Geographic Patterns of Prostate Cancer Mortality and Variations in Access to Medical Care in the United States

Ahmedin Jemal,1 Elizabeth Ward,1 Xiaocheng Wu,2 Howard J. Martin,3 Colleen C. McLaughlin,4 and Michael J. Thun1

1Epidemiology and Surveillance Research, American Cancer Society, Atlanta, Georgia; 2School of Public Health, Louisiana State University Health Sciences Center, New Orleans, Louisiana; 3Virginia Cancer Registry, Richmond, Virginia; and 4New York State Cancer Registry, Albany, New York

Abstract

Background: Striking geographic variation in prostate cancer death rates have been observed in the United States since at least the 1950s; reasons for these variations are unknown. Here we examine the association between geographic variations in prostate cancer mortality and regional variations in access to medical care, as reflected by the incidence of late-stage disease, prostate-specific antigen (PSA) utilization, and residence in rural counties.

Methods: We analyzed mortality data from the National Center for Health Statistics, 1996 to 2000, and incidence data from 30 population-based central cancer registries from the North American Association of Central Cancer Registries, 1995 to 2000. Ecological data on the rate of PSA screening by registry area were obtained from the 2001 Behavioral Risk Factor Surveillance System. Counties were grouped into metro and nonmetro areas according to Beale codes from the Department of Agriculture. Pearson correlation analyses were used to examine associations.

Results: Significant correlations were observed between the incidence of late-stage prostate cancer and death rates for Whites ($r = 0.38$, $P = 0.04$) and Blacks ($r = 0.53$, $P = 0.03$). The variation in late-stage disease corresponded to about 14% of the variation in prostate cancer death rates in White men and 28% in Black men. PSA screening rate was positively associated with total prostate cancer incidence ($r = 0.42$, $P = 0.02$) but inversely associated with the incidence of late-stage disease ($r = -0.58$, $P = 0.009$) among White men. Nonmetro counties generally had higher death rates and incidence of late-stage disease and lower prevalence of PSA screening (53%) than metro areas (58%), despite lower overall incidence rates.

Conclusion: These ecological data suggest that 10% to 30% of the geographic variation in mortality rates may relate to variations in access to medical care. (Cancer Epidemiol Biomarkers Prev 2005;14(3):590–5)

Introduction

In the United States, the death rate from prostate cancer is highest in the Northwest and North Central states among White men but highest in the South Atlantic states among Black men (1). The reasons for these geographic patterns are unclear, although the racial difference partly reflects the more limited geographic distribution of Black men. Prior studies focused primarily on exposures to agricultural and industrial chemicals and reported association with farming and textile and metal-using industries (2-4). To our knowledge, no study has examined whether access to and utilization of medical care, as reflected by differences in stage at diagnosis, may also contribute to these geographic patterns. Hereafter, we refer access to and utilization of medical care as access to medical care.

Until recently, the opportunity to study geographic variability in stage at diagnosis using population-based cancer registries in the United States has been limited to registries in the Surveillance Epidemiology and End Results program (nine geographic areas), covering about 10% of the U.S. population. Since the early 1990s, many other population-based cancer registries have been created or expanded through the National Program of Cancer Registries; these data, available through the North American Association of Central Cancer Registries, provide information on cancer incidence rates and stage of diagnosis for as much as 68% of the United States. Herein, we examine whether geographic patterns of prostate cancer death rates are related to variations in distant-stage disease, an indirect measure of variations in medical care. In 1995, distant-stage prostate cancer comprised about 6% of incident cases but 14% of deaths; for Whites ($r = 0.53$, $P = 0.02$) but inversely for Blacks ($r = 0.38$, $P = 0.04$) and Whites ($r = 0.42$, $P = 0.02$) but inversely associated with the incidence of late-stage disease ($r = -0.58$, $P = 0.009$) among White men. Nonmetro counties generally had higher death rates and incidence of late-stage disease and lower prevalence of PSA screening (53%) than metro areas (58%), despite lower overall incidence rates.

Conclusion: These ecological data suggest that 10% to 30% of the geographic variation in mortality rates may relate to variations in access to medical care. (Cancer Epidemiol Biomarkers Prev 2005;14(3):590–5)

Materials and Methods

We obtained mortality data from the National Center for Health Statistics and incidence data from the North American Association of Central Cancer Registries for 30 geographic areas (28 states, the District of Columbia, and Atlanta), representing about 40% of the U.S. population (7). Criteria for inclusion of cancer registries in the study were completeness of reporting, duplicative records not exceeding 0.2%, internal consistency among data items, <5% unknown in critical data fields, <5% of all cases registered with information only from death certificates, and agreement by the registries to participate (7). All registries agreed to participate.

We computed average annual prostate cancer incidence rates in men ages ≥40 years for 1995 to 2000 for each cancer.
Data on the rate of PSA utilization within the last year among men ages ≥50 years with no history of prostate cancer by state were abstracted from published data (10), derived from the 2001 Behavioral Risk Factor Surveillance System, an annual cross-sectional, population-based, random-digit-dialed telephone survey given by the Centers for Disease Control and Prevention for tracking health care use and risk behaviors at a state level. Using the Beale Codes from the U.S. Department of Agriculture (11), we calculated incidence and death rates by degree of urbanization/population density and tested for differences in rates between metro and nonmetro areas by assuming a Poisson distribution (12). The analyses by county using Beale Codes could not control for covariates other than age and race, due to lack of county identifier.

We measured the association between geographic variations in prostate cancer death rates and incidence rates of distant-stage disease for Whites and for Blacks using Pearson correlations (13). We then estimated the proportion of variability in the death rates explained by the association with the incidence rates by squaring the correlation coefficient. We also assessed the geographic correlations between death rates and overall incidence rates, between PSA screening rate and overall incidence, and between incidence of distant-stage disease and PSA screening rate. All variables used in the Pearson correlation analyses satisfied the bivariate normality assumption. The correlations of the percentage of population residing in nonmetro areas with prostate cancer incidence and death rates were measured as partial correlation (13). Rates based on <25 cases or deaths were excluded from the analyses. Therefore, the analyses for Whites were based on 29 cancer registries (28 states and Atlanta); the analyses for Black men were based on 17 cancer registries (15 states, the District of Columbia, and Atlanta). Correlation analyses pertaining to PSA screening rate among White men and Black men became substantially weaker when adjusted for differences in the percentage of the population residing in nonmetro areas (White men: $r = 0.24$, $P = 0.21$; Black men: $r = 0.31$, $P = 0.24$) but changed minimally when adjusted for the incidence of unstaged disease in either White men ($r = 0.33$, $P = 0.09$) or Black men ($r = 0.56$, $P = 0.02$).

**Results**

The geographic variation in prostate cancer incidence, mortality, and PSA screening is shown in Table 1. Among White men, ages ≥40 years, the age-adjusted prostate cancer death rate (per 100,000 men per year) ranged from 60.8 in Alaska to 86.4 in Wyoming. The incidence rate for all stages combined ranged from 294.8 in Arizona to 427.8 in New Jersey; the incidence rate of distant-stage disease ranged from 10.4 in Atlanta to 28.6 in Hawaii. Among Black men, ages ≥40 years, the corresponding range in rates (per 100,000 per year) was from 129.2 in Rhode Island to 196.7 in North Carolina for mortality, from 374.8 in Hawaii to 692.6 in Michigan for overall incidence, and from 33.3 in Arizona to 76.9 in West Virginia for incidence of distant-stage disease. Rates for unstaged disease also varied widely across cancer registries in both White and Black men. No correlation was seen between prostate cancer death rates and overall incidence rates across states among either White men ($r = 0.17$, $P = 0.39$) or Black men ($r = -0.30$, $P = 0.23$). In contrast, prostate cancer death rates were directly correlated with incidence rates of distant-stage disease for both White men ($r = 0.38$, $P = 0.04$) and Black men ($r = 0.53$, $P = 0.03$; Fig. 1). The variation in late-stage disease could account for 14% of the geographic variation in prostate cancer mortality in White and 28% in Black men. Geographic variations in PSA screening rate among White men correlated directly with overall incidence rates ($r = 0.42$, $P = 0.02$) but inversely with incidence rates of distant-stage disease ($r = -0.58$, $P < 0.0001$; Fig. 2).

Prostate cancer death rates and rates of distant-stage disease were higher in nonmetro than metro areas despite lower overall incidence rates (Table 2). On average, the death rate in nonmetro areas compared with metro areas was 12% higher in Black men and 4% higher in White men. Similarly, the incidence rates of distant-stage disease were 13% higher in Whites and 9% higher in Blacks in nonmetro than in metro areas. Furthermore, the incidence of unstaged disease was 2% higher in Whites and 15% higher in Blacks in nonmetro than in metro areas. The association between prostate cancer death rates and rates of distant-stage disease became substantially weaker when adjusted for differences in nonmetro and metro areas. The correlation in geographic variations between obesity and death rate in nonmetro areas compared with metro areas (White men: $r = 0.24$, $P = 0.21$; Black men: $r = 0.31$, $P = 0.24$) but changed minimally when adjusted for the incidence of unstaged disease in either White men ($r = 0.33$, $P = 0.09$) or Black men ($r = 0.56$, $P = 0.02$).

**Discussion**

Our principal findings are that the geographic variation in prostate cancer death rates is positively associated with incidence of late-stage disease and with residence in nonmetro areas and that the incidence of late-stage disease is inversely associated with the utilization of PSA testing. All of these factors suggest that lower access to medical care may contribute to a higher death rate from prostate cancer in certain regions of the United States. In our analyses, geographic variations in late-stage disease may account for about 14% of the geographic variation of mortality in White men and 28% in Black men.

Other factors that may contribute to the geographic variation in prostate cancer mortality involve regional variations in underlying risk factors or exposures that reduce risk. Farming has been consistently associated with increased risk of prostate cancer (3, 14-19). Dosemeci et al. (3) estimated that occupations related to farming could account for about 38% of the excess prostate cancer death rates in the southeastern United States among Black men. Based on a limited study, however, farm-related occupations at county level did not account for the excess regional risk in death rates from prostate cancer among Whites (4). Historically, elevated rates of prostate cancer mortality in the Northeast and North Central regions of the United States have been associated with exposures from textile and machinery industries (2), although the extent to which these occupations influence state or regional rates is unclear. More recently, mortality from prostate cancer has been associated with obesity in case control and prospective epidemiologic studies (20-22); however, correlation in geographic variations between obesity and mortality has not been established.

Another factor that varies by region and that has been proposed to protect against prostate cancer is UV radiation from sun exposure. Sunlight triggers the synthesis of vitamin D which has been hypothesized to reduce the risk of prostate cancer (23). However, findings from analytic studies have been inconsistent on the role of vitamin D in the development of prostate cancer (24-30).

A strength of our study is that data are based on a much larger geographic area than could be evaluated in the past. Stage at diagnosis is a strong predictor of prognosis and an
Table 1. Prostate cancer death rates, incidence rates (overall and stage specific), and PSA testing for selected U.S. cancer registries, men ages ≥40 years

<table>
<thead>
<tr>
<th>Cancer registry/state</th>
<th>White</th>
<th>Incidence</th>
<th>Recent PSA test (%), age ≥50, 2001*</th>
<th>Black</th>
<th>Incidence</th>
<th>Recent PSA test (%), age ≥50, 2001*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Death rate</td>
<td>All cases rate</td>
<td>Local and regional rate</td>
<td>Distant stage rate</td>
<td>Unstaged rate</td>
<td></td>
</tr>
</tbody>
</table>
for the relationship between overall incidence rate and prostate cancer death rates in which the time lag between diagnosis and death is more protracted.

The variations in incidence of unstaged disease across cancer registries may in part be related to lack of standardized procedures for staging of prostate cancer cases with unknown lymph node status because such cases could be classified differently as either localized/regional or unknown. Unstaged prostate cancer rates were also slightly higher in nonmetro than metro areas, particularly among Blacks. Other researchers have reported similar rural-urban differences in unstaged cases for a number of cancers including prostate cancer in Georgia; these patterns were thought to reflect less rigorous diagnostic evaluation and/or more incomplete medical record documentation in the rural medical facilities (33). The less rigorous diagnostic evaluation in rural areas may be associated with greater comorbid diseases and might reflect further differences in access to medical care. However, adjusting for variation in unstaged incidence across registries did not affect the relationship we observed between prostate cancer death rates and rates of distant-stage disease in either White or Black men.

**Table 2. Prostate cancer death and incidence rates in men ages ≥40 years by degree of urbanization, 1995-2000**

<table>
<thead>
<tr>
<th>Degree of urbanization/population size</th>
<th>White incidence rate*</th>
<th>Black incidence rate*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Death rate</td>
<td>Overall</td>
</tr>
<tr>
<td>Metro counties</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central county metro area ≥1</td>
<td>71.7</td>
<td>368.9</td>
</tr>
<tr>
<td>million population</td>
<td>71.2</td>
<td>379.9</td>
</tr>
<tr>
<td>Fringe county Metro Area GE ≥1</td>
<td>74.4</td>
<td>341.9</td>
</tr>
<tr>
<td>million population</td>
<td></td>
<td></td>
</tr>
<tr>
<td>County metro area 250,000-1 million</td>
<td>72.1</td>
<td>358.1</td>
</tr>
<tr>
<td>population</td>
<td></td>
<td></td>
</tr>
<tr>
<td>County metro area &lt;250,000 population</td>
<td>72.2</td>
<td>360.1</td>
</tr>
<tr>
<td>Nonmetro counties</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban population ≥20,000, adjacent</td>
<td>74.9</td>
<td>342.1</td>
</tr>
<tr>
<td>metro area</td>
<td>73.2</td>
<td>344.1</td>
</tr>
<tr>
<td>Urban population ≥20,000, not adjacent</td>
<td>73.8</td>
<td>372.2</td>
</tr>
<tr>
<td>metro area</td>
<td>73.3</td>
<td>331.4</td>
</tr>
<tr>
<td>Urban population 2,500-19,999, adjacent</td>
<td>75.3</td>
<td>347.1</td>
</tr>
<tr>
<td>metro area</td>
<td>75.7</td>
<td>347.1</td>
</tr>
<tr>
<td>Rural or &lt;2,500 urban population,</td>
<td>78.6</td>
<td>313.8</td>
</tr>
<tr>
<td>adjacent metro area</td>
<td>75.5</td>
<td>330.8</td>
</tr>
<tr>
<td>Rural or &lt;2,500 urban population,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>not adjacent metro area</td>
<td>1.04†</td>
<td>0.93†</td>
</tr>
</tbody>
</table>

NOTE: Rates are per 100,000 and are adjusted to the 2000 U.S. population standard.
* Cases were staged according to SEER Summary Stage 1977 (8, 9).
† Rate ratios were statistically significant ($P < 0.05$).
We correlated incidence rates for 1995 to 2000 with self-reported PSA utilization in 2001 because every state included questions about prostate cancer screening in the Behavioral Risk Factor Surveillance System survey for the first time in 2001. Limitations of data from the Centers for Disease Control and Prevention’s Behavioral Risk Factor Surveillance System have been discussed in detail elsewhere (35). Briefly, the response rates widely vary across states and the survey relies exclusively on telephone interviews. Although men with a history of prostate cancer who receives PSA testing for follow-up were excluded, the survey cannot distinguish between tests conducted for screening from those for diagnostic purposes and may overestimate the actual utilization rates (36, 37). Despite these methodologic limitations, PSA utilization rates positively correlated with overall incidence rates and inversely correlated with incidence rates of distant-stage disease.

In conclusion, our data suggest that variations in medical care should be considered in future studies of the geographic variation in prostate cancer mortality.

References


