hospitals covered by these registries and had been newly diagnosed with pathologically confirmed prostate cancer between August 1, 1986 and April 30, 1989. Identified cases were included for study based on an age- and race-stratified sampling scheme to ensure representation of both blacks and whites in a broad age range. The planned sampling frequency ranged from 100% for those younger than 55 years to 20% for white males ages 65–74 years and 17% for black males ages 65–74 years. Study cases were classified from routinely collected information by tumor stage [localized and advanced (regional/distant)] and grade (well differentiated, moderately differentiated, and undifferentiated). Population controls were selected in the three geographic areas proportional to the expected age, sex, and race distribution of the combined cases for the four cancer sites. Controls younger than 65 years of age were selected by the Waksberg method of random digit dialing (10); older controls were selected by random sampling from the computerized records of the Health Care Financing Administration.

Data Collection. After obtaining informed consent, cases and controls were interviewed in person, usually in their homes. Prostate cancer cases and male controls were questioned about a number of factors, including dietary intake, height and weight, occupational history, family history of cancer, tobacco and alcohol use, and demographics. The dietary section of the interview was designed to collect information about usual adult dietary intake (excluding the most recent 5 years) by means of a 60-item food frequency questionnaire plus 6 additional questions about consumption of fried foods.

To ensure that food items were included that were representative of the diets of both blacks and whites, data from 24-h dietary recall exams from NHANES[6] I were examined to identify foods that were commonly consumed by both groups. Subjects were asked to recall their usual adult frequency (*i.e.*, times per day, week, month, or year) of consumption of specific food items, excluding the past 5 years. Subjects were asked about the duration and frequency over their adult lives (excluding the most recent 5 years) of consumption of specific vitamin supplements including multivitamins, B-complex, and vitamins A and C, but the dose of individual supplements was not determined.

To evaluate dietary patterns, individual foods were categorized into food groups. Nutrient intakes were estimated based on the frequency of consumption of foods and the nutrient content of an average serving of the food items for males, which was derived from the NHANES II (11). Race-specific portion sizes were not derived from the NHANES II data because the estimates for blacks are based on relatively small numbers and are considered unreliable (12). Dietary intake was expressed as the frequency of intake (converted to times/week) for food groups (see "Appendix") and as the amount of intake for energy (kilocalories/day) and other macronutrients (grams/day) including total fat, fat from animal sources, fat from other and mixed sources, protein, and carbohydrates.

Perceived height and weight at 8 years of age (relative to peers), adult height, weight at 25 years of age, usual adult weight, and maximum weight were determined by questionnaire. BMI (kilograms/meter^2) was calculated as a measure of body weight, adjusted for height. A socioeconomic status score [modified from Green (13)] and a physical activity score were derived from a review of the reported usual occupation by methods described previously (14).

Statistical Analysis. ORs for prostate cancer were estimated by unconditional logistic regression (15) with adjustment for age (40–49, 50–54,...70–74, 75+), study site (Atlanta, Georgia; Detroit, Michigan; New Jersey), and, where appropriate, for race (black, white). All categories were defined with common cut points for blacks and whites. ORs for frequency of intake of food groups, calories, and nutrients were carried out after categorizing subjects into quartiles, based on the distribution in the controls, with the lowest quartile as the referent. Trend tests for food groups and micronutrients were calculated based on scores for the median intake in each quartile, whereas for macronutrients and caloric intake, trend tests were determined over deciles of intake. ORs for selected food items were based on the frequency of intake (none, 1–3 times/month, 1 time/week, 2–4 times/week, and 5+ times/week), with trend tests based on the median intake in the respective groups. Where indicated, energy-adjusted risks were calculated by the nutrient partition (16) and multivariate nutrient density methods (17). The nutrient partition approach to energy adjustment models the effects on risk on changes in intake of a specific nutrient, holding other calories constant, whereas the multivariate nutrient density approach models risk in relation to changes in the percentage of calories from a specific nutrient, holding total calories constant (18–20).

Study Subjects. In total, 1292 cases and 1767 controls were identified for the study. Interviews were obtained for 988 cases [76% (black, 78%; white, 75%; Atlanta, 77%; Detroit, 79%; New Jersey, 74%)] and 1336 controls (76%). After accounting for nonresponse in the initial phase of screening for eligibility among random digit dialing contacts, the response rate in controls was 70% (black, 71.4%; white, 68.2%; Atlanta, 79.0%; Detroit, 68.0%; New Jersey, 66.4%). Six cases and six controls were dropped from the analysis due to incomplete interviews. Sixteen subjects (1 case and 15 controls) were excluded due to a prior history of prostate cancer. The final study group consisted of 981 cases (479 black men and 502 white men) and 1315 controls (594 black men and 721 white men). This analysis was further limited to subjects who answered 95% or more of the line items in the dietary questionnaire or whose dietary records were considered to be reliable (*e.g.*, excluding extremely high or low values for total amount of foods consumed), resulting in a dietary study group of 932 cases (449 black men and 483 white men) and 1201 controls (543 black men and 658 white men). Among cases, 164 blacks (36.5%) and 129 whites (25.7%) had advanced disease (regional/distant stage), whereas 121 blacks (26.9%) and 107 whites (22.2%) had high-grade (poorly differentiated/undifferentiated) cancers.

Results

Among American blacks, education and socioeconomic status were unrelated to prostate cancer risk. Among whites, education beyond the eighth grade was associated with modest increases in risk. Physically active occupations were associated with modest increases in risk for advanced prostate cancer

[6] The abbreviations used are: NHANES, National Health and Nutrition Survey; OR, odds ratio; BMI, body mass index; CI, confidence interval.

Table 1 Risk[a] of prostate cancer among American blacks and whites, by selected characteristics

Characteristic	American blacks							American whites						
	Controls	All cases			Advanced cases			Controls	All cases			Advanced cases		
		Cases	OR	95% CI	Cases	OR	95% CI		Cases	OR	95% CI	Cases	OR	95% CI
Education														
0–8th grade	200	179	1.0		66	1.0		80	50	1.0		12	1.0	
9–11th grade	125	113	1.1	0.8–1.6	41	1.0	0.6–1.6	87	85	1.7	1.0–2.7	24	1.9	0.9–4.1
12th grade/technical	112	95	1.0	0.7–1.5	39	1.0	0.6–1.6	185	152	1.6	1.0–2.5	38	1.5	0.7–3.0
Some college	106	62	0.8	0.6–1.2	18	0.6	0.3–1.1	304	196	1.4	0.9–2.1	55	1.3	0.6–2.6
Missing data								2						
Socioeconomic status														
Low	381	316	1.0		123	1.0		235	187	1.0		57	1.0	
Moderate	127	116	1.1	0.8–1.5	37	0.9	0.6–1.4	276	189	0.9	0.7–1.2	43	0.6	0.4–1.0
High	32	17	0.8	0.4–1.5	4	0.5	0.2–1.4	144	107	1.0	0.7–1.4	29	0.8	0.5–1.4
Missing data	2							3						
Occupational physical activity														
Sedentary	230	181	1.0		66	1.0		450	321	1.0		81	1.0	
Moderate	217	180	1.0	0.7–1.3	60	0.9	0.6–1.4	150	115	1.0	0.7–1.3	30	1.1	0.7–1.7
Active	93	88	1.1	0.8–1.6	38	1.4	0.9–2.3	55	47	1.2	0.8–1.9	18	1.8	1.0–3.3
Missing data	3							3						
All subjects	543	449			164			658	483			129		

[a] Adjusted for age and study site.

among blacks and whites (Table 1). Greater childhood height and weight and adult height were linked to increased risk of prostate cancer among whites, but not among blacks (Table 2), with similar patterns of risk for all cases and for advanced disease. BMI during adulthood did not show consistent associations with prostate cancer risk among blacks or whites, although excesses were seen in some subgroups.

Food Groups. Frequency of consumption of foods high in animal fat was strongly associated with prostate cancer risk (P_{trend} = 0.008), particularly advanced disease (P_{trend} = 0.0001). The ORs in the highest quartile of intake were 1.5 (95% CI, 1.1–1.9) for all cancer and 2.2 (95% CI, 1.4–3.3) for advanced disease (Table 3). When restricted to localized disease (data not shown), the risks were more modest; the trend with increasing consumption of foods high in animal fat did not reach statistical significance (P_{trend} = 0.10). Risks for high-grade prostate cancer were also higher with greater consumption of foods high in animal fat among blacks [by quartile of intake, OR = 1.0 (referent), 1.5, 2.7, and 2.4; P_{trend} = 0.005] and whites (OR = 1.0, 1.2, 1.6, and 1.9; P_{trend} = 0.04; data not shown).

Although numbers are small for stratified analyses, the finding of increased risk with foods high in animal fat, particularly for advanced-stage disease, was consistent within subgroups, by age, adult height, and BMI (data not shown). Additional statistical adjustment for job-related physical activity, education, and socioeconomic status did not substantially alter the observed associations.

In general, a high level of consumption of foods high in animal fat tended to be associated with a greater relative risk among blacks than among whites. Among blacks, significant trends with increasing frequency of intake of foods high in animal fat were observed for all cancer (P_{trend} = 0.005) and for advanced cancer (P_{trend} = 0.004), whereas among whites, a significant trend was found only with advanced disease (P_{trend} = 0.01). Red meat consumption was associated with risk for all disease and advanced disease among blacks, whereas among whites, the risk of advanced disease was elevated at higher levels of red meat intake, but the trend was not statistically significant. Risks for prostate cancer and advanced prostate cancer increased with increasing intake of dairy products among whites, but not among blacks.

For blacks and whites combined, risks were unrelated to the frequency of consumption of fruits and vegetables, and no consistent patterns were observed when blacks and whites were compared (Table 3). These findings were essentially unchanged after an adjustment for consumption of foods high in animal fat. Consumption of breads, grains, and cereals was modestly associated with risk among blacks, but not among whites.

Energy Intake and Dietary Fat. In agreement with the findings for frequency of consumption of food groups, the intake of animal fat by amount (grams/day) was associated with risk for advanced cancer among blacks (P_{trend} = 0.0001) and whites (P_{trend} = 0.02) and for all prostate cancer among blacks (P_{trend} = 0.0009; Table 4). Among blacks, however, risks for prostate cancer also increased with increasing intake of calories (energy) from foods (all cancer, P_{trend} = 0.004; advanced cancer, P_{trend} = 0.0004) including protein and carbohydrates, whereas among whites, prostate cancer was only weakly associated with overall energy intake (all cancer, P_{trend} = 0.15; advanced cancer, P_{trend} = 0.16).

Animal fat contributes substantially to food calories (24.8% among black controls and 23.8% among white controls), and their intakes are highly correlated (r = 0.85 among black controls and r = 0.79 among white controls). Tables 5 (all cancer) and 6 (advanced cancer) show the partition of prostate cancer risk by levels of intake of animal fat and other sources of calories.

Among blacks, risks for prostate cancer tended to rise with increasing intake of fat from animal sources after an adjustment for calories from other sources (Ref. 16; P_{trend} = 0.007; Table 5). Among whites, no clear trends were found for prostate cancer with increasing intake of animal fat (P_{trend} = 0.90) after an adjustment for other calories. These trends were not changed by further adjustment for job-related physical activity and body size index (P_{trend} for blacks = 0.006; P_{trend} for whites = 0.98). However, after an adjustment for animal fat no increases in risk were found with increasing intake of calories from other sources for blacks [by quartile, OR = 1.0 (referent), 1.0, 0.8,

Table 2 Risk[a] of prostate cancer among American blacks and whites, by selected anthropometric characteristics

Characteristic	American blacks						American whites					
	All cases			Advanced cases			All cases			Advanced cases		
	Cases	OR	95% CI	Cases	OR	95% CI	Cases	OR	95% CI	Cases	OR	95% CI
Childhood height												
Short	82	1.0		29	1.0		60	1.0		15	1.0	
Somewhat short	31	0.8	0.5–1.5	15	1.1	0.5–2.4	36	1.1	0.6–1.8	9	1.0	0.4–2.6
Average height	245	0.9	0.6–1.3	88	0.9	0.6–1.6	274	1.4	0.9–2.0	77	1.6	0.9–2.7
Somewhat tall	35	1.3	0.7–2.3	10	1.1	0.5–2.6	55	2.2	1.3–3.7	15	2.4	1.1–5.4
Tall	55	0.9	0.6–1.5	21	1.0	0.5–2.0	56	1.9	1.1–3.1	13	1.8	0.8–4.0
Missing data	1			1			2					
P for trend		0.89			0.97			0.0009			0.04	
Childhood weight												
Thin	136	1.0		49	1.0		145	1.0		33	1.0	
Somewhat thin	48	1.0	0.6–1.5	17	1.0	0.5–1.8	69	1.2	0.8–1.8	20	1.6	0.9–2.9
Average weight	200	1.1	0.8–1.4	72	1.1	0.7–1.7	207	1.2	0.9–1.6	60	1.6	1.0–2.6
Somewhat heavy	49	1.0	0.7–1.6	21	1.3	0.7–2.4	45	1.5	1.0–2.4	8	1.1	0.5–2.6
Heavy	15	1.0	0.5–2.0	5	0.9	0.3–2.7	16	1.9	0.9–4.1	8	4.0	1.5–10.5
Missing data	1						1					
P for trend		0.79			0.56			0.04			0.02	
Adult height (meters)												
1.67[b]	123	1.0		49	1.0		90	1.0		17	1.0	
1.75	125	1.2	0.9–1.7	40	1.0	0.6–1.6	111	1.3	0.9–1.9	37	2.2	1.2–4.2
1.80	103	1.1	0.7–1.5	43	1.1	0.7–1.8	147	1.6	1.2–2.3	40	2.2	1.2–4.2
1.85	98	1.0	0.7–1.5	32	0.8	0.5–1.4	135	1.7	1.2–2.4	35	2.1	1.1–3.9
P for trend		0.92			0.66			0.002			0.03	
BMI at 25 years of age												
19.7[b]	106	1.0		28	1.0		139	1.0		36	1.0	
21.8	103	0.8	0.5–1.1	44	1.1	0.7–2.0	113	0.9	0.7–1.3	28	0.9	0.5–1.6
23.6	91	0.8	0.5–1.2	26	0.8	0.5–1.5	96	0.8	0.5–1.1	27	0.8	0.4–1.3
26.5	139	1.1	0.8–1.6	59	1.8	1.0–3.0	125	1.2	0.9–1.7	38	1.2	0.7–2.0
Missing data	10			7			10					
P for trend		0.29			0.03			0.32			0.49	
BMI at usual adult weight												
21.9[b]	134	1.0		51	1.0		129	1.0		28	1.0	
24.3	103	0.8	0.6–1.1	37	0.8	0.5–1.2	107	0.8	0.6–1.1	28	1.0	0.5–1.7
25.8	91	0.8	0.5–1.2	26	0.6	0.3–1.0	122	0.9	0.7–1.3	37	1.3	0.7–2.2
28.9	120	0.8	0.6–1.2	49	0.9	0.5–1.4	125	1.1	0.8–1.4	36	1.3	0.8–2.3
Missing data	1			1								
P for trend		0.32			0.58			0.43			0.20	
BMI at maximum weight												
23.9[b]	120	1.0		48	1.0		111	1.0		25	1.0	
26.5	100	0.9	0.6–1.3	34	0.7	0.5–1.3	111	1.0	0.7–1.4	30	1.2	0.7–2.1
29.1	112	0.9	0.6–1.2	38	0.7	0.4–1.2	140	1.2	0.9–1.8	42	1.6	1.0–2.8
32.8	115	0.8	0.6–1.1	44	0.8	0.5–1.2	119	1.4	0.9–1.9	32	1.5	0.9–2.7
Missing data	2						2					
P for trend		0.40			0.30			0.04			0.09	

[a] All ORs are adjusted for age and study site.
[b] Median in category.

and 1.0; $P_{trend} = 0.71$] or whites (by quartile, OR = 1.0 (referent), 1.1, 1.2, and 1.2; $P_{trend} = 0.38$].

Risks for advanced prostate cancer tended to rise with increasing intake of fat from animal sources (after adjustment for calories from other sources) among blacks ($P_{trend} = 0.006$) and whites ($P_{trend} = 0.02$; Table 6). Trends were not changed by further adjustment for job-related physical activity and body size index (P_{trend} for blacks = 0.004; P_{trend} for whites = 0.04). After adjustment for animal fat, no increases in risk were noted with intake of calories from other sources for blacks [by quartile, OR = 1.0 (referent), 1.0, 1.0, and 1.1; $P_{trend} = 0.55$] or whites [by quartile, OR = 1.0 (referent), 0.9, 0.9, and 0.8; $P_{trend} = 0.64$].

In a previous report (21), we showed increasing risk for prostate cancer with increasing intake of alcohol among blacks (highest intake group of ≥57 drinks/week, OR = 1.8; 95% CI, 1.1–3.0; $P_{trend} < 0.01$) and whites (highest intake group of ≥57 drinks/week, OR = 2.0; 95% CI, 1.2–3.4; $P_{trend} < 0.05$), with similar risks for localized and advanced cancer. The associations found here with animal fat were independent of alcohol intake.

Risks for high-grade prostate cancer also were higher with greater intake of animal fat (after adjustment for calories from other sources) among blacks [by quartile, OR = 1.0 (referent), 1.9 (95% CI, 0.9–3.9), 2.8 (95% CI, 1.3–5.9), and 2.9 (95% CI, 1.3–6.4); $P_{trend} = 0.04$] and whites [by quartile, OR = 1.0, 1.5 (95% CI, 0.8–3.0), 1.8 (95% CI, 0.9–3.6), and 2.0 (95% CI, 0.9–4.4); $P_{trend} = 0.08$].

When animal fat intake was expressed as a proportion of energy intake (nutrient density), no associations were found (after adjustment for total caloric intake; Ref. 17) with total prostate cancer among blacks [by quartile, OR = 1.0 (referent),

Table 3 ORs for prostate cancer according to consumption level of selected food groups

Food group	All cancer					Advanced cancer				
	Quartiles of consumption				*P* for trend	Quartiles of consumption				*P* for trend
	Low 1	2	3	High 4		Low 1	2	3	High 4	
Fruits										
All subjects[a]	1.0	1.1	1.2	1.1	0.48	1.0	1.1	1.0	1.0	0.90
Blacks[b]	1.0	1.3	1.2	1.3	0.29	1.0	1.5	1.4	1.6	0.12
Whites[b]	1.0	1.0	1.1	1.0	0.98	1.0	0.9	0.7	0.6	0.06
Vegetables										
All subjects	1.0	1.1	1.1	1.0	0.89	1.0	1.0	1.1	1.1	0.48
Blacks	1.0	1.3	1.2	1.2	0.30	1.0	1.3	1.4	1.4	0.24
Whites	1.0	0.9	1.0	0.8	0.38	1.0	0.8	0.9	0.9	0.79
Breads, grains, and cereals										
All subjects	1.0	1.1	1.1	1.2	0.15	1.0	0.9	1.0	1.2	0.18
Blacks	1.0	1.1	1.1	1.4	0.05	1.0	1.0	1.2	1.7	0.03
Whites	1.0	1.1	1.1	1.0	0.90	1.0	0.9	0.9	0.9	0.63
Dairy foods										
All subjects	1.0	1.1	1.2	1.2	0.17	1.0	1.2	1.3	1.4	0.10
Blacks	1.0	0.9	1.1	0.9	0.75	1.0	1.2	1.5	1.1	0.57
Whites	1.0	1.6[c]	1.5[c]	1.7[c]	0.03	1.0	1.4	1.2	1.7	0.07
Meat										
All subjects	1.0	1.3[c]	1.2	1.4[c]	0.06	1.0	1.5[c]	1.4	1.8[c]	0.006
Blacks	1.0	1.4	1.5	1.8[c]	0.003	1.0	1.6	2.1[c]	2.4[c]	0.002
Whites	1.0	1.2	1.0	1.0	0.76	1.0	1.4	1.0	1.4	0.56
Red meat										
All subjects	1.0	1.3	1.2	1.4[c]	0.04	1.0	1.7[c]	1.8[c]	2.0[c]	0.002
Blacks	1.0	1.4	1.5[c]	1.9[c]	0.0007	1.0	1.7	1.8[c]	2.5[c]	0.0008
Whites	1.0	1.2	1.0	1.0	0.62	1.0	1.7	1.6	1.5	0.34
Poultry and fish										
All subjects	1.0	1.1	1.2	1.1	0.38	1.0	0.9	1.0	1.0	0.89
Blacks	1.0	1.2	1.3	1.3	0.20	1.0	0.8	1.2	1.1	0.29
Whites	1.0	1.1	1.1	1.0	0.93	1.0	1.0	0.9	0.8	0.33
Foods high in animal fat										
All subjects	1.0	1.4[c]	1.7[c]	1.5[c]	0.008	1.0	1.6[c]	2.9[c]	2.2[c]	0.0001
Blacks	1.0	1.3	2.0[c]	1.8[c]	0.005	1.0	1.6	4.0[c]	2.4[c]	0.004
Whites	1.0	1.6[c]	1.6[c]	1.3	0.29	1.0	1.6	2.2[c]	2.1[c]	0.01
Sweets										
All subjects	1.0	1.1	1.2	1.3[c]	0.02	1.0	1.0	1.3	1.6[c]	0.005
Blacks	1.0	1.1	1.2	1.3	0.21	1.0	0.6	1.2	1.2	0.15
Whites	1.0	1.2	1.1	1.5[c]	0.02	1.0	1.4	1.4	2.2[c]	0.006

[a] Adjusted for age, study site, and race.
[b] Adjusted for age and study site.
[c] $P < 0.05$.

1.2 (95% CI, 0.8–1.8), 1.0 (95% CI, 0.7–1.5), and 1.3 (95% CI, 0.9–1.9); $P_{trend} = 0.40$] or whites [by quartile, OR = 1.0, 1.1 (95% CI, 0.8–1.5), 1.2 (95% CI, 0.9–1.7), and 1.0 (95% CI, 0.7–1.4); $P_{trend} = 0.90$]. However, for advanced prostate cancer, weak associations were noted for blacks [by quartile, OR = 1.0, 1.5 (95% CI, 0.9–2.7), 1.2 (95% CI, 0.7–2.1), and 1.8 (95% CI, 1.1–3.1); $P_{trend} = 0.13$] and whites [by quartile, OR = 1.0, 1.4 (95% CI, 0.8–2.5), 2.2 (95% CI, 1.3–3.9), and 1.4 (95% CI, 0.8–2.6); $P_{trend} = 0.08$].

Other Dietary Components. After adjustment for fat from animal sources and other sources of energy, no consistent associations were found with the amount of dietary intake of calcium or vitamin A from animal or plant sources (Table 7). No clear associations were seen with frequency of intake of foods high in lycopene, except for modest decreases in risk for advanced cancer associated with greater consumption of raw tomatoes ($P_{trend} = 0.04$). Consumption of cooked tomatoes was unrelated to risk (Table 8). Also, use of multivitamins was only weakly related to decreased cancer risk among blacks [all cancer, OR = 0.8 (95% CI, 0.6–1.0); advanced cancer, OR = 0.8 (95% CI, 0.5–1.2)] and among whites [all cancer, OR = 1.0 (95% CI, 0.7–1.3); advanced cancer, OR = 0.8 (95% CI, 0.5–1.3)]. No associations were noted with the use of vitamin A, B vitamins (vitamin B complex or single B vitamins such as riboflavin, thiamine, niacin, or B_{12}), vitamin C, or cod liver oil, although numbers for these comparisons are small.

Discussion

In this multicenter case-control study, we found that greater consumption of foods high in animal fat was linked to prostate cancer among American blacks and to advanced prostate cancer among both blacks and whites. In agreement with national surveys (22), we previously reported (12) that the patterns of dietary intake, including animal fat and caloric consumption, were similar among black and white controls, but herein we show that risk for prostate cancer associated with a given level of animal fat intake tended to be greater among blacks.

Our overall findings are consistent with several case-control (8, 23–32) and cohort (33–36) studies that have linked

Table 4 ORs for prostate cancer according to calories from food and consumption level of food components

	All cancer					Advanced cancer				
	Quartiles of consumption				*P* for trend	Quartiles of consumption				*P* for trend
	Low 1	2	3	High 4		Low 1	2	3	High 4	
Calories from food										
All subjects[a]	1.0	1.5[b]	1.6[b]	1.5[b]	0.002	1.0	1.4	2.0[b]	1.8[b]	0.0004
Blacks[c]	1.0	1.5[b]	1.5[b]	1.8[b]	0.004	1.0	1.3	2.4[b]	2.2[b]	0.0004
Whites[c]	1.0	1.5[b]	1.7[b]	1.3	0.15	1.0	1.4	1.6	1.5	0.16
Fat										
All subjects	1.0	1.4[b]	1.5[b]	1.4[b]	0.003	1.0	1.4	1.9[b]	2.0[b]	0.0003
Blacks	1.0	1.5[b]	1.4	1.9[b]	0.004	1.0	1.9[b]	2.3[b]	2.4[b]	0.002
Whites	1.0	1.2	1.6[b]	1.1	0.17	1.0	0.9	1.5	1.6	0.04
Animal fat										
All subjects	1.0	1.6[b]	1.8[b]	1.5[b]	0.004	1.0	2.1[b]	3.1[b]	2.6[b]	<0.0001
Blacks	1.0	1.5	2.0[b]	1.9[b]	0.0009	1.0	2.2[b]	4.3[b]	3.3[b]	0.0001
Whites	1.0	1.7[b]	1.7[b]	1.2	0.39	1.0	2.1[b]	2.4[b]	2.1[b]	0.02
Other fat										
All subjects	1.0	1.1	1.1	1.3[b]	0.02	1.0	1.2	1.5[b]	1.5	0.03
Blacks	1.0	1.1	1.0	1.3	0.10	1.0	1.3	1.5	1.3	0.18
Whites	1.0	1.1	1.1	1.4	0.11	1.0	1.1	1.5	1.7	0.07
Protein										
All subjects	1.0	1.2	1.3[b]	1.3	0.01	1.0	1.2	1.8[b]	1.6[b]	0.001
Blacks	1.0	1.4	1.5[b]	1.8[b]	0.002	1.0	2.1[b]	2.9[b]	2.6[b]	0.0006
Whites	1.0	1.0	1.2	0.9	0.59	1.0	0.7	1.1	1.0	0.34
Carbohydrates										
All subjects	1.0	1.1	1.2	1.4[b]	0.008	1.0	1.1	1.4	1.5[b]	0.01
Blacks	1.0	1.0	1.0	1.3	0.02	1.0	0.8	1.4	1.7[b]	0.002
Whites	1.0	1.3	1.4	1.4	0.14	1.0	1.3	1.3	1.3	0.71

[a] Adjusted for age, study site, and race.
[b] $P < 0.05$.
[c] Adjusted for age and study site.

Table 5 OR for prostate cancer (all cases) according to fat from animal sources and other sources of energy

Other calories (quartiles)[a]			Fat from animal sources (quartiles)[b]				
			Low 1	2	3	High 4	*P* for trend
			A. American blacks				
Low	1	OR[c]	1.0	1.1	2.8[d]		0.08
		Cases/controls	49/84	29/45	19/14	0/1	
	2	OR	0.7	1.4	2.0[d]	1.8	0.01
		Cases/controls	17/37	38/49	43/36	11/14	
	3	OR	1.1	1.8	1.3	1.4	0.87
		Cases/controls	7/9	27/24	37/48	36/45	
High	4	OR	0.3	1.1	2.1[d]	1.9[d]	0.47
		Cases/controls	1/5	10/14	35/27	90/91	
Calorie-adjusted OR[e]			1.0	1.5	2.1	2.0	0.007
95%CI				1.0–2.3	1.3–3.2	1.2–3.1	
			B. American whites				
Low	1	OR[c]	1.0	1.6	1.3	1.0	0.48
		Cases/controls	43/92	32/45	8/15	2/4	
	2	OR	1.0	1.5	1.9[d]	1.6	0.30
		Cases/controls	23/47	39/55	43/48	10/14	
	3	OR	1.4	2.3[d]	2.2[d]	0.9	0.14
		Cases/controls	14/19	55/47	65/62	23/47	
High	4	OR	1.4	1.9	1.4	1.4	0.98
		Cases/controls	4/7	22/21	36/51	64/84	
Calorie-adjusted OR[e]			1.0	1.6	1.5	1.1	0.90
95%CI				1.1–2.3	1.0–2.3	0.7–1.7	

[a] Quartiles of other sources of energy (calories): ≤1043, 1044–1327, 1328–1637, ≥1638.
[b] Quartiles of animal fat (grams): ≤33, 34–46, 47–61, ≥62.
[c] Adjusted for age and study site.
[d] $P < 0.05$.
[e] Adjusted for age, study site, and other calories.

Table 6 OR for advanced prostate cancer according to fat from animal sources and other sources of energy

Other calories (quartiles)[a]			Fat from animal sources (quartiles)[b] Low 1	2	3	High 4	*P*
			A. American blacks				
Low	1	OR[d]	1.0	2.2	8.2[e]		0.005
		Cases/controls	10/84	10/45	10/14	0/1	
	2	OR	1.2	2.3	5.3[e]	1.8	0.02
		Cases/controls	5/37	11/49	18/36	2/14	
	3	OR	1.6	3.3[f]	3.3[g]	4.1[g]	0.20
		Cases/controls	2/9	8/24	17/48	17/45	
High	4	OR	1.5	2.9	5.5[e]	3.9[e]	0.56
		Cases/controls	1/5	4/14	14/27	35/91	
Calorie-adjusted OR[c]			1.0	2.2	4.2	3.1	0.006
95%CI				1.1–4.3	2.2–8.3	1.5–6.5	
			B. American whites				
Low	1	OR[d]	1.0	2.0	0.6		0.54
		Cases/controls	13/92	12/45	1/15	0/4	
	2	OR	0.5	1.8	2.3	1.2	0.41
		Cases/controls	4/47	12/55	14/48	2/14	
	3	OR	0.7	1.5	2.3[f]	1.5	0.20
		Cases/controls	2/19	9/47	18/62	9/47	
High	4	OR		1.1	1.3	1.9	0.03
		Cases/controls	0/7	3/21	9/51	21/84	
Calorie-adjusted OR[c]			1.0	2.2	2.6	2.4	0.02
95%CI				1.2–4.1	1.3–5.1	1.1–5.0	

[a] Quartiles of other sources of energy (calories): ≤1043, 1044–1327, 1328–1637, ≥1638.
[b] Quartiles of animal fat (grams): ≤33, 34–46, 47–61, ≥62.
[c] Adjusted for age, study site, and other calories.
[d] Adjusted for age and study site.
[e] $P < 0.001$.
[f] $P < 0.05$.
[g] $P < 0.01$.

Table 7 Dietary intake of selected micronutrients and risk of prostate cancer

	All cancer					Advanced cancer				
	Quartiles of consumption				*P* for trend	Quartiles of consumption				*P* for trend
	Low 1	2	3	High 4		Low 1	2	3	High 4	
Vitamin A: animal sources										
All subjects[a]	1.0	1.0	1.0	0.9	0.41	1.0	1.1	1.1	1.2	0.70
Blacks[b]	1.0	1.1	1.2	1.1	0.88	1.0	1.4	1.5	1.7	0.25
Whites[b]	1.0	1.0	1.0	0.8	0.23	1.0	1.1	1.0	0.9	0.62
Vitamin A: fruit and vegetable sources										
All subjects	1.0	1.0	1.0	1.0	0.84	1.0	1.2	1.1	1.1	0.98
Blacks	1.0	1.3	1.3	0.2	0.56	1.0	1.1	1.4	1.5	0.23
Whites	1.0	0.9	0.9	0.8	0.86	1.0	1.3	0.8	0.7	0.08
Calcium: food sources										
All subjects	1.0	1.0	1.0	0.9	0.58	1.0	0.9	1.0	0.9	0.58
Blacks	1.0	0.8	0.7	0.6	0.06	1.0	1.0	1.1	0.8	0.44
Whites	1.0	1.2	1.4	1.4	0.22	1.0	0.7	1.0	0.9	0.90

[a] Adjusted for age, study site, calories (animal fat and other sources), and race.
[b] Adjusted for age, study site, and calories (animal fat and other sources).

prostate cancer risk to dietary intake of animal products, particularly animal or saturated fat. However, some studies have shown no association (37–41), whereas others have also implicated unsaturated fat (4, 29, 35, 36) and specific fatty acids such as linolenic acid (35, 36). As in our investigation, several of these reports suggested that fat enhances tumor progression because the risk was most pronounced among men with advanced disease (8, 29, 33, 35).

Only one other large case-control study of prostate cancer has examined diet-associated risks among ethnic groups in the United States. Whitemore *et al.* (8) found a positive relation between prostate cancer risk and saturated

Table 8 Dietary intake of selected foods and risk of prostate cancer

	All cancer						Advanced cancer					
	No. of servings					*P* for trend	Quartiles of consumption					*P* for trend
	0	1–3/mo	1/wk	2–4/wk	5+/wk		0	1–3/mo	1/wk	2–4/wk	5+/wk	
Raw tomatoes												
All subjects[a]	1.0	0.9	1.0	1.0	0.8	0.16	1.0	0.5	0.9	0.8	0.5[b]	0.04
Blacks[c]	1.0	0.9	0.9	1.0	0.8	0.41	1.0	0.5	0.7	0.8	0.5[b]	0.19
Whites[c]	1.0	1.0	1.3	1.1	0.9	0.23	1.0	0.5	1.2	0.8	0.5	0.13
Cooked tomatoes and tomato sauces												
All subjects	1.0	1.2	0.8	1.0	1.3	0.71	1.0	1.8[b]	1.4	1.6	1.6	0.95
Blacks	1.0	1.3	1.1	1.3	1.3	0.98	1.0	1.7	1.5	1.8	1.9	0.57
Whites	1.0	0.8	0.5[b]	0.7	0.9	0.62	1.0	1.7	1.2	1.4	0.7	0.32
Tomato juice												
All subjects	1.0	1.1	1.0	1.1	1.4	0.20	1.0	0.9	1.0	1.1	1.1	0.68
Blacks	1.0	1.0	1.1	1.1	1.3	0.36	1.0	0.8	0.9	0.9	0.2	0.07
Whites	1.0	1.2	1.0	1.1	1.5	0.36	1.0	1.1	1.1	1.3	2.8[b]	0.02
Watermelon												
All subjects	1.0	0.8	0.9	0.6		0.05	1.0	0.7	0.7	0.8		0.63
Blacks	1.0	0.9	0.9	0.6		0.13	1.0	0.8	0.9	1.0		0.89
Whites	1.0	0.8	0.8	0.6		0.16	1.0	0.6[b]	0.4	0.6		0.29
Lycopene sources: combined food groups[d]												
All subjects	1.0		1.2	1.2	0.9	0.07	1.0		1.5	1.3	1.0	0.13
Blacks	1.0		1.2	1.3	1.0	0.26	1.0		1.5	1.4	1.0	0.14
Whites	1.0		1.1	1.0	0.9	0.17	1.0		1.4	1.0	1.0	0.54

[a] Adjusted for age, study site, calories (animal fat and other sources), and race.
[b] $P < 0.05$.
[c] Adjusted for age, study site, and calories (animal fat and other sources).
[d] Raw tomatoes; cooked tomatoes, tomato sauce, or spaghetti sauce; tomato juice; watermelon.

fat intake among a combined group of blacks, whites, and Asian Americans. Risks associated with increased saturated fat intake tended to be greater for advanced disease than for all cancers combined but did not show a pattern of higher risks among blacks than whites. In fact, the trends were most pronounced for Asian Americans.

In our study, the statistical association of prostate cancer with animal fat intake was more pronounced when caloric adjustment was made by the energy partition method than by the nutrient density method. This finding suggests that risk may be lowered by reducing animal fat intake without substituting calories from other sources (17, 19). However, the survey instruments used to assess intake are limited, and these differences in model specification may be artifactual to some extent. Greater understanding is needed about the impact of changes in physical activity, body size, and macronutrient intake on metabolism and energy balance before recommendations can be made to either strictly reduce animal fat or to substitute other macronutrients (20).

Additional studies are needed to determine the mechanisms by which animal fat, its metabolites, or other constituents of foods high in animal fat enhance the progression of small prostatic tumors to clinically detectable disease. Microscopic (and presumably indolent) tumors of the prostate are common in aging men and show a similar prevalence in populations at low or high risk of clinical disease, but high-risk populations including American blacks have a greater prevalence of aggressive (*i.e.*, large and invasive) or multifocal tumors (2, 3, 42). The high relative mortality from prostate cancer among blacks compared to whites also suggests that clinical prostate cancer is biologically more aggressive among blacks (1), although differences in survival may also reflect racial variations in the patterns of diagnosis and treatment.

In an earlier analysis of our data (12), we found that black controls were more frequent consumers than white controls of vegetables rich in vitamin A. In the present analysis, however, the risk of prostate cancer was unrelated to intake of vegetables, vitamin A from plant or animal sources, lycopene-rich foods, or vitamin supplements. The findings from earlier epidemiological studies are equivocal regarding the effects of vitamin A, carotenoids, and fruits and vegetables (6, 43). A protective role for selected lycopene-rich foods has been suggested (44) but was not confirmed in our study. Increased calcium intake from diet and supplements has also been suggested as a risk factor for prostate cancer (45), but we found no association with calcium in the diet.

Among whites only, we found an increased risk associated with greater adult height, as reported in some other studies (46–49), as well as with larger childhood body size. In Sweden (50), high birth weight was correlated with increased prostate cancer mortality, suggesting that perinatal determinants of body size may influence the risk of prostate cancer in later life. However, another study (49) reported an inverse association of risk with obesity at a young age. Studies of body build in adults and prostate cancer risk have not shown consistent results (6), but further examination of anthropometric factors at various ages are needed, particularly in relation to race, diet and nutrition, physical activity, endogenous hormones, and growth factors.

In summary, greater consumption of fat from animal sources was linked to increased risk for prostate cancer among American blacks and to advanced prostate cancer among American blacks and whites. Thus, the greater occurrence and clinical aggressiveness of prostate cancer among American blacks compared to whites may result from differential effects of animal fat in these populations. Reduction in the American diet of fat from animal sources could lead to decreased incidence and mortality rates for prostate cancer, particularly among American blacks.

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support, and the interviewers, support staff, physicians, and hospital personnel in the study areas for participation.

Appendix

Fruits: grapefruit, oranges, raw apples/pears, apricots, bananas, cantaloupe, watermelon, fresh peaches or nectarines, canned peaches, and orange juice or grapefruit juice.

Vegetables: raw tomatoes, cauliflower, broccoli, okra, cooked tomatoes, white potatoes, red beets, collards/mustard greens/kale, spinach, carrots or carrot salad or peas and carrots, mixed vegetables, tossed salad, coleslaw, cooked cabbage, green peas, black-eyed peas, green string beans or lima beans, zucchini or yellow squash, sweet potatoes or yams, tomato juice, and soup with mixed vegetables.

Foods high in lycopene: raw tomatoes, cooked tomatoes, tomato sauce or spaghetti sauce, tomato juice, and watermelon.

Breads, grains, and cereals: bread or rolls, rice, pasta, hot cereal, and cold cereal.

Foods high in animal fat (animal products that were major contributors to total fat intake): beef, lunch meat, bacon, hot dogs, mixed dishes with meat, salt pork, other pork, gravy, stew/pot pie, baked chicken, fried chicken, liver and liverwurst, eggs, cheese, whole milk, half and half, and ice cream.

Sweets: cake and cookies, ice cream, doughnuts, and added sugar.

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