Geographical analysis can be used to respond to select barriers that contribute to disparities in prostate care.

Geographical Factors Associated With Health Disparities in Prostate Cancer

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Background: Treatment variation in prostate cancer is common, and it is driven by clinical and clinician factors, patient preferences, availability of resources, and access to physicians and treating facilities. Most research on treatment disparities in men with prostate cancer has focused on race and socioeconomic factors. However, the geography of disparities — capturing racial and socioeconomic differences based on where patients live — can provide insight into barriers to care and help identify outlier areas in which access to care, health resources, or both are more pronounced.

Methods: Research regarding treatment patterns and disparities in prostate cancer using the Geographical Information System (GIS) was searched. Studies were limited to English-language articles and research focused on US populations. A total of 43 articles were found; of those, 30 provided information about or used spatial or geographical analyses to assess and describe differences or disparities in prostate cancer and its treatment. Two additional GIS resources were included.

Results: The research on geographical and spatial determinants of prostate cancer disparities was reviewed. We also examined geographical analyses at the state level, focusing on Florida. Overall, we described a geographical framework to disparities that affect men with prostate cancer and reviewed existing published evidence supporting the interplay of geographical factors and disparities in prostate cancer.

Conclusions: Disparities in prostate cancer are common and persistent, and notable differences in treatment are observable across racial and socioeconomic strata. Geographical analysis provides additional information about where disparate groups live and also helps to map access to care. This information can be used by public health officials, health-systems administrators, clinicians, and policymakers to better understand and respond to geographical barriers that contribute to disparities in care.

Introduction

Prostate cancer is the most common nondermatological cancer diagnosed among American men, accounting for approximately 180,000 new cases each year in the United States.1 Although it is typically characterized by a protracted clinical course, prostate cancer is also one of the most common causes of cancer-related death (fourth most common overall following lung, colorectal, and breast cancers) and accounts for more than 26,000 deaths related to cancer each year in the United States alone.2
Although most prostate cancers (80%) are detected at an early stage and 10-year survival rates surpass 90%, 16% of men present with either locally advanced or metastatic disease. Metastatic prostate cancer is an incurable disease despite advances in treatment. Early-stage prostate cancer is also a heterogeneous disease defined by variable clinical behavior and outcomes. Following local treatment, prostate cancer recurs in up to 40% of men with early-stage disease. An estimated 2.85 million American men are living with prostate cancer, making this patient group the second largest group of cancer survivors. With health care expenditures surpassing an estimated $9.8 billion each year, prostate cancer is also one of the most costly cancers in the United States.

Although these figures underscore the personal and public health burdens associated with prostate cancer, not all men fare equally. Disparities in risk of aggressive disease and differences in treatment and outcomes are consistently observed. For example, incidence rates among black men (214.5 per 100,000 persons) are significantly higher compared with their white counterparts (130.0 per 100,000 persons), and death rates from prostate cancer are more than double for black men compared with their white counterparts (46.3 per 100,000 persons vs 19.8/100,000 persons, respectively). Several factors may contribute to observed racial disparities, including biological determinants (differences in genetic polymorphisms related to testosterone metabolism and the androgen receptor) differences in health behaviors, and access to health care resources. Beyond racial factors, men with lower social status and educational level are also more frequently diagnosed with more aggressive, clinically significant forms of prostate cancer than men from higher socioeconomic backgrounds, and prior research indicates that health seeking and literacy issues, as well as access to health care resources, may partially explain why some men have poorer outcomes than others. Certainly social and demographical factors may be signals for other yet-to-be identified sources that drive divergent outcomes, or they may be principal factors that explain why some men die from prostate cancer and others do not. Disparate risk factors and outcomes can be defined by geographical boundaries, and there may be a geographical component to health disparities.

Methods
In addition to studying broader reviews of racial and sociodemographic disparities, our search of available literature databases focused on geographical factors associated with health and outcome disparities, and use of spatial analyses, including the Geographical Information System (GIS), in disparity research studies related to prostate cancer. Additional, nonindexed prostate cancer treatment and outcome reports using the GIS were searched online, and reports were examined and included if they were related to geographical and health disparities.

Studies were limited to research focusing on US populations and those published in the English language. A total of 43 publications were identified, 30 of which were relevant and included in our review.

Results
The geographical and prostate cancer factors found in selected disparity studies have been summarized in the Table.

Racial and Sociodemographic Disparities
Disparities in treatment and survival between black and non-black men have long been observed. Research has shown that black men are at significantly higher risk of dying from prostate cancer than white men, they are less likely to receive curative local therapy for intermediate- and high-risk disease than their white counterparts, and small but significant differences in 5-year survival rates have been documented. Mahal et al reported that black men are 12% more likely to die from prostate cancer than white men (hazard ratio 1.12; 95% confidence interval [CI]: 1.01–1.25), corresponding to an absolute risk of death of 4.5% for blacks (95% CI: 4.1–4.9) compared with 3.4% for whites (95% CI: 3.3–3.6). They also found that black men were 18% less likely to receive curative treatment than their white counterparts. Other studies have also reported lower rates of screening and appropriate staging rates among black men compared with white men. Black men less frequently receive curative therapy, they may receive treatment later after diagnosis, and they are less likely to be treated with adjuvant therapy than white men.

Increased risk of mortality has been observed in black men as well as in men from disadvantaged social, educational, and economic backgrounds: these men have higher rates of death from prostate cancer, regardless of race. Inequity in mortality related to prostate cancer is generally ascribed to 1 of 3 factors: disease factors (eg, differences in biology, risk of more aggressive disease in some groups), patient factors (eg, health behaviors), and issues endemic to the health care system (eg, differences in access to health care facilities and resources, screening and detection practices, treatment variation).

Social, economical, and education disparities may be linked to significant differences in disease management and outcomes. Several studies have shown that men from disadvantaged groups (eg, those with lower socioeconomic status) are less likely to receive aggressive local treatment, such as radical surgery or radiotherapy, than those of higher socioeconomic status. Screenings are also less commonly performed in poorer and less-educated communities, possibly leading to diagnoses at a later-stage disease when fewer treatment options
may be available or cure is less likely. Level of health literacy and patient decision-making capacity may also contribute to socioeconomic disparities, a hypothesis partly supported by research showing that racial disparities appear to be modified by socioeconomic status. This suggests that the gap between white and black men residing in higher-income and higher-level education neighborhoods is narrower than the gap separating residents from low socioeconomic status regions.

A systematic review analyzing the association between socioeconomic status and risk of prostate cancer-related death reported that most research supports a significant link between socioeconomic status and prostate cancer-related mortality, even after adjusting for factors such as patient comorbidities and differences in treatment. In aggregate, these data suggest that low socioeconomic status increases the risk of prostate cancer-related death in men with prostate cancer, even after accounting for differences in health, stage at diagnosis, and treatment. It is worth noting that socioeconomic status disparities do not appear to have decreased in the last 10 years. By contrast, average survival rates of prostate cancer have improved during that same time.

**Geographical Disparities**

Examining nationwide treatment trends, Harlan et al noted significant regional variation across definitive treatment modalities among both white and black men. The age-adjusted proportion of men treated with prostatectomy ranged from 22.5% in Connecticut to...
47.8% in Utah, although use of radiotherapy varied less across Surveillance, Epidemiology, and End Results (SEER) cancer registry sites. In addition to confirming widespread variation in treatment modality in another SEER cohort, Krupski et al also documented significant racial and socioeconomic variation in care, with black and low-income men receiving surgery for localized disease significantly less commonly than white, higher-income men. The adjusted likelihood of surgical therapy was less than one-half (odds ratio [OR] 0.44; 95% CI: 0.41–0.47) in the lowest utilization region compared with the highest, and the investigators documented that black men were one-half as likely to be treated with surgery than whites (OR 0.52; 95% CI: 0.48–0.56). Regional variation in radiotherapy was observed: it was typically more common in regions with low rates of surgery. The results of another study examining ecological correlations between variation in prostate cancer–related deaths and surrogate measures of access to medical care (eg, prostate-specific antigen [PSA] screening uptake, late-stage presentation) suggest that between 10% and 30% of observed variations in mortality rates may be attributable to access issues.

Although regional differences in treatment for prostate cancer have been well described, a paucity of research has focused on the underlying determinants of geographically linked disparities. Access, distance, and travel time to health care facilities are germane when compared with concerns related to disparities in treatment and subsequent outcomes among US residents living in rural areas. One review examined the differences in incidence and mortality rates between residents of rural and urban areas. Few differences were observed in incidence rates, particular in the post–PSA screening era, but the findings of the review suggested that men living in rural areas are at higher risk of prostate cancer–related death than those living in urban areas, presumably due to issues related to health care accessibility. Other research has also shown that patients living in rural areas, regardless of their racial/ethnic background, are less likely to undergo PSA screening and more likely to present with more advanced disease, so they may have fewer curative treatment options. Another study found that awareness of and knowledge about prostate cancer were lower among rural men, and another confirmed that screening and detection practices are significantly less common in rural than urban areas. Rates of mortality and survival are also significantly associated with race/ethnicity, socioeconomic status, and accessibility to health care among men with prostate cancer.

**Geographical Information System and Its Role in Disparity Research**

The GIS is a computer system designed to capture, store, analyze, manage, and display spatially referenced data. It was developed in the 1960s by Tomlinson and then further refined and commercialized by Fisher. Applying the GIS to visualize and analyze spatial and temporal disease patterns has become more prevalent in health care research in recent years. Health conditions such as cardiovascular disease, hepatitis C virus infection, birth defects, and various cancers have been displayed in a spatial context to better understand these disease states. By merging health data and geography, the GIS can also help inform decision-making when allocating resources. Thus, research involving GIS brings together several different fields, including medicine, epidemiology, geography, computer sciences, and statistics. In recent years, GIS has started to extend to areas of epidemiological and health services research — focusing on health disparities — to examine the availability of health resources, utilization of health care, the geographical distribution and clustering of cancers, treatment, and rates of mortality. For example, health-related GIS studies have increased the ability of public health officials to monitor diseases and to identify areas of need. The National Cancer Institute has an interactive website that uses the GIS for cancer control purposes.

In the field of prostate cancer, research using GIS approaches has been conducted to investigate diagnoses, management, and treatment outcomes across different geographical levels, such as counties, census division/tracts, cancer registry areas, and other aggregate geographical scales. Several different fields, including medicine, epidemiology, geography, computer sciences, and statistics. In recent years, GIS has started to extend to areas of epidemiological and health services research — focusing on health disparities — to examine the availability of health resources, utilization of health care, the geographical distribution and clustering of cancers, treatment, and rates of mortality. For example, health-related GIS studies have increased the ability of public health officials to monitor diseases and to identify areas of need. The National Cancer Institute has an interactive website that uses the GIS for cancer control purposes.

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the United States and found that a higher density rate of radiation oncologists was associated with lower rates of prostate cancer-related mortality. Cetnar et al compared trends in first-line treatment of prostate cancer in rural and urban areas in Wisconsin and found that a person's place of residence was not associated with treatment choice.

GIS projects in other states have also examined disparities related to geography. Research involving men with prostate cancer has shown that the risk of late-stage prostate cancer diagnoses among black men living in Florida consistently exceeds that of white Floridians, although this gap has decreased in recent years. These studies used geographically weighted regression to account for the geographical variation in racial and sociodemographic composition, which provides estimates more likely to indicate the actual local impact of sociodemographic and clinical characteristics on patient outcomes. Using multiscale join-point regression analysis to investigate geographical, temporal, and racial/ethnic disparities in the incidence rates of late-stage prostate cancer among men living in Florida, researchers illustrated how the proportion of late-stage incidence can change over time. They observed striking geographical and racial disparities within a single state (Fig 1). Although the percentage of late-stage disease was halved between 1980 and 2000, nonmetropolitan areas lagged behind urban parts of the state, suggesting that late-stage presentation is a larger problem in rural areas compared with nonrural areas in Florida. Larger differences in temporal trends for whites and blacks were also observed in rural counties of Florida.

Another study used boundary analysis and reported significant regional differences in relation to when a decline of late-stage cases was seen, suggesting that the introduction of PSA testing and urbanization in several areas of Florida led to fewer late-stage diagnoses than that seen in nonurbanized areas, where uptake of screening practices are likely to have been slower. Al-
though this gap has narrowed across most Florida counties and the rate of late-stage diagnoses continues to decrease, some parts of the state still demonstrate persistent disparity. In another study, researchers compared the impact of comorbidities on late-stage diagnoses at the local level with the expected state-level risk and found significant differences in observed-to-expected results in Tallahassee and Pensacola, where the local OR was smaller than expected, and in Palm Beach, where the OR was larger than expected.65

Racial/ethnic differences in how prostate cancer is treated have also been documented in Florida through GIS-based studies.66,67 These results point to the importance of more granular, local analyses to evaluate potential disparities and gaps, although the stability of estimated incidence, treatment, and mortality rates can become an issue when using small geographical units (eg, zip codes, census tracts), particularly when cases are further stratified by race, socioeconomic status, or both. It is worth noting that empirical research suggests that the census tract is the most reliable unit of analysis for spatial analyses.69,70

Another Florida study examining racial/ethnic and sociodemographic disparities focused on access to health care resources and differences in state-wide treatment patterns.71 The Florida Prostate Cancer Atlas Project71 chronicled geographical variation in the burden of disease (eg, late-stage diagnosis), distribution and availability of health care resources relevant to prostate cancer, as well as access to those resources, as assessed by travel times to treatment facilities using cancer registry data from 1998 through 2007. The results of the project demonstrate that low-income areas and areas characterized by a high percentage of black residents were associated with the greatest distance to travel and time to high-volume treatment centers.71 Furthermore, low income and rural areas of Florida also appear to be characterized by limited resources for prostate cancer care and specialist health care professionals (eg, urologists, radiation oncologists).71 Treatment facilities are more sparse in the North-Central and Panhandle regions of Florida, thus resulting in longer travel times for residents in those regions that appear to disproportionately affect disadvantaged men (Fig 2); by contrast, the southeastern and western parts of the state are characterized by a greater number and higher density of treatment facilities, shorter average travel times (particularly along the coastal areas and in high-income, low-minority areas).71 However, low income and black communities are still located beyond the close access bands even in those regions of Florida, thus indicating a disproportionate and disparate service coverage for disadvantaged men (Fig 3).71

Fig 3. — Service area coverage and average travel times to high-volume prostate cancer treatment facilities in the Southwest Florida CCC area. Reproduced from reference 71.

CCC = Cancer Control Collaborative.
Differences in resource accessibility may be associated with differences in how prostate cancer presents and how it is treated. The Florida Prostate Cancer Atlas Project observed an overlap between low health care resource regions and areas in which the case proportion of late-stage or aggressive disease is highest (Fig 4). This geospatial data indicate significant differences in access to health care, treatment, and outcomes that underlie and contribute to racial/ethnic, rural, and socioeconomic disparities, and they potentially point to areas in which public health efforts and resources could be directed to address access, awareness, and treatment gaps.

Conclusions

Geographical variation in the presentation and management of prostate cancer is well documented. Although biological and disease-related factors most likely explain some of this variation, differences in the health care system, such as availability of and access to treating physicians and treatment facilities, are likely to contribute to disparate treatment and outcomes. Geographical level analyses augment disparities research, providing a lens through which clinicians, public health officials, and policymakers can identify underserved areas and make informed decisions about how to address mutable factors that contribute to health disparities. Responses to actionable geographical health information include outreach and awareness campaigns, community-based health service efforts, such as screening events, organizing providers and resources into more accessible networks, and creating local infrastructure in underserved communities to allow better access and care to needed health services.

References
