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Prostate cancer incidence in light of the spatial distribution of another screening-detectable cancer

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ABSTRACT

Bias in spatial analyses that overlook compositional and contextual factors of communities can be substantial. We first examined spatial patterns among 11,728 prostate cancer cases across Connecticut, 1994–98. A spatial scan statistic (SatScan™) identified two locations where average annual incidence rates significantly exceeded the statewide level and two locations with significantly lower disease rates. Extending the analysis to adjust rates for age and race/ethnicity greatly minimized, but did not eliminate, geographic variation. Adjustment for age and poverty level of communities eliminated significant variability across locales. Similarly, analysis adjusted for age and covariation of colorectal cancer incidence rates across the state accounted for all significant variation previously observed. These results suggest that accounting for a "detection effect" due to clinical patterns of another screenable condition may be as useful as adjusting spatial data for variability of socio-economic conditions.

1. Introduction

Prostate cancer remains a significant challenge to clinical medicine and public health. This most common malignancy and second leading cause of cancer death among U.S. men will have produced roughly 239,000 new cases and 30,000 deaths in 2013 (American Cancer Society, 2013). Recent concern about the suitability of routine prostate cancer screening underscores the uncertainty about its etiology and effective control (Shao et al., 2011; USPSTF, 2012).

Spatial variation of prostate cancer incidence across the U.S. is evident and has been tied to age, racial/ethnic and socioeconomic composition of communities. Jemal et al. (2002) found prostate cancer incidence rates to vary from fewer than 135 cases per 100,000 men in Indiana, Hawaii, Missouri and Tennessee, to more than 179 cases per 100,000 men in Delaware, Michigan, Minnesota and Utah. What accounts for these observed differences? Thus far, explanations have focused on racial and socio-economic differences of at-risk populations. DeChello et al. (2006) observed distinct spatial variation in incidence of prostate cancer among Whites and Non-whites living in Connecticut. Cheng et al. (2009) found a direct association between prostate cancer rates and the socioeconomic status of communities from which cases originated.

Less clear is whether the delivery of health services affected geographic differences of observed rates. To the extent that preventive services (e.g., screening) influence the frequency of diagnosed disease within a population, geographic variation in community-based screening efforts could be construed as a reason for differential prostate cancer incidence rates (Shao et al., 2011). That the discovery, dissemination and routinization of screening at-men by Prostate Specific Antigen (PSA) testing may have had an impact on spatio-temporal variation in disease rates over the past 20 years seems clear. Gregorio et al. (2004) noted

Abbreviations: BRFSS, Behavioral Risk Factor Surveillance System; CTR, Connecticut Tumor Registry; EXP, expected; NCI, National Cancer Institute; OBS, observed; PSA, Prostate-Specific Antigen; RR, relative rate/risk; SEER, Surveillance Epidemiology and End Results.

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important changes in the geographic distribution of prostate cancer as PSA testing was increasingly utilized across Connecticut over a 20 year period. Potosky et al. (1995) associated regional differences in prostate cancer incidence to differential use of PSA testing in those locales. Legler et al. (1998), comparing SEER and Medicare claims data, illustrated the parallels over this period between rates of prostate cancer incidence and first-time PSA testing.

The accurate assessment of prostate cancer rate variability must take into account potential bias associated with variable disease detection activities. As yet, however, the availability of geographically referenced data on community-wide screening is limited. In their place however, the incidence rates of another screening-detectable cancer may offer a reasonable surrogate under assumptions that (a) the disease does not share a common etiology with prostate cancer, and (b) the capacities for case finding through screening are roughly comparable. If so, the geographic variation in incidence of one screening-detectable condition may offer insight into community-level differences in screening activities that contribute to differential incidence rates for another screening-detectable cancer.

We hypothesized that prostate cancer incidence observed without regard for a possible "detection effect" of variation in clinical prevention (i.e., screening) will overstate geographic variation of the disease, whereas consideration of spatial covariation of another screening-detectable condition will account for much of otherwise observed variability. That is, the volume and/or gradations of prostate cancer rate variation across locales will be greater in the absence than the presence of adjustment for the rates of another screening-detectable disease. To test this idea, we initially examined the spatial distribution of 11,728 incident prostate cancers from Connecticut, 1994–98, with customary adjustments to account for variation in age at diagnosis and race/ethnicity as well as age and socio-economic conditions. Those results, in turn, were compared to an analysis adjusted for age and incidence rates of colorectal cancer across the state. As such, this work illustrates the utility of alternative approaches to evaluating disparities in geography of disease so that disease control specialists may have multiple ways of determining locales that could benefit from enhanced intervention.

2. Methods

2.1. Cases

Between January 1, 1994 and December 31, 1998, the Connecticut Tumor Registry (CTR), a statewide participant in the NCI-SEER program, recorded 12,276 incident prostate cancer cases (International Classification of Diseases for Oncology, 2nd ed., ICD-O-2; C61.9) among men 50 years and older. Though two decades old, these data represent an era of ambitious dissemination of PSA screening for at-risk men (Etizioni et al., 2002; Lu-Yao et al., 2002; Shao et al., 2011) that rapidly accelerated prostate cancer incidence (Potosky et al., 1995). The effect of steadily depleting pre-clinical cases among the screening-eligible population was to substantially modify the geographic distribution of cases over this time period (Gregorio et al., 2004). The Institutional Review Boards of the University of Connecticut and the Connecticut State Department of Public Health approved our access to, and analysis of, this information.

To each of 11,728 records (96% of recorded cases), latitude-longitude coordinates were assigned to a person's census tract of residence at the time of cancer diagnosis using Maptitude® software (Caliper Corporation, 2004). Records not assigned geographic coordinates due to missing or contradictory information on place of residence were not appreciably different than others regarding age, race/ethnicity, tumor grade, stage at diagnosis or survival time.

2.2. Population data

The "at-risk" population (i.e., men, 50+ years of age), was estimated for 1994–1998 through interpolation of the 1990 and 2000 decennial census of the population (U.S. Census Bureau, 1992, 2001) for each of Connecticut's 815 census tracts and grouped separately for white and non-white men according to 7 categories (20–29, 30–39, 40–49, 50–59, 60–69, 70–79 and 80+ years). Using the method of Plane and Rogerson (1994), we specified the latitude-longitude coordinates of a census-tract's population-weighted centroid to represent a demographic, rather than geographic, "average" location of persons residing there. Connecticut's census tracts, in relation to its five largest municipalities, are illustrated in Fig. 1.

Poverty level of census tracts was estimated as the average annual percent of persons living below poverty, as defined by the U.S. Census. Age-adjusted rates of male colorectal cancer incidence (ICD-O-2; C180–189; C199, C209 or C260) for each census tract were calculated from CTR data for the same time period.

2.3. Statistical analysis

Using indirect rate adjustment to control for the possible confounding effects of age at diagnosis, race, poverty level of communities or colorectal cancer incidence rates, we estimated prostate cancer case counts for each census tract within the state. With observed and estimated counts of incident cases, at-risk men and covariates aggregated by census tracts, a spatial scan statistic (Kulldorff, 1997) was used to discern geographic variation of prostate cancer incidence rates across the state. SatScan™ 9.1 software examined scanning circles at random locations and of varying sizes to discern places, indifferent to of geo-political boundaries, where observed case counts differed from the expectation of rate homogeneity (i.e., that adjusted incidence rates were proportional to population densities). The method reported "most-likely" and secondary clusters based on likelihood test statistics produced through Monte Carlo simulations (Kulldorff, 2013). Results are understood to offer conservative estimates of incidence rate variation across locales (Day and Breslow, 1987) and are believed to have superior power (>0.94) to detect event clusters in rural and mixed environments, and good power (>0.89) for cluster detection within urban settings (Kulldorff et al., 2003).