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Socioeconomic status, health care density, and risk of prostate cancer among African-American and Caucasian men in a large prospective study

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Abstract

Objectives—The purpose of this study was to separately examine the impact of neighborhood socioeconomic deprivation and availability of healthcare resources on prostate cancer risk among African-American and Caucasian men.

Methods—In the large, prospective NIH-AARP Diet and Health Study, we analyzed baseline (1995–1996) data from adult men, ages 50–71 years. Incident prostate cancer cases (n=22,523; 1,089 among African Americans) were identified through December 2006. Life-style and health risk information was ascertained by questionnaires administered at baseline. Area-level socioeconomic indicators were ascertained by linkage to the US Census and the Area Resource File. Multilevel Cox models were used to estimate hazard ratios (HRs) and 95% confidence intervals (CIs).

Results—A differential effect among African Americans and Caucasians was observed for neighborhood deprivation (*P*-interaction = 0.04), percent uninsured (*P*-interaction = 0.02), and urologist density (*P*-interaction = 0.01). Compared to men living in counties with the highest density of urologists, those with fewer had a substantially increased risk of developing advanced prostate cancer (HR=2.68, 95% CI=1.31, 5.47) among African-American.

Conclusions—Certain socioeconomic indicators were associated with an increased risk of prostate cancer among African-American men compared to Caucasians. Minimizing differences in health care availability may be a potentially important pathway to minimizing disparities in prostate cancer risk.

Keywords

cohort; prostate cancer; multilevel; neighborhood; socioeconomic deprivation; healthcare availability; Census

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INTRODUCTION

Prostate cancer is the most commonly diagnosed malignancy and the second leading cause of cancer-related deaths in men in the United States (1). The incidence of prostate cancer has increased over the past two decades. This may reflect an increase in true occurrence of disease, but may also reflect changes in diagnostic practices (i.e., an increase in prostate-specific antigen screening) leading to detection of indolent cases. African-American men have a disproportionate burden of prostate cancer compared with other racial groups (2–6). The prostate cancer incidence rate for African Americans is 233.8/100,000 compared with 149.5/100,000 for Caucasians (7). The reason for the racial disparity in prostate cancer is not well understood, presenting a major challenge in prostate cancer disparities research (8). Environmental and life-style factors are thought to influence the development of prostate cancer and studies have found an association between indicators of poverty (e.g., lower education) and the risk of prostate cancer; however, most observations are based on predominantly Caucasian populations and may therefore not apply to individuals with different life-styles and racial backgrounds. In addition, the number of African Americans represented in existing population-based studies generally has been small.

Ecological studies suggest contributory factors to the racial disparity may be differences in socioeconomic factors of the environment a person resides (9, 10), however, those studies did not account for an individual's life-style. One study evaluating racial disparities in prostate cancer incidence that looked at both individual age and area-based sociodemographic characteristics found no association between poverty and poor education and increased prostate cancer incidence among African Americans in Virginia (11). This study, however, assessed data from 1990 to 1999 from only one state cancer registry.

Given the large racial differences in prostate cancer risk and the potential role of socioeconomic status (SES), simultaneous investigation of area- and individual-level SES factors remains warranted. To date, no cohort studies to our knowledge have investigated the risk of prostate cancer while examining neighborhood socioeconomic deprivation and availability of health care resources. Area-level socioeconomic inequalities may contribute to disparities in risk of prostate cancer among African-American and Caucasian men. Prostate cancer incidence patterns by socioeconomic variables such as education, poverty level, and median household income can provide insight into whether the increased incidence of prostate cancer is related to possible racial disparities in healthcare access and utilization. Furthermore, the number of hospitals and number and type of care providers in an area a person resides may influence screening practices and, therefore, impact incidence rates (12, 13). The purpose of the present study was to separately examine the association between area-level SES indicators with subsequent risk of total and advanced prostate cancer incidence among African-American and Caucasian men while accounting for individual-level demographic and health risk factors in a large prospective study of U.S. adult men.

METHODS

Our study sample included participants in the NIH-AARP Diet and Health Study, a cohort consisting of over 500,000 men and women designed to investigate the relation between diet and health (14). Participants were recruited from 1995 through 1996, who were between the ages of 50–71 years and residing in one of six U.S. states (California, Florida, Louisiana, New Jersey, North Carolina, and Pennsylvania) or two metropolitan areas (Atlanta, Georgia, and Detroit, Michigan) were recruited to participate in the NIH-AARP Diet and Health Study. The NIH-AARP Diet and Health Study was approved by the Special Studies Institutional Review Board of the U.S. National Cancer Institute, and written informed

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consent was obtained from all participants by completing and returning the baseline questionnaire.

Our baseline cohort included 566,401 persons. We excluded individuals whose questionnaire was completed by someone else on their behalf (n=15,760), females (n=225,467), subjects who reported having end-stage renal disease or previous cancer (n=29,921), and subjects reporting extreme daily total energy intake defined as more than two inter-quartile ranges above the 75th percentile or below the 25th percentile (n=2,557; <1% of the subjects), which was necessary for appropriate energy-adjustment of dietary intake (15). Men who were later diagnosed with *in Situ* cancer were excluded (n=8). After exclusions, there were 292,688 adult men of whom 7,949 African-Americans and 271,992 Caucasians comprised the final analytic cohort.

Case ascertainment

Case ascertainment for the NIH-AARP study has been described elsewhere (16). Briefly, cancer cases were identified through linkage with the cancer registry databases of the states of residence with the addition of Arizona and Texas, which were certified by the North American Association of Central Cancer Registries as being at least 90% complete within 2 years of cancer occurrence and the National Death Index Plus. Prostate cancer cases with information on cancer stage and histology were identified from study entry through December 2006; information on Gleason sum was not available. Advanced cases were defined as those with clinical stages of T3, T4, N1, or M1 according to the American Joint Committee on Cancer 1997 tumor-node-metastasis classification system(17).

Individual-level demographics and behavioral risk factors

Information on demographic and life-style factors, including dietary intake, cigarette use, and alcohol consumption were ascertained at baseline through a mailed questionnaire sent to members of the cohort in 1995. A validated 124-item food frequency questionnaire was used to assess a participant's usual dietary intake in the prior 12-months, as well as to estimate energy and nutrient intakes. Daily intake of food was energy-adjusted using the nutrient density method (18). Self-reported body weight (lbs) and height (ft-inches) were used to derive body mass index [weight (kg)/height (m^2)].

Area-level SES indicators

We linked the addresses of study participants to census data from 2000. We obtained the 2000 data from the U.S. Census Bureau at the census-tract level. As previously reported, we used the census-tract data to generate a composite index of neighborhood socioeconomic deprivation (19, 20). In brief, the deprivation index score was based on 10 census variables shown to explain the most variance using a principal components analysis approach. The index score was derived for census tracts using the weighted sum of the coefficients for each variable and standardized to have a mean of 0 and standard deviation of 1. The deprivation composite index includes percentage of persons in the census tract who had less than high school education, were unemployed, in managerial jobs, on public assistance, and the percent of households headed by a female, crowding, without a car, had annual income of < $30,000, or with incomes below 1999 federal poverty levels. In our analyses, the index was categorized into tertiles based on the distribution of the study's census tracts (n=18,603): the upper tertile indicates the most deprived.

The NIH-AARP data was also linked to the Area Resource File (ARF), a national county-level health resource information database (www.arf.hrsa.gov) to examine measures of healthcare access and utilization. Published by the Health Resources and Services Administration of the United States Department of Health and Human Services, the ARF provides aggregated data from several sources, including the Bureau of Economic Analysis, Bureau of Labor Statistics, and the American Medical Association of Physicians. Population densities of hospitals, specialists, and urologists were calculated by dividing the number by the population of the county according to the United States Census Population Estimates (per 10,000 individuals). Quantiles were based on the distribution of the study's counties (n=401).

Statistical Analysis

Descriptive statistics were calculated for baseline characteristics of participants and area SES indicators. Due to highly skewed physician distributions, with 34% of counties not having a urologist, hospital and physician density was categorized based on median cut points. Multivariable Cox proportional hazard regression models were used to assess the associations between neighborhood deprivation and county-level health care resources and prostate cancer with follow-up time as the underlying time metric. Multilevel models using robust variance estimation were implemented when examining area-level factors. Participants were followed from the date the baseline questionnaire was returned to the date of prostate cancer diagnosis, moving out of the study area, death, or the end of 2006, whichever came first. The proportional hazards assumption was assessed using cross-product terms for interaction between deprivation and follow-up time; no significant deviations from proportionality were found. The hazard ratio (HR) and 95% confidence interval (CI) were calculated for each variable in the multivariable Cox models. Fully adjusted models included baseline age (continuous), education, marital status, family history of prostate cancer, history of diabetes, smoking (never, former ≤ 20 cigarettes/d, former >20 cigarettes/d, current ≤20 cigarettes/d, current >20 cigarettes/d, missing), self-reported health status (excellent/great, good, fair/poor), body mass index (<18.5, 18.5 to <25, 25 to <30, ≥30 kg/m^2), alcohol consumption (none, 0 to <5, 5 to <15, 15 to <30, ≥30 g/d), all of which altered risk estimates by 10% or more. Tests for interaction between the socioeconomic indicators and race were performed by including a cross-product term in the model with the main effects and by stratifying the analysis by racial group. In sensitivity analyses, tests for trend were based on quantile-specific median values entered as a continuous term in the regression model. Statistical significance was based on two-sided P values of < 0.05. Data were analyzed using SAS® (version 9.2, SAS Institute Inc., Cary, NC).

RESULTS

In the present study, 23,612 men (1,089 African-American and 22,523 Caucasian men) were diagnosed with prostate cancer during the median follow-up period of 10 years. Of the prostate cancers among African-American men, 108 were advanced carcinomas at the time of diagnosis and 28 were fatal. In general, African-American men with prostate cancer were more likely to be married and have a family history of prostate cancer, less likely to report having a history of diabetes or perception of poor health than African-American men without prostate cancer (Table 1). Similar patterns were observed between prostate cancer cases and noncases among Caucasian men (Supplementary Table 1).

Descriptive information on SES indicators and health care resources among the census tracts (n=18,603) and counties (n=401) within the NIH-AARP Study are shown in Table 2. Among census variables, the distributions of the Gini coefficient and individual components of the neighborhood deprivation index are reported. The range for the standardized neighborhood deprivation index scores was −2.34 to 5.25 (mean=0, standard deviation=1). The median value for the Gini coefficient, a measure of income inequality, was 0.44 (25th, 75th percentiles: 0.42, 0.46). With regards to availability of healthcare resources, approximately 11% of the counties within the NIH-AARP Study were lacking hospitals and 34% any urologists. The median percent of persons without health insurance across counties was 15%. Neighborhood deprivation was positively correlated with the percent of persons without health insurance (r = 0.18) and negatively correlated with individual-level years of education (r = −0.26) (data not shown). Although statistically significant, these correlations were not particularly strong.

Results of the multilevel modeling for SES indicators show a differential effect among nonadvanced and advanced prostate cancer (Table 3). Among African-American men, SES and health care resources showed no significant effects on development of nonadvanced prostate cancer; however, a suggested increased risk of advanced prostate cancer was observed for several SES indicators and a significant association observed for African American men living in counties with fewer urologists (HR=2.68, 95% CI=1.31, 5.47). The SES-related associations with risk of prostate cancer varied according to race. For nonadvanced prostate cancer, no association was observed with neighborhood deprivation among African American men, however, among Caucasian men, the risk of developing nonadvanced cancer decreased for a 1-standard deviation increase in neighborhood deprivation scores (HR=0.88, 95% CI=0.85, 0.92; *P*-interaction =0.04). The test for linear trend was significant (*P*<0.01, Supplemental Table 2). For advanced disease, interactions with race were observed for uninsured (*P*=0.02) and urologist density (*P*=0.01). Although there was a suggested inverse association of advanced prostate cancer among African American men living in counties with a higher proportion of uninsured residents (HR=0.85, 95% CI=0.52, 1.41), Caucasian men living in similar counties had an increased risk of developing advanced prostate cancer (HR=1.34, 95% CI=1.19, 1.59).

DISCUSSION

This study is the largest prospective study to examine the association of socioeconomic indicators and health care resources with prostate cancer risk among African-American and Caucasian men. We found differential effects among African-Americans and Caucasians for certain SES indicators and increased risk of advanced prostate cancer, with the strongest association being observed for African-American men living in counties with fewer urologists. These results suggest that the ratio of urologists to population may be associated with reduced prostate cancer risks and may play a role in the variation in rates observed between African-American and Caucasian men.

Our findings are supported by those of recent cancer registry studies. Oliver and colleagues observed that poverty and residing in areas with fewer physicians were associated with a decreased incidence of any prostate cancer among Caucasians but not African Americans in Virginia (11). Advanced stage prostate cancer was associated with lack of health insurance in a national hospital-based cancer registry comprised of predominantly Caucasian patients (OR=1.85, 95% CI=1.69, 2.03) (21). Although prostate cancer severity (i.e., tumor Gleason score ≥ 7) was associated with neighborhood socioeconomic deprivation among African-American patients (OR=1.71, 95% CI: 1.21, 2.40, highest versus lowest quartile) and Caucasian patients (OR=1.34, 95% CI: 1.19, 1.52, highest versus lowest quartile) from the Pennsylvania Cancer Registry (22), no associations were observed between neighborhood deprivation and advanced (high-stage) prostate cancer for African Americans or Caucasians (OR=1.13, 95% CI: 0.77, 1.64 and OR=0.98, 95% CI: 0.82, 1.18, respectively). The estimated risks for advanced stage prostate cancer, however, were similar in magnitude and direction to those observed in the present study. These previous studies were cross-sectional and therefore unable to examine temporal relationships between SES, healthcare availability, and subsequent development of prostate cancer and often restricted to a specific geographic region (e.g., a single state). Studies examining area-level SES or healthcare population density and prostate cancer through the linkage of census or county level data to

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cancer registries are unable to account for a person's lifestyle or other individual health risk factors, including family history of prostate cancer.

Other factors that were not assessed in the NIH-AARP study may play a role in the increased incidence of advanced prostate cancer among African Americans residing in areas with fewer urologists. A recent ecologic study suggests that the patterns of urologist density are influenced by factors other than traditional socioeconomic measures, such as climate (23). In addition, it has been suggested that transportation and longer distance to a urologist may disproportionally impact African-American patients (24, 25). The lack of a strong association between health insurance and non-advanced prostate cancer in our study may be related to our older participants qualifying for Medicare, as prostate cancer often occurs after age 65 (26). Our observation that higher neighborhood deprivation was associated with decreased risk among Caucasians was unexpected and may be related to differences in the disease and screening. Because Caucasians are more likely to have indolent disease, it is possible that they are less likely to experience symptoms and therefore, may be less likely to seek screening for prostate cancer; whereas African American men residing in similarly deprived areas may seek out screening since they are more likely to have symptomatic, aggressive disease (6). Another possibility is that African-American men may be targeted differently by physicians for screening because they are in a high-risk group (27).

Among the inherent strengths of the present study is that it is based on a cohort rather than only a case series from cancer registries where in our cohort individual health risk factors were measured and study subjects were then followed forward in time allowing for direct assessment of cancer incidence. The large size of the NIH-AARP Diet and Health Study allowed us to examine potential associations among African-Americans, a high-risk population for prostate cancer. A limitation of our study is that information on household income was not ascertained in the NIH-AARP Study thus limiting our ability to account for individual socioeconomic characteristics beyond education. In addition, the cohort was predominantly older, middle class participants; therefore, results may not apply to other socioeconomically-diverse populations. Our findings may reflect incomplete adjustment for changes in SES, health care availability, and behavioral health risk factors which were not available in our study cohort. Unmeasured area-level characteristics that may play a role in prostate cancer risk include perceived neighborhood safety and social support.

In conclusion, the results of this study suggest that minimizing differences in health care availability is a potentially important pathway to minimizing disparities in prostate cancer incidence. Additional population-based studies are needed to confirm these associations and to examine the potential influence of neighborhood SES and healthcare population density on prostate cancer progression and/or the potential mediating effects of biological and molecular cancer markers.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Characteristics of African-American men by prostate cancer status in the NIH-AARP Diet and Health study (N = 7,949)

Characteristic	Non cases	Prostate Cancer	Advanced Prostate Cancer
Individual-level characteristics, n	6,860	1,089	108
Age, yrs	61.8 (.06)	61.8 (.15)	61.3 (.50)
BMI, kg/m^2	28.1 (.06)	27.9 (.14)	27.7 (.44)
Family history of prostate cancer, %	7.8	12.2*	11.1
History of diabetes, %	19.2	14.7*	14.8
College graduate, %	32.3	34.2	30.6
Currently married, %	70.7	74.8*	77.8
Smoking status, %			
Never	29.1	31.5	25.5
Former ≥1 yr	51.7	51.1	53.9
Current or former <1 yr	19.2	17.4	20.6
Vigorous physical activity ≥5 times/wk, %	17.5	18.0	17.6
Use of ≥1 vitamin supplement/month, %	48.2	49.8	46.3
Self-perceived health, fair/poor %	19.2	14.2*	8.5*
Dietary intake			
Energy, kcal/d	2080 (12.7)	2060 (31.9)	2131 (113.5)
Alcohol, g/d	13.7 (.48)	15.6 (1.3)	16.3 (4.2)
Cholesterol, mg/d	242 (1.9)	233 (4.7)	258 (16.3)
Protein, g/d	73.1 (.49)	71.1 (1.2)	73.8 (4.2)
Tomatoes, srv/1000 kcal	0.25 (.003)	0.24 (.01)	0.24 (.02)
Fruit, srv/1000 kcal	2.0 (.02)	2.2 (.05)*	2.0 (.13)
Vegetables, srv/1000 kcal	1.8 (.01)	1.8 (.04)	1.9 (.12)
Saturated fat, g/1000 kcal	10.2 (.04)	9.9 (.09)*	10.1 (.29)
α-Linolenic acid, g/1000 kcal	0.71 (.003)	0.70 (.01)	0.74 (.03)
Total calcium, mg/d	782 (4.4)	786 (11.5)	767 (34.5)
Total vitamin E, μg/d	57.6 (1.1)	57.3 (2.7)	48.1 (7.7)

Mean (SE) reported unless otherwise indicated.

* = P<.05; Significance indicated for non-prostate cancer comparisons

Table 2

Area-level socioeconomic characteristics and healthcare resources

Variable	25th percentile	Median	75th percentile
Census-tract level			
Deprivation index	−0.74	−0.14	0.56
Without high school education, %	10	18	30
Unemployment, %	3	5	9
Below poverty, %	5	9	17
Single-parent households, %	4	6	10
Receiving public assistance, %	1	2	5
Households without car, %	3	7	13
Household income < $30,000, %	21	33	47
Employed in managerial/professional jobs			
Males, %	18	27	42
Females, %	26	34	44
Non-white population, %	1	4	15
Gini coefficient	0.42	0.44	0.46
County level			
Without health insurance, %	12	15	18
Medicare beneficiaries, n	4,807	11,451	32,841
Total hospitals, n	1	2	4
Total specialists, n	5	23	115
Total urologists, n	0	2	8

County values based on the 401 distinct counties within NIH-AARP Diet and Health Study; census values are based on 18,603 distinct census tracts.

Table 3

Adjusted hazard ratios of area-level socioeconomic factors and prostate cancer by race

	African-American Men (n=7,949)		Caucasian-American Men (n=271,992)		Interactions	
	Any prostate cancer (n=1,089)	**Advanced prostate cancer (n=108)**	**Any prostate cancer (n=22,523)**	**Advanced prostate cancer (n=2,126)**	**Any PC *P* value**	**Adv PC *P* value**
Deprivation index (1-unit)	1.04 (0.93–1.17)	1.13 (0.79–1.63)	0.88 (0.85–0.92)	0.90 (0.79–1.03)	0.04	0.23
Gini coefficient (.05 unit)	1.08 (0.99–1.17)	0.88 (0.68–1.14)	1.00 (0.98–1.02)	1.21 (1.05–1.38)	0.05	0.14
More uninsured	1.07 (0.94–1.23)	0.85 (0.52–1.41)	0.95 (0.92–0.99)	1.34 (1.19–1.59)	0.08	0.02
Fewer Medicare beneficiaries	0.89 (0.67–1.19)	1.61 (0.76–3.39)	0.91 (0.85–0.98)	1.15 (0.93–1.42)	0.98	0.39
Fewer hospitals	0.95 (0.71–1.28)	1.81 (0.83–3.97)	0.94 (0.89–0.98)	1.05 (0.85–1.31)	0.83	0.18
Fewer specialists	0.93 (0.71–1.21)	1.49 (0.72–3.08)	0.91 (0.86–0.96)	1.10 (0.89–1.36)	0.77	0.41
Fewer urologists	1.11 (0.80–1.54)	2.68 (1.31–5.47)	0.90 (0.84–0.96)	0.98 (0.79–1.21)	0.10	0.01

HRs (95% CIs) reported. *P* values are reported for the interaction between race and each socioeconomic factor. Census-tract level: socioeconomic deprivation index and Gini coefficient; county-level: percent no insurance, Medicare beneficiaries, population density of hospitals, specialists, and urologists. Models adjusted for age, education, marital status, family history of prostate cancer, history of diabetes, smoking, perceived health status, BMI, alcohol.