Published in final edited form as:

Am J Mens Health. 2016 July ; 10(4): 285–295. doi:10.1177/1557988314564593.

Impact of Comorbidities on Prostate Cancer Stage at Diagnosis in Florida

Hong Xiao, PhD¹, Fei Tan, PhD², Pierre Goovaerts, PhD³, Georges Adunlin, MA¹, Askal Ayalew Ali, MA¹, Clement K. Gwede, PhD, MPH, RN⁴, and Youjie Huang, MD, DrPH⁵

¹Florida A&M University, Tallahassee, FL, USA

²Indiana University-Purdue University Indianapolis, IN, USA

³BioMedware Inc., Ann Arbor, MI, USA

⁴University of South Florida, Tampa, FL, USA

⁵Centers for Disease Control and Prevention Foundation, Atlanta, GA

Abstract

To examine the association of major types of comorbidity with late-stage prostate cancer, a random sample of 11,083 men diagnosed with prostate cancer during 2002–2007 was taken from the Florida Cancer Data System. Individual-level covariates included demographics, primary insurance payer, and comorbidity following the Elixhauser Index. Socioeconomic variables were extracted from Census 2000 data and merged to the individual level data. Provider-to-case ratio at county level was also computed. Multilevel logistic regression was used to assess associations between these factors and late-stage diagnosis of prostate cancer. Higher odds of late-stage diagnosis was significantly related to presence of comorbidities, being unmarried, current smoker, uninsured, and diagnosed in not-for-profit hospitals. The study reported that the presence of certain comorbidities, specifically 10 out of the 45, was associated with late-stage prostate cancer diagnosis. Eight out of 10 significant comorbid conditions were associated with greater risk of being diagnosed at late-stage prostate cancer. On the other hand, men who had chronic pulmonary disease, and solid tumor without metastasis, were less likely to be diagnosed with late-stage prostate cancer. Late-stage diagnosis was associated with comorbidity, which is often associated with increased health care utilization. The association of comorbidity with late-stage prostate cancer diagnosis suggests that individuals with significant comorbidity should be offered routine screening for prostate cancer rather than focusing only on managing symptomatic health problems.

Keywords

prostate cancer; health inequality/disparity; health screening; health care utilization; comorbidity

Reprints and permissions: sagepub.com/journalsPermissions.nav

Corresponding Author: Hong Xiao, Florida A&M University, Division of Economic, Social & Administrative Pharmacy, College of Pharmacy and Pharmaceutical Sciences, 200 Dyson Pharmacy Building, 1520 Martin Luther King Jr. Boulevard, Tallahassee, FL 32307, USA. ; Email: hong.xiao@fam.u.edu

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Introduction

Prostate cancer is the most common solid malignancy and the second leading cause of cancer-related death for American men. It has been estimated that there will be 233,000 new cases and 29,480 deaths from this disease in the United States in 2014 (American Cancer Society, 2013). The State of Florida ranks second behind California for both incidence (16,590 estimated new cases) and mortality (2,170 estimated deaths) from prostate cancer in 2014 (American Cancer Society, 2013).

Striking racial and ethnic differences in incidence and mortality persist in the United States and the State of Florida. Racial differences are greater for prostate cancer than for any other major cancer sites (e.g., colorectal and lung). Prostate cancer incidence rates are approximately 60% higher for African Americans than for non-Hispanic Whites, and death rate are twice higher for African Americans than any other racial/ethnic group (American Cancer Society, 2013).

Previous studies attempted to explain racial differences in prostate cancer incidence and mortality. Tumor grade, stage of disease at diagnosis, and differences in access to definitive and adjuvant treatment contribute to mortality (Marlow, Halpern, Pavluck, Ward, & Chen, 2010; Shavers & Brown, 2002; Shavers et al., 2004; Tewari et al., 2005). Diet and cooking practices, selenium intake, exposure to pesticides and fertilizers, physical activity, use of health care services, genetic susceptibility, and both individual-level and area-level socioeconomic status (SES) are linked to racial difference in prostate cancer incidence (Brawley, Knopf, & Thompson, 1998; Klassen et al., 2004; Klassen & Platz, 2006; M. N. Oliver, Smith, Siadaty, Hauck, & Pickle, 2006). A growing body of evidence supports the association of prostate cancer risk to farming due to exposure to toxic chemicals, especially pesticides (Alavanja et al., 2003; Meyer, Coker, Sanderson, & Symanski, 2007; Settini, Masina, Andrion, & Axelson, 2003). Geographical disparities in late-stage diagnosis have been associated with poor access to primary health care, lack of health insurance, and difference in coverage (Mandelblatt, Yabroff, & Kerner, 1999; Mullins, Blatt, Gbarayor, Yang, & Baquet, 2005; Roetzheim et al., 1999; Talcott et al., 2007).

Another important correlate of late-stage diagnosis is the presence and severity of comorbidity. Comorbidity is the co-occurrence of one or more diseases or disorders in an individual (Bartsch et al., 1992; Siu, Lau, Tam, & Shiu, 2002). Comorbidity reflects the aggregate effect of all clinical conditions a patient might have, excluding the disease of primary interest (Arcangeli, Smith, Ratliff, & Catalona, 1997). In other cancer sites, comorbidity was reported to be an important consideration in both screening and early detection as well as treatment decision making (Siddiqui & Gwede, 2012). Effective management of chronic diseases such as prostate cancer often presents enormous challenges (Boeglin, Wessels, & Henshel, 2006). Clinicians and patients alike can be overwhelmed by the need to address comorbid chronic conditions in addition to patients' prostate cancer-specific treatment goals. Ignoring concurrent disease management, however, can lead to ineffective control of prostate cancer-specific risk factors and may miss opportunities to improve patients' functioning and quality of life and to decrease mortality risk (Knapp, Quist, Walton, & Miller, 2005).

To our knowledge, no retrospective studies have investigated the risk of late-stage prostate cancer taking into consideration individual characteristics including comorbidities, area-level characteristics, and availability of health care resources. Although a previous study examined the disparities in prostate cancer diagnosis among racial/ethnic groups and across Florida for the period 1996-2002 (Xiao, Tan, & Goovaerts, 2011), the study did not account for comorbidity, which may have an impact on stage of diagnosis and, subsequently, affect treatment and outcomes. The objective of this study was to examine association of major types of comorbidity with late-stage prostate cancer in Florida, using both individual- and area-level characteristics.

Method

Population studied

Men aged 40 years or older who were diagnosed with prostate cancer in the State of Florida between January 1, 2002 and December 31, 2007, were the focus of this study.

Data Sources

The study used data from four sources. First, prostate cancer incidence data for years 2002-2007 were obtained from the State of Florida Department of Health, which contracts with Florida Cancer Data System (FCDS) housed at the University of Miami. The FCDS was established as the state central cancer registry in 1981 and is the largest single population-based cancer incidence registry in the nation (Florida Department of Health, 2014). The FCDS contains 2.3 million cancer records, 3.5 million discharge records, and 3.1 million mortality records. The FCDS has been part of the Centers for Disease Control and Prevention National Program of Cancer Registries since 1996. The FCDS has met or exceeded the highest standard of completeness, quality, and timeliness set by the North American Association of Central Cancer Registries since 2002. The FCDS collects information on patient demographics, residence, prostate tumor characteristics, and other information such as tobacco use and primary payer of health insurance.

Second, data on sociodemographic characteristics and presence of farmhouse were extracted at the census tract level from the U.S. Census Bureau (Census 2000, Summary File 3) public use files for the State of Florida.

Third, health provider information by county was obtained from the Florida Department of Health Division of Medical Quality Assurance to calculate provider-to-case ratios. Specifically, the number of primary health providers and urologists was divided by the number of diagnosed prostate cancer cases for each county during 2002-2007. This measure was used to capture provider availability.

Fourth, comorbidity data were obtained from the Florida Agency for Health Care and Administration (AHCA). AHCA maintains two databases (Hospital Patient Discharge Data and Ambulatory Outpatient Data) on all patient encounters within hospitals and freestanding ambulatory surgical and radiation therapy centers in Florida. Comorbidity was computed following the Elixhauser Index method (Elixhauser, Steiner, Harris, & Coffey, 1998) based on diagnoses information from AHCA. Comorbidity index for prostate cancer patients

linking state cancer registry with inpatient and outpatient data was constructed, and further details on the linkage process are provided elsewhere (Xiao et al., 2013). The version of the comorbidity software provided by the Healthcare Cost and Utilization Project was valid for the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes and diagnosis-related groups (DRGs) effective October 1, 2000. To capture comorbidity condition, the analysis started on January 1, 2002. A time window of 1 year before and 1 year after prostate cancer diagnosis date was used to capture inpatient admissions and outpatient visits for any diseases other than prostate cancer or its complications. All diagnoses of diseases independent of prostate cancer and its possible complications during this 2-year time window were included for comorbidity computation (Xiao et al., 2013). The following rule was adopted to distinguish if a metastatic cancer should or should not be considered as a comorbidity: If prostate stage is localized, then any metastatic cancer in AHCA data is a comorbidity; if prostate stage is late, then metastatic cancers of the lymph nodes (ICD-9 code: 196), bone (spine and ribs, 198.5), brain (198.3), and lung (197.0) in AHCA data should not be considered as a morbidity (Xiao et al., 2013).

The study used a total of 45 conditions, including 29 from the Elixhauser Index plus 16 new additional conditions based on prevalent clinical characteristics of the study population. A detailed list of those conditions can be found in another publication from the same authors (Xiao et al., 2013). Data obtained from the four sources were merged into a single data set for analyses, representing one record per patient.

Statistical Analysis

Characteristics of the study population were examined using descriptive statistics. Bivariate associations between diagnosis stage and other covariates were assessed using chi-square or Fisher's exact test. The associations between major comorbidity categories and late-stage prostate cancer diagnosis in Florida were assessed using a multilevel logistic model.

The response variable in logistic regression was stage of prostate cancer diagnosis, categorized as early or late. Surveillance Epidemiology and End Results summary staging was used to classify prostate cancer stages based on FCDS coding. If the patient was diagnosed with localized prostate cancer, tumor stage was labeled as early stage, whereas if the patient was diagnosed with regional or distant then tumor stage was labeled as late-stage. Explanatory variables were available at three levels (individual, census tract, and county). Individual-level characteristics included age, race, marital status, tobacco use, health insurance, year of diagnosis, comorbidity, and characteristics of the medical facility where the patient was diagnosed. Using the primary payer code, each case was allocated to one of the following three health insurance types: public, private, and uninsured. If the primary payer was Medicare, Medicaid, Department of Defense (tricare), military personnel (military), Veterans Affairs, or Indian/Public Health Service then health insurance type was defined as public health insurance. Private insurance includes managed care, health maintenance organization, preferred provider organization or fee-for-services. If the patient did not have public insurance or private insurance at the time of diagnosis then this person was categorized as uninsured. At the census tract level, median household income expressed in thousands of dollars and presence of farmhouse was included. Presence of farmhouse was

used to capture some aspects of the agricultural exposure to potential toxic substance. Last, provider availability was computed at the county level as the ratio of primary health providers and urologists to prostate cancer cases.

To account for heterogeneity across counties and across census tracts, a census tract-level random intercept as well as a county-level random intercept were included in the logistic regression model. The chance of prostate cancer late-stage diagnosis was then modeled through the following equation:

$$\ln \left(\frac{p_{ijk}}{1 - p_{ijk}} \right) = x_{ijk}^T \beta + u_{ij} + v_i,$$

where $p_{ijk} = P(Y_{ijk} = 1)$ is the probability that diagnosis was late-stage, and Y_{ijk} is the stage outcome of the k th person from the j th census tract located in the i th county. In the above model, x_{ijk}^T represents covariate vector measured at three geographical levels (i.e., individual, census tract and county), the regression coefficient vector is β , and v_i and u_{ij} denote the county-level and census tract-level random intercepts, respectively. The random intercepts v_i and u_{ij} were assumed to be independent realizations of zero-mean normal distributions with variance σ_v^2 and σ_u^2 , respectively. The two distributions were assumed to be independent.

Likelihood ratio test was used for assessing whether u_{ij} and v_i should be dropped from the model; this is equivalent to testing whether an independent logistic model is appropriate. The model with county and census tract random intercepts significantly improved model with independent observation assumption ($\chi^2 = 8.90$, $p = .0043$). This suggests that a logistic regression model with independent observation assumption would not be adequate. Therefore, county and census tract random intercepts were included in the final model. Odds ratios for explanatory variables were calculated. The statistical analyses were performed using SAS/STAT® software, Version 9.3, of the SAS System for Windows. GLIMMIX procedure was used for multilevel modeling.

Results

Population characteristics

Demographic characteristics of the study population and bivariate associations with diagnosis stage are summarized in Table 1. A total of 11,083 men diagnosed with prostate cancer in Florida during 2002-2007 were included in the study, among which 1,404 were diagnosed as late-stage, and 8,653 patients had at least one coexisting condition in the study population. Average age at diagnosis for patients with early-stage diagnosis was 66.31 years and that for patients with late-stage diagnosis was 66.30 years. Among early-stage patients 1,119 were Black and among late-stage patients 221 were Black, which generated a significantly higher proportion of Black patients in the late-stage diagnosis category ($p < .0001$). Most cases were married ($n = 7,758$ for early stage, $n = 1,018$ for late stage) and self-reported as noncurrent smokers ($n = 8,201$ for early stage, $n = 1,108$ for late stage). The majority of the sample used public insurance ($n = 5,531$ for early stage, $n = 789$ for late

stage) and were diagnosed in not-for-profit facilities ($n = 7,034$ for early stage, $n = 1,091$ for late stage). The majority of cases were diagnosed in hospitals ($n = 9,390$ for early stage, $n = 1,397$ for late stage).

Multilevel Modeling

Results of multilevel logistic regression are reported in Table 2. At the individual level, being unmarried, current tobacco user, and uninsured were associated with elevated odds of late-stage diagnosis. Cases diagnosed at non-profit-taking facilities were more likely to be late-stage diagnoses. Compared with men diagnosed in hospital, those who were diagnosed in ambulatory settings were 76% less likely to be diagnosed with late-stage prostate cancer (odds ratio [OR] = 0.240, $p = .0004$).

At the census tract level, individuals living in a poor neighborhood were associated with a higher likelihood of late-stage prostate cancer diagnosis (OR = 0.996, $p = .0576$), although the p value of this effect was not significant. Specifically, the odds of being diagnosed with late-stage prostate cancer were 0.4% lower per additional \$1,000 in median household income.

Among all comorbidities considered, presence of congestive heart failure, metastatic cancer, fluid and electrolyte disorders, deficiency anemias, infection, skin and subcutaneous tissue disease, musculoskeletal and connective tissue disease, and brain and other neurological disorders were associated with higher odds of late-stage prostate cancer. Presence of chronic pulmonary circulation disease (OR = 0.760, $p = .0115$), and solid tumor without metastasis (OR = 0.404, $p < .0001$) were associated with reduced odds of late-stage diagnosis. None of the interactions tested was significant; hence they were not included in the model.

Discussion

Prostate cancer is the most commonly diagnosed malignancy and the second leading cause of cancer-related deaths in men in the United States (American Cancer Society, 2013). The association between comorbidity and prostate cancer has been a public health issue for a long time (Alibhai, Naglie, Nam, Trachtenberg, & Krahn, 2003; Post et al., 1999). This study attempted to explain whether the presence of comorbid conditions is associated with prostate cancer stage at diagnosis by using a population-based registry linked with disease diagnosis information for prostate cancer patients.

The study reported that presence of certain comorbidities, specifically 10 out of the 45, was associated with late-stage prostate cancer diagnosis. Eight out of 10 significant comorbid conditions were associated with greater risk of being diagnosed at late-stage. On the other hand, men who had chronic pulmonary disease and solid tumor without metastasis were less likely to be diagnosed with late-stage prostate cancer. Some comorbidities in the Elixhauser Index, such as weight loss, may be etiologically related to other comorbid conditions or late-stage prostate cancer. Such variables were included in the list of comorbidities because the administrative data provided by the AHCA did not provide information to discern the etiology of these conditions. Comorbidity has important implications for prostate cancer screening and management, particularly for older men, who commonly have multiple health

conditions. However, the mechanisms behind the relationship between comorbidities and late-stage prostate cancer diagnosis are unclear. It might be possible that individuals with severe comorbidities are more likely to be engaged with the health care system and may be more likely to be tested for prostate cancer. On the other hand individuals with significant comorbidity may not be offered routine screening, including for prostate cancer. The focus may be toward management of existing health problems rather than routine screening (Siddiqui & Gwede, 2012). Additionally, comorbidities could cover symptoms of prostate cancer, and delay earlier diagnosis. The relationship between comorbidity and PCa screening warrant further investigation in light of the U.S. Preventive Services Task Force (2013) recommendation against prostate-specific antigen screening, on the basis that there is moderate or high certainty that the harms outweigh the benefits (U.S. Preventive Services Task Force, 2013).

A particular strength of the study is the linkage of cancer registry data with patient diagnosis information in addition to prostate cancer. The linkage enabled the researchers to have a whole picture of patients in terms of their disease profile instead of just cancer diagnosis. This provided additional data modifiers, including comorbid conditions, improved follow-up, socioeconomic details, and health care access information.

Married men were less likely to be diagnosed at late-stage compared with unmarried men. This finding suggests that being married confers a substantial protective effect in preventing late-stage prostate cancer diagnosis. The unfavorable effect of unmarried marital status on disease stage has been confirmed in prostate cancer and several other malignancies (Abdollah et al., 2011; Campbell et al., 2001; Osborne, Ostir, Du, Peek, & Goodwin, 2005; Wang, Wilson, Stewart, & Hollenbeak, 2011).

Our findings on smoking confirm the detrimental effect of tobacco use on late-stage prostate cancer diagnosis. The relation between smoking and many cancers is established, but its role in prostate cancer is not clear (U.S. Department of Health and Human Services, 2014). The tobacco-related biologic mechanisms most commonly considered to explain how smoking could cause or accelerate the course of prostate cancer involve cadmium. Cadmium is thought to be present in tobacco smoke due to the use of phosphate fertilizers that contain cadmium on tobacco plants. However, this relationship is not clearly established (Chen et al., 2009; Verougstraete, Lison, & Hotz, 2003).

Consistent with past studies (Bennett et al., 1998; Halpern et al., 2008; Jones et al., 2008; Vijayakumar, Weichselbaum, Vaida, Dale, & Hellman, 1996), men without health insurance had worse diagnoses than those with coverage. This finding reinforce the fact that having health insurance is a crucial factor for receiving appropriate cancer screening and timely access to medical care (Fedewa, Etzioni, Flanders, Jemal, & Ward, 2010; Marlow et al., 2010).

Other studies reported that hospital characteristics play an important role in the variations in the early diagnosis of prostate cancer cases as well as outcomes from the disease (Barbiere et al., 2012; Chornokur, Dalton, Borysova, & Kumar, 2011; Jayadevappa, Chhatre, Johnson, & Malkowicz, 2011). Men diagnosed in for-profit facilities were less likely to be diagnosed

at late-stage. The study indicated that patients diagnosed with prostate cancer in ambulatory settings were 76% less likely to have late-stage diagnosis (OR = 0.240, $p = .0004$). The data elements that we had in our possession did not allow distinguishing between private and public hospitals. However, a study reported that being diagnosed in private hospital is associated with early-stage prostate cancer diagnosis, higher use of surgery, and lower use of radiotherapy (Barbieri et al., 2012). Research on the effects of hospital characteristics and ownership on prostate cancer diagnosis is needed to confirm our findings.

At the census tract level, higher median household income was associated with lower likelihood of late-stage diagnosis, which confirms findings from other studies (Clegg et al., 2009). Because low SES is known to affect access to care, income level has been hypothesized to explain the observed difference in stage at diagnosis for prostate cancer (Bennett et al., 1998, J. A. S. Oliver, Grindel, DeCoster, Ford, & Martin, 2011). Opportunities for early detection of prostate cancer are suggested to be lower for low-income men because of financial, cultural, and social factors and distance to care (Barber et al., 1998, Holmes et al., 2012, Steele, Miller, Maylahn, Uhler, & Baker, 2000).

The current study has a number of limitations. Census tract and county-level data were used due to lack of some individual-level information that would have provided richer information for the analyses. Large databases like the FCDS, however, are not without limitations. The data used for this study were from cases diagnosed from 2002 through 2007; therefore the observations made in this analysis may not necessarily reflect the most current trends.

In conclusion, disparities in late-stage diagnosis based on race, SES, and comorbidities continue to exist in prostate cancer. Racial and socioeconomic disparities may partly be explained by the lack of access to care and problems of delayed diagnosis. This research identifies segments of the population that may benefit from targeting interventions. Efforts to narrow these disparities must include earlier diagnosis of prostate cancer in Black men, uninsured men, smokers, men of low SES, and those who have certain comorbid conditions. Comorbidity information must be incorporated into the mainstream of prostate cancer clinical research and in clinical trials to evaluate cancer treatment options for older men.

Acknowledgments

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: The study was funded by Grant #RSGT-10-082-01-CPHPS from the American Cancer Society.

References

- Abdollah F, Sun M, Thuret R, Abdo A, Morgan M, Jeldres C, Karakiewicz PI. The effect of marital status on stage and survival of prostate cancer patients treated with radical prostatectomy: A population-based study. *Cancer Causes & Control*. 2011; 22:1085–1095. [PubMed: 21643929]
- Alavanja MCR, Samanic C, Dosemeci M, Lubin J, Tarone R, Lynch CF, Blair A. Use of agricultural pesticides and prostate cancer risk in the Agricultural Health Study Cohort. *American Journal of Epidemiology*. 2003; 157:800–814. [PubMed: 12727674]

- Alibhai SMH, Naglie G, Nam R, Trachtenberg J, Krahn MD. Do older men benefit from curative therapy of localized prostate cancer? *Journal of Clinical Oncology*. 2003; 21:3318–3327. [PubMed: 12947068]
- American Cancer Society. *Cancer facts & figures 2013*. Atlanta, GA: 2013.
- Arcangeli CG, Smith DS, Ratliff TL, Catalona WJ. Stability of serum total and free prostate specific antigen under varying storage intervals and temperatures. *Journal of Urology*. 1997; 158:2182–2187. [PubMed: 9366340]
- Barber KR, Shaw R, Folts M, Taylor DK, Ryan A, Hughes M, Abbott RR. Differences between African American and Caucasian men participating in a community-based prostate cancer screening program. *Journal of Community Health*. 1998; 23:441–451. [PubMed: 9824793]
- Barbiere J, Greenberg D, Wright K, Brown C, Palmer C, Neal D, Lyratzopoulos G. The association of diagnosis in the private or NHS sector on prostate cancer stage and treatment. *Journal of Public Health*. 2012; 34:108–114. [PubMed: 21745831]
- Bartsch C, Bartsch H, Schmidt A, Ilg S, Bichler KH, Fluchter SH. Melatonin and 6-sulfatoxymelatonin circadian rhythms in serum and urine of primary prostate cancer patients: Evidence for reduced pineal activity and relevance of urinary determinations. *Clinica Chimica Acta*. 1992; 209:153–167.
- Bennett CL, Ferreira MR, Davis TC, Kaplan J, Weinberger M, Kuzel T, Sartor O. Relation between literacy, race, and stage of presentation among low-income patients with prostate cancer. *Journal of Clinical Oncology*. 1998; 16:3101–3104. [PubMed: 9738581]
- Boeglin ML, Wessels D, Henshel D. An investigation of the relationship between air emissions of volatile organic compounds and the incidence of cancer in Indiana counties. *Environmental Research*. 2006; 100:242–254. doi:10.1016/j.envres.2005.04.004. [PubMed: 15992796]
- Brawley O, Knopf K, Thompson I. The epidemiology of prostate cancer: Part II. The risk factors. *Seminars in Urologic Oncology*. 1998; 16:193–201. [PubMed: 9858325]
- Campbell RJ, Ferrante JM, Gonzalez EC, Roetzheim RG, Pal N, Herold A. Predictors of advanced stage colorectal cancer diagnosis: Results of a population-based study. *Cancer Detection and Prevention*. 2001; 25:430–438. [PubMed: 11718449]
- Chen YC, Pu Y, Wu HC, Wu T, Lai M, Yang C, Sung FC. Cadmium burden and the risk and phenotype of prostate cancer. *BMC Cancer*. 2009; 9(1):429. [PubMed: 20003241]
- Chornokur G, Dalton K, Borysova ME, Kumar NB. Disparities at presentation, diagnosis, treatment, and survival in African American men, affected by prostate cancer. *The Prostate*. 2011; 71:985–997. [PubMed: 21541975]
- Clegg LX, Reichman ME, Miller BA, Hankey BF, Singh GK, Lin YD, Edwards BK. Impact of socioeconomic status on cancer incidence and stage at diagnosis: Selected findings from the surveillance, epidemiology, and end results: National longitudinal mortality study. *Cancer Causes & Control*. 2009; 20:417–435. [PubMed: 19002764]
- Elixhauser A, Steiner C, Harris DR, Coffey RM. Comorbidity measures for use with administrative data. *Medical Care*. 1998; 36(1):8–27. [PubMed: 9431328]
- Fedewa SA, Etzioni R, Flanders WD, Jemal A, Ward EM. Association of insurance and race/ethnicity with disease severity among men diagnosed with prostate cancer, national cancer database 2004–2006. *Cancer Epidemiology, Biomarkers & Prevention*. 2010; 19:2437–2444.
- Florida Department of Health. Florida cancer registry. 2014. Retrieved from <http://www.floridahealth.gov/diseases-and-conditions/cancer/cancer-registry/index.html>
- Halpern MT, Ward EM, Pavluck AL, Schrag NM, Bian J, Chen AY. Association of insurance status and ethnicity with cancer stage at diagnosis for 12 cancer sites: A retrospective analysis. *Lancet Oncology*. 2008; 9:222–231. [PubMed: 18282806]
- Holmes JA, Carpenter WR, Wu Y, Hendrix LH, Peacock S, Massing M, Chen RC. Impact of distance to a urologist on early diagnosis of prostate cancer among Black and White patients. *Journal of Urology*. 2012; 187:883–888. [PubMed: 22248516]
- Jayadevappa R, Chhatre S, Johnson JC, Malkowicz SB. Association between ethnicity and prostate cancer outcomes across hospital and surgeon volume groups. *Health Policy*. 2011; 99:97–106. [PubMed: 20708815]

- Jones BA, Liu WL, Araujo AB, Kasl SV, Silvera SN, Soler-Vilá H, Dubrow R. Explaining the race difference in prostate cancer stage at diagnosis. *Cancer Epidemiology, Biomarkers & Prevention*. 2008; 17:2825–2834.
- Klassen AC, Curriero FC, Hong JH, Williams C, Kulldorff M, Meissner HI, Ensminger M. The role of area-level influences on prostate cancer grade and stage at diagnosis. *Preventive Medicine*. 2004; 39:441–448. [PubMed: 15313082]
- Klassen AC, Platz EA. What can geography tell us about prostate cancer? *American Journal of Preventive Medicine*. 2006; 30(Suppl. 2):S7–S15. [PubMed: 16458793]
- Knapp KK, Quist RM, Walton SM, Miller LM. Update on the pharmacist shortage: National and state data through 2003. *American Journal of Health-System Pharmacy*. 2005; 62:492–499. [PubMed: 15745912]
- Mandelblatt JS, Yabroff KR, Kerner JF. Equitable access to cancer services. *Cancer*. 1999; 86:2378–2390. [PubMed: 10590381]
- Marlow NM, Halpern MT, Pavluck AL, Ward EM, Chen AY. Disparities associated with advanced prostate cancer stage at diagnosis. *Journal of Health Care for the Poor and Underserved*. 2010; 21:112–131. doi:10.1353/hpu.0.0253. [PubMed: 20173259]
- Meyer TE, Coker AL, Sanderson M, Symanski E. A case-control study of farming and prostate cancer in African-American and Caucasian men. *Occupational & Environmental Medicine*. 2007; 64:155. [PubMed: 16912087]
- Mullins CD, Blatt L, Gbarayor CM, Yang HWK, Baquet C. Health disparities: A barrier to high-quality care. *American Journal of Health-System Pharmacy*. 2005; 62:1873–1882. [PubMed: 16141106]
- Oliver JAS, Grindel CG, DeCoster J, Ford CD, Martin MY. Benefits, barriers, sources of influence, and prostate cancer screening among rural men. *Public Health Nursing*. 2011; 28:515–522. [PubMed: 22092461]
- Oliver MN, Smith E, Siadat M, Hauck FR, Pickle LW. Spatial analysis of prostate cancer incidence and race in Virginia, 1990–1999. *American Journal of Preventive Medicine*. 2006; 30(Suppl. 2):S67–S76. [PubMed: 16458792]
- Osborne C, Ostir GV, Du X, Peek MK, Goodwin JS. The influence of marital status on the stage at diagnosis, treatment, and survival of older women with breast cancer. *Breast Cancer Research and Treatment*. 2005; 93(1):41–47. [PubMed: 16184457]
- Post P, Kil P, Hendriks A, Janssen-Heijnen M, Crommelin M, Coebergh J. Comorbidity in patients with prostate cancer and its relevance to treatment choice. *BJU International*. 1999; 84:652–656. [PubMed: 10510110]
- Roetzheim RG, Pal N, Tennant C, Voti L, Ayanian JZ, Schwabe A, Krischer JP. Effects of health insurance and race on early detection of cancer. *Journal of the National Cancer Institute*. 1999; 91:1409–1415. [PubMed: 10451447]
- Settimi L, Masina A, Andron A, Axelson O. Prostate cancer and exposure to pesticides in agricultural settings. *International Journal of Cancer*. 2003; 104:458–461. [PubMed: 12584743]
- Shavers VL, Brown ML. Racial and ethnic disparities in the receipt of cancer treatment. *Journal of the National Cancer Institute*. 2002; 94:334–357. [PubMed: 11880473]
- Shavers VL, Brown ML, Potosky AL, Klabunde CN, Davis W, Moul JW, Fahey A. Race/ethnicity and the receipt of watchful waiting for the initial management of prostate cancer. *Journal of General Internal Medicine*. 2004; 19:146–155. [PubMed: 15009794]
- Siddiqui F, Gwede CK. Head and neck cancer in the elderly population. *Seminars in Radiation Oncology*. 2012; 22:321–333. [PubMed: 22985815]
- Siu SW, Lau KW, Tam PC, Shiu SY. Melatonin and prostate cancer cell proliferation: Interplay with castration, epidermal growth factor, and androgen sensitivity. *The Prostate*. 2002; 52:106–122. doi:10.1002/pros.10098. [PubMed: 12111702]
- Steele CB, Miller DS, Maylahn C, Uhler RJ, Baker CT. Knowledge, attitudes, and screening practices among older men regarding prostate cancer. *American Journal of Public Health*. 2000; 90:1595–1600. [PubMed: 11029994]
- Talcott JA, Spain P, Clark JA, Carpenter WR, Do YK, Hamilton RJ, Godley PA. Hidden barriers between knowledge and behavior. *Cancer*. 2007; 109:1599–1606. [PubMed: 17354220]

- Tewari A, Horninger W, Pelzer AE, Demers R, Crawford ED, Gamito EJ, Menon M. Factors contributing to the racial differences in prostate cancer mortality. *BJU International*. 2005; 96:1247–1252. [PubMed: 16287439]
- U.S. Department of Health and Human Services. The health consequences of smoking—50 years of progress: A report of the surgeon general. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health; Atlanta, GA: 2014.
- U.S. Preventive Services Task Force. Screening for prostate cancer: US Preventive Services Task Force Recommendation Statement. 2013. Retrieved from <http://www.uspreventiveservicestaskforce.org/Page/Document/RecommendationStatementFinal/prostate-cancer-screening>
- Verougstraete V, Lison D, Hotz P. Cadmium, lung and prostate cancer: A systematic review of recent epidemiological data. *Journal of Toxicology and Environmental Health: Part B. Critical Reviews*. 2003; 6:227–256.
- Vijayakumar S, Weichselbaum R, Vaida F, Dale W, Hellman S. Prostate-specific antigen levels in African-Americans correlate with insurance status as an indicator of socioeconomic status. *Cancer Journal From Scientific American*. 1996; 2:225–233. [PubMed: 9166537]
- Wang L, Wilson SE, Stewart DB, Hollenbeak CS. Marital status and colon cancer outcomes in US surveillance, epidemiology and end results registries: Does marriage affect cancer survival by gender and stage? *Cancer Epidemiology*. 2011; 35:417–422. [PubMed: 21466984]
- Xiao H, Tan F, Goovaerts P. Racial and geographic disparities in late-stage prostate cancer diagnosis in Florida. *Journal of Health Care for the Poor and Underserved*. 2011; 22:187–199. [PubMed: 22102314]
- Xiao H, Tan F, Goovaerts P, Ali A, Adunlin G, Huang Y, Gwede C. Construction of a comorbidity index for prostate cancer patients linking state cancer registry with inpatient and outpatient data. *Journal of Registry Management*. 2013; 40:159–164. [PubMed: 24625768]

Table 1
Characteristics of a Random Sample of Men Diagnosed With Prostate Cancer in Florida,
2002-2007 (N = 11,083)

Variable	Stage		P
	Early ^a	Late ^a	
Age at diagnosis, years	66.31 [8.81]	66.30 [10.05]	.9859
Race			
White	8,560 (88%)	1,183 (12%)	<.0001
Black	1,119 (84%)	221 (16%)	
Marital status			
Unmarried	1,921 (83%)	386 (17%)	<.0001
Married	7,758 (88%)	1,018 (12%)	
Smoking			
Noncurrent smokers	8,201 (88%)	1,108 (12%)	<.0001
Current smokers	1,478 (83%)	296 (17%)	
Insurance			
Privately insured	3,994 (88%)	558 (12%)	<.0001
Publicly insured	5,531 (88%)	789 (12%)	
Uninsured	154 (73%)	57 (27%)	
For-profit facility			
No	7,034 (87%)	1,091 (13%)	<.0001
Yes	2,645 (89%)	313 (11%)	
Facility type			
Hospital	9,390 (87%)	1,397 (13%)	<.0001
Ambulatory	289 (98%)	7 (2%)	
Year of diagnosis			
2002	1,995 (88%)	281 (12%)	.7856
2003	1,431 (88%)	189 (12%)	
2004	1,459 (87%)	219 (13%)	
2005	1,456 (87%)	218 (13%)	
2006	1,621 (87%)	244 (13%)	
2007	1,717 (87%)	253 (13%)	
Congestive heart failure			
No	9,513 (88%)	1,334 (12%)	<.0001
Yes	166 (70%)	70 (30%)	
Valvular disease			
No	9,417 (87%)	1,350 (13%)	.0165
Yes	262 (83%)	54 (17%)	
Pulmonary circulation disease			
No	9,651 (87%)	1,394 (13%)	.0230
Yes	28 (74%)	10 (26%)	
Peripheral vascular disease			

Variable	Stage		<i>P</i>
	Early ^a	Late ^a	
No	9,491(87%)	1,367(13%)	.0853
Yes	188 (84%)	37 (16%)	
Paralysis			
No	9,650 (87%)	1,386(13%)	<.0001
Yes	29 (62%)	18 (38%)	
Other neurological disorders			
No	9,548(87%)	1,379 (13%)	.2042
Yes	131(84%)	25(16%)	
Chronic pulmonary disease			
No	8,798 (88%)	1,244 (12%)	.0059
Yes	881(85%)	160 (15%)	
Diabetes with/without chronic complications			
No	8,619 (87%)	1,252 (13%)	.8882
Yes	1060 (87%)	152 (13%)	
Diabetes with chronic complications			
No	9,614 (87%)	1,385(13%)	.0059
Yes	65 (77%)	19 (23%)	
Hypothyroidism			
No	9,447(87%)	1,365(13%)	.3879
Yes	232 (86%)	39 (14%)	
Renal failure			
No	9,501(88%)	1,333(12%)	<.0001
Yes	178 (71%)	71(29%)	
Liver disease			
No	9,631(87%)	1,388 (13%)	.0029
Yes	48 (75%)	16 (25%)	
Peptic ulcer disease excluding bleeding			
No	9,653(87%)	1,400 (13%)	.7868
Yes	26 (87%)	4 (13%)	
Acquired immune deficiency syndrome			
No	9,669 (87%)	1,401(13%)	.2218
Yes	10 (77%)	3 (23%)	
Lymphoma			
No	9,623(87%)	1,396 (13%)	.9677
Yes	56 (88%)	8 (12%)	
Metastatic cancer			
No	9,440 (89%)	1,192 (11%)	<.0001
Yes	239 (53%)	212 (47%)	
Solid tumor with/without metastasis			
No	9,125 (87%)	1,340 (13%)	.0754
Yes	554 (90%)	64 (10%)	

Variable	Stage		<i>P</i>
	Early ^a	Late ^a	
Rheumatoid arthritis/collagen vas			
No	9,628 (87%)	1,396 (13%)	.8365
Yes	51 (86%)	8 (14%)	
Coagulopathy			
No	9,576 (88%)	1,354 (12%)	<.0001
Yes	103 (67%)	50 (33%)	
Obesity			
No	9,460 (87%)	1,369 (13%)	.5900
Yes	219 (86%)	35 (14%)	
Weight loss			
No	9,636 (88%)	1,361 (12%)	<.0001
Yes	43 (50%)	43 (50%)	
Fluid and electrolyte disorders			
No	9,250 (89%)	1,183 (11%)	<.0001
Yes	429 (66%)	221 (34%)	
Blood loss anemias			
No	9,609 (87%)	1,374 (13%)	<.0001
Yes	70 (70%)	30 (30%)	
Deficiency anemias			
No	9,297 (89%)	1,193 (11%)	<.0001
Yes	382 (64%)	211 (36%)	
Alcohol abuse			
No	9,600 (88%)	1,368 (12%)	<.0001
Yes	79 (69%)	36 (31%)	
Drug abuse			
No	9,668 (87%)	1,399 (13%)	.0426
Yes	11 (69%)	5 (31%)	
Psychoses			
No	9,630 (87%)	1,386 (13%)	.0005
Yes	49 (73%)	18 (27%)	
Depression			
No	9,485 (87%)	1,360 (13%)	.0064
Yes	194 (82%)	44 (18%)	
Hypertension (combined uncomplicated and complicated)			
No	5,411 (88%)	741 (12%)	.0276
Yes	4,268 (87%)	663 (13%)	
Endocrine disorders, nutritional and metabolic, immunity			
No	7,734 (88%)	1,063 (12%)	.0003
Yes	1,945 (85%)	341 (15%)	
Ischemic heart disease			

Variable	Stage		<i>P</i>
	Early ^a	Late ^a	
No	8,383 (88%)	1,186 (12%)	.0293
Yes	1,296 (86%)	218 (14%)	
Digestive system disease			
No	8,180 (88%)	1,099 (12%)	<.0001
Yes	1,499 (83%)	305 (17%)	
Genitourinary system disease			
No	7,407 (89%)	957 (11%)	<.0001
Yes	2,272 (84%)	447 (16%)	
Injury and poisoning			
No	8,884 (88%)	1,244 (12%)	<.0001
Yes	795 (83%)	160 (17%)	
Respiratory disorders			
No	9,255 (88%)	1,269 (12%)	
Yes	424 (76%)	135 (24%)	<.0001
Infection			
No	9,392 (88%)	1,258 (12%)	<.0001
Yes	287 (66%)	146 (34%)	
Other circulatory disease			
No	9,385 (88%)	1,307 (12%)	<.0001
Yes	294 (75%)	97 (25%)	
Benign neoplasm and in-situ cancer			
No	9,356 (87%)	1,365 (13%)	.2705
Yes	323 (89%)	39 (11%)	
Other nervous system and sense organs disorder			
No	9,366 (88%)	1,336 (12%)	.0020
Yes	313 (82%)	68 (18%)	
Skin and subcutaneous tissue disease			
No	9,562 (88%)	1,349 (12%)	<.0001
Yes	117 (68%)	55 (32%)	
Musculoskeletal and connective tissue disease			
No	8,551(88%)	1,138 (12%)	<.0001
Yes	1,128 (81%)	266 (19%)	
Other mental disorders			
No	9,564 (87%)	1,372 (13%)	.0008
Yes	115 (78%)	32 (22%)	
Other anemias			
No	9,563 (88%)	1,350 (12%)	<.0001
Yes	116 (68%)	54 (32%)	
Congenital anomalies			
No	9,632 (87%)	1,395 (13%)	.4427

Variable	Stage		<i>p</i>
	Early ^a	Late ^a	
Yes	47 (84%)	9 (16%)	
Brain and other neurological disorders			
No	9,606 (88%)	1,366 (12%)	<.0001
Yes	73 (66%)	38 (34%)	

^aFrequency (row %) or Mean [SD]

Table 2
Multilevel Logistic Regression for Late-Stage Versus Early-Stage (N = 11,083)

	95% confidence interval			
Explanatory variables	Odds ratio	Upper	Lower	p
Individual level				
Age 40	1.002	0.993	1.010	.7130
Year 2007 vs. 2002	1.018	0.795	1.304	.8856
Year 2006 vs. 2002	1.131	0.885	1.444	.3256
Year 2005 vs. 2002	0.965	0.788	1.183	.7324
Year 2004 vs. 2002	1.013	0.827	1.241	.9036
Year 2003 vs. 2002	0.859	0.695	1.060	.1566
Black vs. White	1.189	0.989	1.429	.0660
Married vs. unmarried	0.829	0.717	0.957	.0106**
Current smoker vs. noncurrent smoker	1.361	1.165	1.589	.0001**
Uninsured vs. privately insured	1.918	1.350	2.725	.0003**
Publicly insured vs. privately insured	0.882	0.756	1.029	.1115
For-profit facility vs. non-for-profit facility	0.820	0.705	0.953	.0098**
Ambulatory vs. hospital	0.240	0.108	0.531	.0004**
Census tract level				
Median income 1000	0.996	0.992	1.000	.0576
Farm house vs. no farmhouse	1.032	0.868	1.226	.7241
County level				
Provider urologist-to-case ratio	0.604	0.289	1.262	.1799
Comorbidities				
Congestive heart failure	1.746	1.224	2.492	.0021**
Valvular disease	0.945	0.666	1.341	.7517
Pulmonary circulation disease	1.134	0.483	2.664	.7727
Peripheral vascular disease	0.911	0.606	1.370	.6544
Paralysis	1.920	0.938	3.930	.0745
Other neurological disorders	0.877	0.538	1.427	.5965
Chronic pulmonary disease	0.760	0.614	0.940	.0115**
Diabetes without chronic complications	0.872	0.715	1.065	.1805
Diabetes with chronic complications	0.845	0.453	1.577	.5961
Hypothyroidism	1.048	0.723	1.518	.8044
Renal failure	0.899	0.627	1.287	.5594
Liver disease	1.112	0.577	2.141	.7517
Peptic ulcer disease excluding bleeding	0.791	0.243	2.570	.6961
Acquired immune deficiency syndrome	0.784	0.187	3.290	.7395
Lymphoma	0.496	0.209	1.178	.1120
Metastatic cancer	4.904	3.936	6.109	<.0001**
Solid tumor without metastasis	0.404	0.294	0.557	<.0001**

Explanatory variables	Odds ratio	95% confidence interval		<i>p</i>
		Upper	Lower	
Rheumatoid arthritis/collagen VAS (visual analogue scale)	0.738	0.319	1.711	.4794
Coagulopathy	1.362	0.886	2.092	.1588
Obesity	1.051	0.714	1.546	.8011
Weight loss	1.698	0.983	2.934	.0578
Fluid and electrolyte disorders	1.866	1.485	2.346	<.0001**
Blood loss anemias	1.390	0.825	2.340	.2161
Deficiency anemias	2.397	1.924	2.986	<.0001**
Alcohol abuse	1.575	0.983	2.524	.0588
Drug abuse	1.354	0.370	4.959	.6472
Psychoses	1.326	0.697	2.520	.3896
Depression	1.132	0.785	1.632	.5074
Hypertension (combined uncomplicated and complicated) ^a	0.967	0.852	1.098	.6056
Endocrine disorders, nutritional and metabolic, immunity ^a	1.087	0.935	1.263	.2797
Ischemic heart disease ^a	0.979	0.815	1.176	.8207
Digestive system disease ^a	1.009	0.857	1.187	.9163
Genitourinary system disease ^a	1.073	0.929	1.240	.3382
Injury and poisoning ^a	0.835	0.672	1.037	.1029
Respiratory disorders ^a	1.202	0.933	1.549	.1542
Infection ^a	1.468	1.112	1.939	.0068**
Other circulatory disease ^a	1.283	0.966	1.706	.0856
Benign neoplasm and in-situ cancer ^a	0.720	0.491	1.055	.0918
Other nervous system and sense organs disorders ^a	1.233	0.908	1.675	.1795
Skin and subcutaneous tissue disease ^a	1.604	1.084	2.374	.0182**
Musculoskeletal and connective tissue disease	1.414	1.198	1.669	<.0001**
Other mental disorders ^a	1.028	0.640	1.652	.9097
Other anemia ^a	0.974	0.643	1.476	.9009
Congenital anomalies ^a	1.084	0.494	2.377	.8414
Brain and other neurological disorders ^a	2.141	1.353	3.389	.0012**

Note. "Median Income1000" is median household income expressed in thousands. "Age 40" represents men 40 years of age and older diagnosed with prostate cancer and is a continuous variable.

^a Additional comorbidities not in Elixhauser that were identified from the data set.

**
p < .05.