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Racial disparities in prostate cancer incidence rates by census division in the United States, 1999–2008

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Abstract

Background—Black men have a higher incidence of prostate cancer than white men in the U.S., but little is known whether incidence or racial differences vary geographically. Understanding these differences may assist future studies on causes of prostate cancer. To address such, we leverage the unique resource of the National Program of Cancer Registries (NPCR) combined with Surveillance, Epidemiology and End Results (SEER).

Methods—Prostate cancer counts and population denominators by race (black, white), age, calendar year, and U.S. census division, for the period 1999–2008, were extracted from NPCR and SEER. We calculated age-standardized incidence rates (ASR) and estimated annual percent changes (EAPC) by race and census division. We assessed black-to-white incidence rate ratios (BWIRR) by census division and by calendar period.

Results—This analysis included 1,713,471 prostate cancer cases and 1,217 million person-years. Black ASRs ranged from 176 per 100,000 person-years in Mountain division to 259 in Middle Atlantic. BWIRRs ranged from 1.20 in Western divisions to 1.72 in Southeastern divisions. EAPCs indicated that prostate cancer incidence is not decreasing in East South Central, unlike all

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other divisions. White EAPCs displayed similar variations by census division, resulting in modest temporal changes in BWIRRs.

Conclusions—Within the U.S., there exists significant geographic variability in prostate cancer incidence rates. Although there are large geographic differences in BWIRRs, temporal trends are fairly stable. This may indicate that primary factors affecting prostate cancer incidence rates vary geographically but affect both black and white men to a similar degree.

Keywords

prostate cancer; incidence rate; census division; regional variation; epidemiology; SEER program

Introduction

Black men are known to have a higher incidence of prostate cancer than white men in the United States (U.S.), while both races have been shown to have declining incidence trends in the post-PSA era (1). Such epidemiologic insight has been derived using Surveillance, Epidemiology and End Results (SEER) Program of cancer registries, with implicit inference that such is representative of the general U.S. population. However, SEER registries only cover a limited percentage and geographical area of the U.S. population. Moreover, understanding racial differences in prostate cancer incidence trends at a more granular geographical level than the U.S. as a whole may provide additional scientific insight that may aid future studies further elucidate the causes of prostate cancer and racial differences. Therefore, we designed and conducted a unique analysis to assess whether there has been significant racial and/or geographic heterogeneity in prostate cancer incidence patterns within the U.S. Leveraging the unique resources of NPCR and SEER, we determined incidence rates and trends of prostate cancer by race and geographic census division for the U.S. population for the period 1999–2008.

Materials & Methods

Data source

The cancer registries from the NPCR and SEER programs combined cover the entire U.S. population (2). Uniform methodologies for data collection and reporting ensure robust, high quality data for analysis (3). Only data from statewide registries that met strict high-quality standards for all years (1999–2008) were included in the study (4–6). Data in six states (AR, NC, MS, SD, TN, VA) and the District of Columbia did not meet case ascertainment and quality criteria for at least one of the years of the analytic period and were thus excluded. Data from the remaining 44 states were included in our analyses and this covered ~85% of the total U.S. population for the analytic period 1999–2008. Prostate cancer counts by race (black, white), age (all, by five year age groups), calendar year, and U.S. census division, for the period 1999–2008, were extracted. Population data used for denominators were obtained from the SEER program, which uses a slight modification of the annual population estimates from the Census Bureau.

We used National Health Interview Survey (NHIS) data to estimate prevalence of prostate-specific antigen (PSA) testing by race, census division and calendar year to contextualize

our results. NHIS conducts nationally representative surveys of the health of civilian, non-institutionalized U.S. population (www.cdc.gov/nchs/nhis/aboutnhis.htm). Within the time period of the prostate cancer incidence analysis, NHIS 2000, 2003, 2005 and 2007 had included PSA test questions as part of the Cancer Screening (NAF) supplement for men aged 40 years and older. These data enabled us to construct a variable for each survey as to whether an individual had undergone a PSA test in the last 12 months. We modified the census division variable to exclude states and the district which were excluded from the analysis of prostate cancer incidence. Prevalence estimates were weighted using Sample Adult Weight - Interim Annual (WTIA_SA) with an additional post-stratification adjustment for age using the 2000 U.S. Standard Population (19 age groups – Census P25-1130) with weights re-standardized for ages 40 to 85+ years. Since state is a restricted variable, we accessed these data through the Research Data Center. Data collection for NHIS was approved by the NCHS Research Ethics Review Board. Analysis of deidentified data from the survey is exempt from the federal regulations for the protection of human research participants. Analysis of restricted data through the NCHS Research Data Center is also approved by the NCHS ERB.

Statistical analyses

We calculated age-standardized incidence rates (ASR) and estimated annual percent changes (EAPC) by race and census division. We assessed black-to-white incidence rate ratios (BWIRR) by census division and by calendar period. Rates provided are per 100,000 man-years age-adjusted to the 2000 U.S. Standard Population (19 age groups – Census P25-1130) and 95% confidence intervals (CIs) were calculated using the modification of Tiwari et al. (7). EAPCs were calculated by fitting a weighted-least-squares regression to the natural logarithm of the ASRs with 95% CIs calculated using a normal approximation (8). Census division ASRs, EAPCs, and BWIRRs were compared with equivalent national statistics using methods that account for correlations due to overlapping regions (8–11). In addition, we assessed geographic variability of rates and rate ratios across census divisions using the heterogeneity (global) test based on Cochran's Q statistic from fixed effects meta-analysis. Differences between census regions and estimated national statistics were considered significant at P values less than <0.05 were considered to be statistically significant.

Results

Prostate cancer ASRs and EAPCs by race and census division are shown in Table 1. ASRs for black men ranged from 176 per 100,000 person-years in Mountain division to 259 in Middle Atlantic. Many of the incidence rates deviated significantly from the national of 239 per 100,000 person years and the global test comparing rates across the nine census divisions was <0.001. North and east divisions had higher incidence rates for blacks compared with other census divisions (Table 1 and Figure). Prostate cancer incidence rates for whites showed a slightly different pattern to those of blacks, with highest rates in north, north-eastern and west divisions. Incidence rates for south (West South Central: 143) and east divisions (East South Central: 137; South Atlantic: 143) were comparatively lower in the ranking of white incidence rates. The highest incidence rates for whites were confined to the north-east in the census divisions of New England (165) and Middle Atlantic (162). The

global test comparing prostate cancer rates for whites across the nine census divisions was <0.001 . The BWIRRs highlight the different patterns in prostate cancer incidence rates between these two races. As can be seen from Table 1 and the Figure, the highest prostate cancer rate ratio between black and white was observed in South Atlantic census division, black incidence was 1.7 fold greater than white. Census divisions directly adjacent to South Atlantic show similarly high BWIRRs, while the lowest was observed in Mountain at 1.20. The high geographic variability in BWIRRs can be appreciated from the confidence intervals of these estimates and was confirmed by a statistically significant global test ($p<0.001$).

Temporal trends in prostate cancer incidence rates are shown in the Figure and summarized in the form of EAPCs in Table 1. Rates for black men have been slowly declining between 1999 and 2008 for all divisions except East South Central for which the EAPC was 0.85 (95% CI: 0.17, 1.54). This contrasts sharply with the rapid decreases in black incidence rates shown by EAPCs for Mountain (−3.67) and Pacific (−3.30) divisions. All other divisions had EAPCs between −1 and −2.5 for black prostate cancer incidence rates. There was a fairly strong correlation between black EAPCs and white EAPCs ($r=0.75$) as can be deduced from Table 1. Similar to the black EAPC, the white EAPC for East South Central also indicated no change in prostate cancer incidence rates (−0.26, 95% CI: −0.52, 0.05). Again, all other divisions exhibited decreasing rates for whites, with New England (−2.35) and East North Central (−2.30) divisions displaying the largest average decreases. In concert with the high correlation between black and white EAPCs, temporal trends in BWIRRs between 199 and 2008 were fairly stable.

Table 2 shows the prevalence of PSA testing by race, census division and survey year using data from the NHIS. Only 13 of the 36 sets of estimates for census division by survey year show a higher prevalence of PSA testing for black men compared with white men. Only three sets of prevalence estimates showed differences of $\pm 40\%$ between black and white men and these were all in NHIS 2000 (New England, East South Central, and Mountain). All other sets of estimates had differences that were less than this, and most PSA prevalence estimates were quite similar between the races, even across divisions.

Discussion

In this analysis of NPCR and SEER data, we have demonstrated stark and significant geographic differences in prostate cancer incidence rates between black and white men. The large geographic differences in BWIRRs combined with the temporal stability of these estimates, may indicate that *primary* factors affecting prostate cancer incidence rates vary geographically but affect both black and white men to a similar degree. Causal factors underlying the observed patterns and trends are currently unknown, but these data should spur our continued efforts to understand the etiopathogenesis and racial differences of prostate cancer.

The oft-quoted fact that prostate cancer incidence is higher in blacks than whites has been understood for decades, yet the causal reasons underlying this racial difference remain poorly understood (1). Genetics, environmental exposures, endogenous hormones, access to

health care, screening patterns, and treatment patterns have all been suggested as possible contenders to account for the differences in prostate cancer incidence but, as yet, evidence is lacking. The NHIS data presented here suggest that PSA testing does not differ greatly between the races and, when it does, it is usually higher in whites than blacks. This would appear to be the reverse of what would be expected if it were to account for long-standing and stable BWIRRs.

It should be noted that it is not just blacks in the U.S. who have a relative high prostate cancer incidence; blacks in Brazil are 1.7-fold (12), and in the UK are 3-fold (13) more likely than whites to be diagnosed with prostate cancer. This implies racial differences in pre-disposition to prostate cancer, possibly through differences in genetics, hormones, or metabolism of the prostate. Circulating PSA concentrations are slightly higher in black men compared with white men—whether compared healthy populations or prostate cancer case populations—possibly due to higher testosterone concentrations and/or higher prevalence of prostatic intraepithelial neoplasia, but not attributable to differences in organ size (14). Although these racial differences in PSA concentration distributions may make a small contribution to the racial differences in prostate cancer incidence (15, 16), racial differences in incidence long preceded the PSA era (1). It is of interest that autopsy series indicate a similar prevalence of latent prostate cancer in blacks compared with whites (17), leading some to propose that prostate cancer may have a faster growth rate and/or an earlier transformation to clinically significant prostate cancer in black compared with white men (18).

The geographical variability of racial differences in prostate cancer incidence adds a further element in attempts to describe these patterns. Rather than making it more complex, however, it is hoped that these patterns and statistics can begin to unravel black-white differences of this disease. Why is it that the BWIRR is so low (1.20) in Mountain division? Why are rates for both races not declining in East South Central, as they are for all other census divisions? Why are the BWIRRs fairly stable over time? If these questions can be answered, the racial difference in prostate cancer incidence will begin to be clarified.

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References

1. Brawley OW, Jani AB, Master V. Prostate cancer and race. *Curr Probl Cancer*. 2007; 31:211–25. [PubMed: 17543949]
2. Hankey BF, Ries LA, Edwards BK. The surveillance, epidemiology, and end results program: a national resource. *Cancer Epidemiol Biomarkers Prev*. 1999; 8:1117–21. [PubMed: 10613347]
3. Wingo PA, Jamison PM, Hiatt RA, Weir HK, Gargiullo PM, Hutton M, et al. Building the infrastructure for nationwide cancer surveillance and control--a comparison between the National Program of Cancer Registries (NPCR) and the Surveillance, Epidemiology, and End Results (SEER) Program (United States). *Cancer Causes Control*. 2003; 14:175–93. [PubMed: 12749723]
4. Nathan H, Pawlik TM. Limitations of claims and registry data in surgical oncology research. *Ann Surg Oncol*. 2008; 15:415–23. [PubMed: 17987343]

5. Thoburn KK, German RR, Lewis M, Nichols PJ, Ahmed F, Jackson-Thompson J. Case completeness and data accuracy in the Centers for Disease Control and Prevention's National Program of Cancer Registries. *Cancer*. 2007; 109:1607–16. [PubMed: 17343277]
6. Zippin C, Lum D, Hankey BF. Completeness of hospital cancer case reporting from the SEER Program of the National Cancer Institute. *Cancer*. 1995; 76:2343–50. [PubMed: 8635041]
7. Tiwari RC, Clegg LX, Zou Z. Efficient interval estimation for age-adjusted cancer rates. *Stat Methods Med Res*. 2006; 15:547–69. [PubMed: 17260923]
8. Walters KA, Li Y, Tiwari RC, Zou Z. A Weighted-Least-Squares Estimation Approach to Comparing Trends in Age-Adjusted Cancer Rates Across Overlapping Regions. *J Data Sci*. 2011; 8:631–44. [PubMed: 22375146]
9. Li Y, Tiwari RC. Comparing trends in cancer rates across overlapping regions. *Biometrics*. 2008; 64:1280–6. [PubMed: 18371122]
10. Li Y, Tiwari RC, Zou Z. An age-stratified poisson model for comparing trends in cancer rates across overlapping regions. *Biom J*. 2008; 50:608–19. [PubMed: 18615411]
11. Tiwari RC, Li Y, Zou Z. Interval Estimation for Ratios of Correlated Age-Adjusted Rates. *J Data Sci*. 2010; 8:471–82. [PubMed: 22347884]
12. Romero FR, Romero AW, Almeida RM, Tambara Filho R. The prevalence of prostate cancer in Brazil is higher in Black men than in White men: systematic review and meta-analysis. *Int Braz J Urol*. 2012; 38:440–7. [PubMed: 22951172]
13. Ben-Shlomo Y, Evans S, Patel B, Anson K, Muir G, Persad R, et al. Differences in the epidemiology and presentation of prostate cancer in Black and White men in England: lessons learnt from the process study. *BJU Int*. 2009; 103:723–4. [PubMed: 18990148]
14. Morgan TO, Jacobsen SJ, McCarthy WF, Jacobson DJ, McLeod DG, Moul JW. Age-Specific Reference Ranges for Serum Prostate-Specific Antigen in Black Men. *N Engl J Med*. 1996; 335:304–10. [PubMed: 8663870]
15. Howrey BT, Kuo YF, Lin YL, Goodwin JS. The impact of PSA screening on prostate cancer mortality and overdiagnosis of prostate cancer in the United States. *J Gerontol A Biol Sci Med Sci*. 2013; 68:56–61. [PubMed: 22562961]
16. Espaldon R, Kirby KA, Fung KZ, Hoffman RM, Powell AA, Freedland SJ, et al. Probability of an abnormal screening prostate-specific antigen result based on age, race, and prostate-specific antigen threshold. *Urology*. 2014; 83:599–605. [PubMed: 24439009]
17. Leal J, Hamdy F, Wolstenholme J. Estimating age and ethnic variation in the histological prevalence of prostate cancer to inform the impact of screening policies. *Int J Urol*. 2014
18. Powell IJ, Bock CH, Ruterbusch JJ, Sakr W. Evidence supports a faster growth rate and/or earlier transformation to clinically significant prostate cancer in black than in white American men, and influences racial progression and mortality disparity. *J Urol*. 2010; 183:1792–6. [PubMed: 20299055]

Figure. Prostate cancer incidence rates and temporal trends by race and census division, NPCR and SEER, 1999–2008.

Age-standardized incidence rates and estimated annual percent changes of prostate cancer by race, SEER-NPCR, 1999–2008

Table 1

Division # / Name	Black			White		
	ASR (95%CI)	EAPC (95%CI)	ASR (95%CI)	EAPC (95%CI)	BWIRR (95%CI)	
1 / New England (CT/MA/ME/NH/RI/VT)	240 (219, 261)	-2.45 (-3.36, -1.53)	165 (165, 166)	-2.35 (-2.56, -2.14)	1.45 (1.33, 1.59)	
2 / Middle Atlantic (NJ/NY/PA)	259 (256, 262)	-2.00 (-2.32, -1.69)	162 (162, 162)	-1.72 (-1.85, -1.59)	1.60 (1.58, 1.62)	
3 / East North Central (IL/IN/MI/OH/WT)	241 (238, 244)	-1.71 (-2.04, -1.37)	149 (149, 149)	-2.30 (-2.43, -2.17)	1.62 (1.60, 1.64)	
4 / West North Central (IA/KS/MN/MO/ND/NE)	210 (196, 224)	-2.36 (-3.19, -1.52)	155 (154, 155)	-1.48 (-1.67, -1.29)	1.36 (1.27, 1.45)	
5 / South Atlantic (DE/FL/GA/MD/SC/WV)	244 (242, 247)	-1.90 (-2.19, -1.61)	143 (143, 143)	-2.13 (-2.26, -1.99)	1.71 (1.69, 1.72)	
6 / East South Central (AL/KY)	230 (220, 240)	0.85 (0.17, 1.54)	137 (136, 137)	-0.26 (-0.58, 0.05)	1.68 (1.61, 1.76)	
7 / West South Central (LA/OK/TX)	226 (222, 230)	-1.13 (-1.55, -0.71)	143 (143, 143)	-1.76 (-1.94, -1.59)	1.58 (1.55, 1.61)	
8 / Mountain (AZ/CO/ID/MT/NM/NV/UT/WY)	176 (157, 195)	-3.67 (-4.85, -2.47)	146 (146, 146)	-1.94 (-2.14, -1.74)	1.20 (1.08, 1.34)	
9 / Pacific (AK/CA/HI/OR/WA)	228 (222, 233)	-3.30 (-3.77, -2.82)	153 (152, 153)	-2.11 (-2.25, -1.97)	1.49 (1.46, 1.53)	
U.S. National	239 (239, 240)	-1.86 (-2.01, -1.72)	151 (151, 151)	-1.97 (-2.02, -1.91)	1.59 (1.58, 1.59)	

Abbreviations: ASR, age-standardized incidence rate; BWIRR, black-to-white incidence rate ratio; EAPC, estimated annual percent change. Bold indicates statistically significantly (P<0.05) different from the national estimate.

Table 2
Prevalence of PSA testing by race, census division, and survey years using National Health Interview Survey data

Census Division # / Name	Race	NHIS 2000	NHIS 2003	NHIS 2005	NHIS 2007
1 / New England (CT/MA/ME/NH/RI/VT)	white	23.6 (19.3, 28.6)	32.8 (27.7, 38.4)	25.1 (20.8, 30.0)	32.7 (25.0, 41.4)
	black	39.2 (24.7, 55.8)	46.5 (29.2, 64.6)	15.3 (7.8, 27.7)	36.7 (20.6, 56.4)
2 / Middle Atlantic (NJ/NY/PA)	white	31.5 (28.7, 34.5)	29.9 (26.8, 33.3)	32.5 (29.4, 35.7)	31.6 (27.8, 35.8)
	black	32.4 (24.5, 41.5)	29.1 (21.5, 38.1)	38.9 (23.6, 56.8)	25.0 (15.7, 37.4)
3 / East North Central (IL/IN/MI/OH/WI)	white	30.5 (28.3, 32.7)	30.8 (27.7, 34.1)	26.3 (23.7, 29.2)	36.0 (32.4, 39.9)
	black	18.7 (13.6, 25.1)	28.3 (19.5, 39.2)	23.0 (17.0, 30.3)	29.9 (21.0, 40.8)
4 / West North Central (IA/KS/MN/MO/ND/NE)	white	23.9 (21.2, 26.9)	30.5 (25.4, 36.1)	31.0 (27.7, 34.4)	34.9 (30.3, 39.9)
	black	29.0 (12.0, 54.9)	37.8 (25.1, 52.4)	20.6 (14.2, 28.9)	22.7 (11.7, 39.3)
5 / South Atlantic (DE/FL/GA/MD/SC/WV)	white	32.9 (29.9, 36.1)	36.6 (33.0, 40.3)	33.0 (30.1, 36.1)	33.8 (29.5, 38.4)
	black	28.7 (24.5, 33.3)	36.2 (29.7, 43.3)	28.6 (22.9, 35.1)	35.3 (30.2, 40.8)
6 / East South Central (AL/KY)	white	22.2 (16.1, 29.8)	28.1 (23.1, 33.8)	21.4 (14.0, 31.3)	29.6 (21.8, 38.8)
	black	12.7 (5.3, 27.5)	22.7 (9.8, 44.0)	21.2 (15.1, 29.0)	34.5 (25.6, 44.6)
7 / West South Central (LA/OK/TX)	white	29.6 (26.1, 33.2)	35.3 (30.9, 40.0)	31.4 (28.2, 34.9)	42.1 (36.7, 47.6)
	black	33.0 (24.5, 42.8)	36.4 (30.2, 43.0)	23.7 (17.5, 31.4)	36.5 (27.7, 46.2)
8 / Mountain (AZ/CO/ID/MT/NM/NV/UT/WY)	white	30.8 (25.9, 36.1)	31.5 (27.3, 35.9)	30.7 (26.4, 35.3)	30.8 (25.8, 36.3)
	black	14.1 (4.9, 34.7)	23.4 (20.2, 26.9)	26.4 (15.8, 40.8)	21.9 (10.7, 39.7)
9 / Pacific (AK/CA/HI/OR/WA)	white	22.6 (20.0, 25.4)	31.5 (28.5, 34.7)	26.6 (23.7, 29.8)	31.2 (26.8, 36.1)
	black	26.2 (18.0, 36.5)	32.9 (24.3, 42.7)	23.5 (17.0, 31.6)	34.4 (22.4, 48.9)

Using racerpi_j (2000) and (racerpi2) as race indicator

Age adjusted by the direct method to the year 2000 Census population projections using the age groups 40–44, 45–49, etc

Age-standardized prevalence of males 40 years and older with PSA test in past year