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Past, Current, and Future Incidence Rates and Burden of Metastatic Prostate Cancer in the United States

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Abstract

Background: Metastatic prostate cancer (PCA) remains a highly lethal malignancy in the USA. As prostate-specific antigen testing declines nationally, detailed assessment of current age- and race-specific incidence trends and quantitative forecasts are needed.

Objective: To evaluate the current trends of metastatic PCA by age and race, and forecast the number of new cases (annual burden) and future trends.

Design, setting, and participants: We derived incidence data for men aged ≥45 yr who were diagnosed with metastatic PCA from the population-based Surveillance, Epidemiology, and End Results registries.

Outcome measurements and statistical analysis: We examined the current trends of metastatic PCA from 2004 to 2014, and forecast the annual burden and incidence rates by age and race for 2015–2025, using age–period–cohort models and population projections. We also examined alternative forecasts (2012–2025) using trends prior to the revised screening guidelines issued in 2012.

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Acquisition of data: Kelly.

Analysis and interpretation of data: Kelly, Anderson, Rosenberg, Cook.

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Results and limitations: Metastatic PCA, steadily declining from 2004 to 2007 by 1.45%/yr, began to increase by 0.58%/yr after 2008, which accelerated to 2.74%/yr following the 2012 United States Preventive Services Task Force recommendations—a pattern that was magnified among men aged 69 yr and white men. Forecasts project the incidence to increase by 1.03%/yr through 2025, with men aged 45–54 yr (2.29%/yr) and 55–69 yr (1.53%/yr) increasing more rapidly. Meanwhile, the annual burden is expected to increase 42% by 2025. Our forecasts estimated an additional 15 891 metastatic cases from 2015 to 2025 compared with alternative forecasts using trends prior to 2012.

Conclusions: The recent uptick in metastatic PCA rates has resulted in forecasts that project increasing rates through 2025, particularly among men aged 69 yr. Moreover, racial disparities are expected to persist and the annual burden will increase considerably. The impact of the prior and current PCA screening recommendations on metastatic PCA rates requires continued examination.

Patient summary: In this report, we assessed how the incidence of metastatic prostate cancer has changed over recent years, and forecast future incidence trends and the number of new cases expected each year. We found that the incidence of metastatic prostate cancer has been increasing more rapidly since 2012, resulting in a rise in both future incidence and the number of new cases by 2025. Future incidence rates and the number of new cases were reduced in alternative forecasts using data prior to the 2012 United States Preventive Services Task Force (USPSTF) recommendations against prostate-specific antigen (PSA) testing for prostate cancer, and further study is required to examine if national declines in PSA testing rates, which followed the USPSTF recommendations, have contributed to increasing rates of metastatic disease. The incidence of metastatic disease in black men is still expected to occur at considerably higher rates compared with that in white men.

Summary

The sharp uptick in metastatic prostate cancer rates following the 2012 United States Preventive Services Task Force recommendations may be driving a projected increase in future years, particularly among men aged 69 yr. Racial disparities are expected to persist, and the annual burden will increase considerably.

Keywords

Cancer trends; Disease progression; Epidemiology; Neoplasm metastases; Prostate-specific antigen; Prostate cancer; Prostatic neoplasms; Racial disparities

1. Introduction

Prostate cancer (PCA) is the most frequently diagnosed cancer among men in the USA, with an estimated 161 360 new cases expected in 2017 [1]. After widespread adoption of prostate-specific antigen (PSA) testing in the USA in the late 1980s [2], overall PCA incidence rates doubled followed by a subsequent decline and recent stabilization [3]. Approximately 6% of new PCA cases present with metastatic disease, with a 5-yr survival rate of only 29% [4]. Metastatic PCA often becomes androgen independent, which contributes to its poor prognosis [5]. No improvement has been noted in overall or cause-

specific survival for men presenting with metastatic PCA over the last 2 decades [6]. The incidence of metastatic PCA is of great interest, given that this form of the disease is less amenable to treatment and effective screening should identify tumors that are destined to metastasize at earlier localized/regional stages [7,8].

Whether recent trends of metastatic PCA have been increasing is controversial. Recent research has reported an increasing incidence of metastatic PCA based on relative increases in the absolute number of new cases [9], while other studies have suggested a recent stabilization [7,10,11] or increases among older men [12]. Whether the incidence of metastatic PCA is increasing is important, as declines have been a major contributor to the reductions observed in PCA mortality [13]. In addition, following the US Preventative Services Task Force (USPSTF) guidelines in 2008 and 2012, which advised against routine PSA testing for PCA—first in 2008 among men aged ≥ 75 yr and then in 2012 among men of all ages [14], a recent decline of approximately 20–30% in relative PSA testing rates has been observed from 2010 to 2013 [15,16]. Whether recent decreases in PSA testing rates have influenced current incidence trends in metastatic PCA [17] or could influence future trends remains open to debate.

There is an urgent need to accurately assess recent incidence trends of metastatic PCA, particularly by age and race/ethnicity, as disparities have not been fully characterized. Short-term forecasts could aid in quantifying the burden of metastatic cases projected over the next decade. Therefore, in this study, we assess current incidence trends of metastatic PCA by age and race/ethnicity, and forecast incidence rates and annual burden (number of new cases) of metastatic PCA in the USA through 2025, using population-based cancer surveillance data and national population projections.

2. Patients and methods

We obtained single-year PCA case counts and population estimates for men aged 45–94 yr at diagnosis from 18 of the Surveillance, Epidemiology, and End Results (SEER) registry databases (2004–2014), covering 28% of the US population [18]. In addition to the single-year population estimates available for men aged 45–84 yr in SEER, single-year race-specific population estimates for men aged 85–94 yr were obtained from intercensal (for July 1, 2000–2014) files provided by the National Center for Health Statistics and U.S. Census Bureau's Population Estimates Program.

Primary malignant prostate tumors were defined by International Classification of Diseases for Oncology, Third Edition, using topography code C619. SEER collaborative staging was used to select cases with metastatic disease at initial clinical presentation and those that were pathologically confirmed. Individuals with unknown age at diagnosis were excluded ($N = 2$), as were men whose diagnosis was based solely on autopsy or death certificates ($N = 33$).

The US Census Bureau projected population estimates for the entire USA stratified by age (single years), sex, race, and Hispanic ethnicity through 2060 [19]. These projections are based on 2013 population estimates and assumptions about future deaths, births, and net international migration. We categorized race/ethnicity as non-Hispanic white (white), non-

Hispanic black (black), non-Hispanic Asian (Asian), or all races of Hispanic ethnicity (Hispanic).

2.1. Statistical analysis

Our forecasting method applied age–period–cohort (APC) models to estimate future age- and race-specific incidence rates and 95% confidence intervals [20]. APC models enabled us to distinguish between influences that occurred in specific time periods for all age groups (period effects) versus effects associated with specific birth cohorts (generational effects) [21]. The detailed methodology for the APC models and forecasting has been described previously [22]. Future estimated incidence rates were obtained by multiplying the observed and estimated age-specific rates in a referent birth cohort by the rate ratio of each successive birth cohort to the original, fixed referent birth cohort. As each birth cohort ages into PSA-based screening ranges, the APC models are uniquely tailored to forecast race- and age-specific rates, which should reflect different screening patterns in each subgroup. Forecast rates were obtained by extrapolating the observed age-specific birth-cohort rate ratios using a joinpoint piecewise log-linear regression model [23]. The goodness of fit of underlying APC models was evaluated based on the degree of the overdispersion, normality of the residuals, and how closely fitted rates matched the observed rates.

We calculated age-standardized and age-specific incidence rates per 100 000 person years, and race-specific rate ratios to examine racial disparities by time period and age at diagnosis. We calculated annual percentage changes for the observed and forecast rates.

To compute annual burden of metastatic PCA (annual number of new cases), we summed the product of forecast age-specific incidence rates and projected age-specific population sizes [22]. We also estimated the total (cumulative) percentage change in burden from 2015 to 2025.

We examined the impact of whether the recent national declines in PSA testing following the 2012 USPSTF recommendation influenced forecasts in an alternative pre-2012 USPSTF model by restricting the observed period used for forecasting to 2004–2011, and testing for any excess in rates and burden that was observed versus expected in the 3-yr period (2012–2014) following the 2012 USPSTF recommendations.

Statistical analyses were performed in Matlab, version R2016a. All statistical tests were two sided, and $p < 0.05$ was considered statistically significant.

2.2. Sensitivity analysis

We further examined the impact of the USPSTF recommendations, and subsequent national PSA testing declines forecasts by forecasting a variation of the main model that included extrapolation of any excess in observed-to-expected rates during 2012–2014.

3. Results

For the 25 033 men aged 45–94 yr who were diagnosed with metastatic PCA from 2004 to 2014, the median age at diagnosis was 71 yr (interquartile range: 63–80). A majority of

cases were white (63.3%), were married (55.5%), and died of PCA as their underlying cause of death (65.3%; of which 31.4% died from their PCA within a year). All APC models exhibited sufficient goodness of fit with negligible overdispersion.

During the observed period from 2004 to 2014, age-standardized incidence rates of metastatic PCA gradually declined by 1.45%/yr from 2004 to 2007 and began to increase by 0.58%/yr after 2008, which accelerated to 2.74%/yr from 2012 onward (Table 1 and Fig. 1). Annual rates are presented in Supplementary Table 1. Meanwhile, rates among men aged 45–54 yr have been increasing since 2004, first only gradually and then at a more rapid pace. Rates among men aged 55–69 yr were falling prior to 2009, yet have subsequently risen swiftly. Meanwhile, rates among white men have steadily been increasing since 2009, while rates among nonwhite men have predominantly declined (Fig. 2).

Forecasts from our main model project the incidence to increase by 1.03%/yr from 2015 to 2025, cumulating in an incidence rate of 19.62/100 000 in 2025 (Fig. 1). Men aged 45–54 yr (2.29%/yr) and 55–69 yr (1.53%/yr) are forecast to increase more rapidly, while men aged 70 yr are projected to gradually increase by 0.63%/yr. The overall increase in rates is primarily driven by white men (Fig. 2).

Age group-specific trends by race/ethnicity exhibited slight variations, but overall trends were similar (Supplementary Table 2). Cross-sectional rate forecast for 2015 identified a heightened racial disparity among younger (<50 yr) men, with rates among blacks being 4.5–5 times greater than those in whites (Supplementary Fig. 1). Cohort rate ratios by race/ethnicity exhibited variation such that rates in more recent birth cohorts (relative to the 1945 referent birth cohort) were elevated in white men, lower in black men, and roughly unchanged in Asian and Hispanic men (Supplementary Fig. 2).

The absolute number of new cases of metastatic PCA (annual burden) is projected to increase by 42% over the next decade, with 10 615 cases expected in 2015 and 15 097 in 2025. Even greater relative increases are expected among Hispanics (85%) and men aged 70 yr (52%).

Our alternative model, based on 2004–2011 trends (preceding the 2012 USPSTF recommendation), forecast stable or declining rates among all subpopulations from 2012 to 2014, except among men aged 55–69 yr whose rates were still forecast to increase (Fig. 3). There was a statistically significant excess ($p < 0.0001$) in observed versus expected rates (12.1%) during 2012–2014. Forecast from our alternative model projected the incidence to gradually increase by 0.38%/yr from 2015 to 2025 (Supplementary Table 3). The cumulative (2015–2025) burden forecast from our main model ($n = 15\,097$) estimated an additional 15 891 (11.3%) cases compared with that from our alternative pre-2012 USPSTF model ($n = 13\,075$).

In a sensitivity analysis, which included extrapolation of the differences in observed-to-expected rates during 2012–2014, an even greater difference in future trends was forecast compared with our alternative model (Supplementary Fig. 3).

4. Discussion

Over the next decade, our main models project that the burden of metastatic PCA will increase considerably by 2025 and that incidence rates will steadily rise, particularly among men aged 69 yr. The black-to-white racial disparity in metastatic PCA continued to persist, with black men currently exhibiting rates two times greater than those of white men, which is heightened to almost five times greater among men younger than age 50. If trends had continued under previous patterns from 2004 to 2011, prior to the 2012 USPSTF recommendation against PCA screening, our forecasts estimated 11% fewer PCA cases diagnosed at the metastatic stage during 2015–2025 compared with forecasts from our main model. As survival for men diagnosed with metastatic PCA remains poor, any increase in metastatic disease rates are concerning, and more targeted PSA screening strategies are needed to reduce the likely upsurge in PCA mortality resulting from more men being diagnosed at a metastatic stage [24].

PSA testing remains highly controversial [25], as only recently has the USPSTF issued revised 2017 guidelines that now recommend clinicians to inform men between the ages of 55 and 69 yr about the potential benefits and harms of PSA-based screening, but that the final decision should be an individual one [26]. This is a major policy shift compared with the 2012 grade “D” recommendation advising against routine PSA testing among men of all ages due to concerns of overtreatment of indolent disease [14]. Since the 2012 recommendations, numerous studies have shown that PSA testing rates have fallen among men over 50 yr of age [15,16]. In this study, our main model forecasts steadily increasing metastatic PCA rates from 2015 to 2025. While prior studies have reported PSA screening accounting for 80% of the decline in distant stage (metastatic) PCA incidence since the early 1990s [27], it is unlikely that PSA testing is solely responsible for the reversal in metastatic PCA trends.

Recent research using the National Cancer Data Base noted that the annual incidence of metastatic PCA had increased 72% between 2007 and 2013, with a larger (92%) increase seen among men aged 55–69 yr [9]. Yet this study was based on the absolute number of new cases relative to an earlier point in time, as opposed to assessment of the incidence rate. Using SEER registry data, Jemal et al [10] reported stable rates among men with distant stage PCA from 2011 to 2013, while Hu et al [12] reported an increase in the proportion of distant metastases from 6.6% to 12.0%. In our study, we found an increasing trend in rates since 2008, which accelerated after 2012, following the 2012 USPSTF recommendations. While this stage shift to a greater proportion of metastatic/distant stage disease would require some lead time for the expected lag between any change in clinical testing and stage migration, the lag would likely be relatively short.

Prior studies that forecast overall PCA incidence from 2010 to 2020 projected stable future rates among all races, yet advanced/metastatic disease and the population effects of screening guidelines were not examined [28]. Consistent with our predictions, Gulati et al [29] were the first to forecast incidence rates of metastatic PCA under various PSA testing scenarios, and found that continuation of current screening practices results in stable forecasts through 2025, age-restricted screening (PSA testing among men 70 yr) resulted in

a 46–57% increase from 2013 to 2025, while discontinued screening more than doubled the estimated number of metastatic cases at presentation. Our results are consistent with Gulati et al's model of a continuation of current screening practices, while also assessing racial differences that highlight a likely continuation of racial disparities seen in PCA, particularly among younger men. Our data-driven model predicts a slightly more conservative future increase in metastatic PCA compared with the Gulati et al's study, as it is based on data observed through 2014—a period that includes only a brief time since the USPSTF recommendation and modest 6.8–8.4% absolute declines (20–30% relative decline) in PSA testing. The 2017 USPSTF recommendation for informed decision making regarding screening among men aged 55–69 yr further complicates any attempt to include future PSA testing assumption in PCA forecast models.

Our results are in line with the heightened black-to-white racial disparity that has previously been reported in two prior studies of metastatic and fatal PCA [30,31]. Racial disparities in the prevalence of PSA testing may partially explain the disparity, with blacks (32.9%) and Hispanics (24.3%) exhibiting lower rates based on national surveys than whites (36.5%), as of 2013 [16]. While future trends may vary, reasons for a stable future trend forecast among blacks but an increase among whites through 2025 may be explained by the higher rates in younger birth cohorts among white men.

Taking into account estimated national population changes, we found that the annual burden of metastatic PCA is expected to increase 42% by 2025, due to an aging US population and increasing incidence rates. Prior studies that forecast the future burden estimated the number of new cases of overall PCA to be expected to increase by 55% during 2010–2030 [32]. Even though our alternative pre-2012 USPSTF model found the burden to be lower compared with our main model, an overall increase was still estimated, suggesting that the number of new cases will undoubtedly increase in the future.

Assessing the incidence of metastatic PCA has advantages over studying overall PCA or PCA mortality, in that it provides for an assurance of clinically significant disease, utilization of recent observed data for accurate future forecasts, and a time scale (year of diagnosis) that is concurrent with a period of clinical change. Further strengths of this study include linkage to future national demographic population estimates that incorporates the expected changing age and population structure of the US population.

Our study has several limitations. First, all models extrapolate data from the SEER registries to national forecasts, and these registries may not completely be representatives of the entire USA. SEER utilizes an algorithm to determine Hispanic ethnicity, which may incorrectly classify some individuals. Our forecasts are susceptible to large or swift changes in PSA testing rates or risk factors, and future trends, particularly those a decade from now, in metastatic PCA could evolve differently than predicted by our models. Estimates of the excess in rates from 2012 to 2014 following the 2012 USPSTF recommendations are limited by the availability of only 3 yr of data.

5. Conclusions

This study of current and forecast incidence trends of metastatic PCA highlights the need for prevention efforts to be focused on identifying risk factors that may explain the racial disparities of metastatic PCA. Meanwhile, the downstream effects of the 2012 USPSTF recommendations may have resulted in a reversal of metastatic PCA incidence trends, as the increase in rates from 2012 to 2014 has resulted in future forecasts of rising rates over the next decade, particularly among men under 70 yr of age. It is possible that the 2017 USPSTF recommendation may, again, reverse this. As a result, the impact of the USPSTF screening recommendations on metastatic PCA requires continued examination in order for us to balance the benefits and harms of PCA screening and manage the growing clinical burden.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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References

- [1]. Siegel RL, Miller KD, Jemal A. Cancer statistics, 2017. *CA Cancer J Clin* 2016;67:7–30.
- [2]. Potosky AL, Miller BA, Albertsen PC, Kramer BS. The role of increasing detection in the rising incidence of prostate-cancer. *JAMA* 1995;273:548–52. [PubMed: 7530782]
- [3]. Etzioni R, Gulati R. Recent trends in PSA testing and prostate cancer incidence: a look at context. *JAMA Oncol* 2016;2:955–6. [PubMed: 27010657]
- [4]. Howlader N, Noone AM, Krapcho M, et al., editors. SEER Cancer Statistics Review, 1975–2013 http://seer.cancer.gov/csr/1975_2013
- [5]. James ND, Spears MR, Clarke NW, et al. Survival with newly diagnosed metastatic prostate cancer in the "docetaxel era": data from 917 patients in the control arm of the STAMPEDE trial (MRC PR08, CRUK/06/019). *Eur Urol* 2015;67:1028–38. [PubMed: 25301760]
- [6]. Wu JN, Fish KM, Evans CP, deVere White RW, Dall'Era MA. No improvement noted in overall or cause-specific survival for men presenting with metastatic prostate cancer over a 20-year period. *Cancer* 2014;120:818–23. [PubMed: 24258693]
- [7]. Welch HG, Gorski DH, Albertsen PC. Trends in metastatic breast and prostate cancer—lessons in cancer dynamics. *N Engl J Med* 2015;373:1685–7. [PubMed: 26510017]
- [8]. Van den Bergh RCN, Loeb S, Roobol MJ. Impact of early diagnosis of prostate cancer on survival outcomes. *Eur Urol Focus* 2015;1:137–46. [PubMed: 28723424]
- [9]. Weiner AB, Matulewicz RS, Eggener SE, Schaeffer EM. Increasing incidence of metastatic prostate cancer in the United States (2004–2013). *Prostate Cancer Prostatic Dis* 2016; 19:395–7. [PubMed: 27431496]

- [10]. Jemal A, Ma J, Siegel R, Fedewa S, Brawley O, Ward EM. Prostate cancer incidence rates 2 years after the US preventive services task force recommendations against screening. *JAMA Oncol* 2016;2:1657–60. [PubMed: 27541955]
- [11]. Reese AC, Wessel SR, Fisher SG, et al. Evidence of prostate cancer "reverse stage migration" toward more advanced disease at diagnosis: data from the Pennsylvania Cancer Registry. *Urol Oncol* 2016;34:335.e21–8.
- [12]. Hu JC, Nguyen P, Mao J, et al. Increase in prostate cancer distant metastases at diagnosis in the United States. *JAMA Oncol* 2017;3:705–7. [PubMed: 28033446]
- [13]. Buzzoni C, Auvinen A, Roobol MJ, et al. Metastatic prostate cancer incidence and prostate-specific antigen testing: new insights from the European Randomized Study of Screening for Prostate Cancer. *EurUrol* 2015;68:885–90.
- [14]. Moyer VA, Force UPST. Screening for prostate cancer: US Preventive Services Task Force recommendation statement. *Ann Intern Med* 2012;157:120–34. [PubMed: 22801674]
- [15]. Drazer MW, Huo DZ, Eggen SE. National prostate cancer screening rates after the 2012 US Preventive Services Task Force recommendation discouraging prostate-specific antigen-based screening. *J Clin Oncol* 2015;33:2416–23. [PubMed: 26056181]
- [16]. Smith RA, Andrews K, Brooks D, et al. Cancer screening in the United States, 2016: a review of current American Cancer Society guidelines and current issues in cancer screening. *CA Cancer J Clin* 2016;66:96–114. [PubMed: 26797525]
- [17]. Fleshner K, Carlsson SV, Roobol MJ. The effect of the USPSTF PSA screening recommendation on prostate cancer incidence patterns in the USA. *Nat Rev Urol* 2017; 14:26–37. [PubMed: 27995937]
- [18]. National Cancer Institute. Surveillance, Epidemiology, and End Results (SEER) Program Surveillance, Epidemiology, and End Results (SEER) database: Incidence—SEER 18 Regs Research Data + Hurricane Katrina Impacted Louisiana Cases, Nov 2015 Sub (2000–2014). 4 2017 ed. <http://www.seer.cancer.gov>
- [19]. United States Census Bureau. 2014 National population projections. <http://www.census.gov/population/projections/data/national/2014.html>
- [20]. Rosenberg PS, Anderson WF. Proportional hazards models and age–period–cohort analysis of cancer rates. *Stat Med* 2010;29:1228–38. [PubMed: 20209480]
- [21]. Holford TR. The estimation of age, period and cohort effects for vital-rates. *Biometrics* 1983;39:311–24. [PubMed: 6626659]
- [22]. Rosenberg PS, Barker KA, Anderson WF. Estrogen receptor status and the future burden of invasive and in situ breast cancers in the United States. *J Natl Cancer Inst* 2015;107:djv159.
- [23]. Kim HJ, Fay MP, Feuer EJ, Midthune DN. Permutation tests for joinpoint regression with applications to cancer rates. *Stat Med* 2000; 19:335–51. [PubMed: 10649300]
- [24]. Downer MK, Stampfer MJ, Cooperberg MR. Declining incidence rates of prostate cancer in the United States: is this good news or not? *JAMA Oncol*. In press. 10.1001/jamaoncol.2017.0470
- [25]. Eapen RS, Herlemann A, Washington SL, Cooperberg MR. Impact of the United States Preventive Services Task Force 'O' recommendation on prostate cancer screening and staging. *Curr Opin Urol* 2017;27:205–9. [PubMed: 28221220]
- [26]. Bibbins-Domingo K, Grossman DC, Curry SJ. The US Preventive Services Task Force 2017 draft recommendation statement on screening for prostate cancer. *JAMA* 2017;317:1949–50. [PubMed: 28397958]
- [27]. Etzioni R, Gulati R, Falcon S, Penson DF. Impact of PSA screening on the incidence of advanced stage prostate cancer in the United States: a surveillance modeling approach. *Med Decis Making* 2008;28:323–31. [PubMed: 18319508]
- [28]. Weir HK, Thompson TD, Soman A, Moller B, Leadbetter S. The past, present, and future of cancer incidence in the United States: 1975 through 2020. *Cancer* 2015;121:1827–37. [PubMed: 25649671]
- [29]. Gulati R, Tsodikov A, Etzioni R, et al. Expected population impacts of discontinued prostate-specific antigen screening. *Cancer* 2014;120:3519–26. [PubMed: 25065910]
- [30]. Kelly SP, Rosenberg PS, Anderson WF, et al. Trends in the incidence of fatal prostate cancer in the United States by race. *Eur Urol* 2017;71:195–201. [PubMed: 27476048]

- [31]. 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]
- [32]. Smith BD, Smith GL, Hurria A, Hortobagyi GN, Buchholz TA. Future of cancer incidence in the United States: burdens upon an aging, changing nation. *J Clin Oncol* 2009;27:2758–65. [PubMed: 19403886]

Fig. 1 –.

Observed (2004–2014) and forecast (2015–2025) incidence rates of metastatic PCA by age group and age-specific annual percentage changes in observed and forecast rates. (A) Observed (2004–2014) and forecast (2015–2025) age-standardized incidence rates of metastatic PCA in SEER 18 overall and by age group. Vertical reference line separates observed from forecast period. (B) Annual percentage changes in observed rates of metastatic PCA from 2004 to 2014. (C) Annual percentage changes in forecast rates of metastatic PCA from 2015 to 2025. PCA = metastatic prostate cancer; SEER = Surveillance, Epidemiology, and End Results.

Fig. 2 –.

Observed (2004–2014) and forecast (2015–2025) incidence rates of metastatic PCA, using SEER 18, by racial/ethnic group and race-specific rate ratios by calendar year of diagnosis. (A) Observed (2000–2014) and forecast (2015–2025) incidence rates of metastatic PCA in SEER 18 by racial/ethnic group. (B) Black-to-white incidence rate ratios of metastatic PCA in both observed (2000–2014) and forecast (2015–2025) time periods. (C) Asian-to-white incidence rate ratios of metastatic PCA in both observed (2000–2014) and forecast (2015–2025) time periods. (D) Hispanic-to-white incidence rate ratios of metastatic PCA in both observed (2000–2014) and forecast (2015–2025) time periods. Shaded bands show 95% confidence limits. Vertical reference line separates observed from forecast period. Blue squares indicate white men; red diamonds, black men; green circles, Hispanic men; and yellow inverted triangles, Asian men. PCA = metastatic prostate cancer; SEER = Surveillance, Epidemiology, and End Results.

Fig. 3 –.

Forecasts of metastatic PCA incidence rates pre (2012–2025) and post (2015–2025) the 2012 USPSTF PCA screening recommendations, overall and by age group. (A) Age-standardized incidence rates of metastatic PCA, forecast of pre and post the 2012 USPSTF PCA screening recommendations. (B) Age group–specific incidence rates of metastatic PCA, forecast of pre and post the 2012 USPSTF PCA screening recommendations. Solid lines indicate the main model (from 2015 forward): incidence rates during the observed period of 2004–2014 and forecasts from 2015 to 2025. Dashed lines indicate the alternative model (from 2012 onward): incidence rates restricted to the observed period prior to the 2012 final PCA screening recommendations (2004–2011) and forecasts from 2012 to 2025. Shaded bands show 95% confidence limits. PCA = metastatic prostate cancer; USPSTF = United States Preventive Services Task Force.

Table 1 –

Metastatic prostate cancer incidence rates (per 100 000 person years) and annual burden through 2025 by age group and race

Observed				Forecast											
2004	2014	2004–2007	2008–2011	2012–2014	2004–2014	2020	Rate	No.	Rate	No.	2025	Rate	Burden	% change	2015–2025
Subgroup	Rate	EAPC	EAPC	EAPC	EAPC	No.	Rate	No.	Rate	No.	Rate	Rate	Burden	EAPC	
All cases	17.92	18.60	–1.45%/yr (–2.68, –0.21)	0.58%/yr (–1.09, 2.29)	2.74%/yr (2.64, 2.83)	–0.03%/yr (–0.61, 0.63)	12 668	18.48	15 097	19.62	42.2%		1.03%/yr (0.63, 1.44)		
Race/ethnicity															
White	15.48	17.34	–1.11%/yr (–2.20, –0.02)	2.18%/yr (–0.22, 4.66)	4.07%/yr (1.72, 6.48)	0.58%/yr (–0.44, 1.62)	8756	17.23	10 281	18.36	38.5%		1.29%/yr (1.21, 1.38)		
Black	42.37	38.31	–1.77%/yr (–3.96, 0.47)	–2.47%/yr (–2.97, –1.96)	2.09%/yr (–0.26, 4.51)	–1.75%/yr (–2.38, –1.13)	2325	36.31	2636	36.24	31.4%		–0.29%/yr (–0.51, –0.08)		
Hispanic	24.79	18.93	–6.35%/yr (–11.56, –0.84)	–2.35%/yr (–3.85, –0.83)	–0.95%/yr (–6.88, 5.35)	–2.14%/yr (–3.62, –0.64)	1309	18.09	1811	19.14	85.2%		0.41%/yr (0.10, 0.72)		
Asian	14.30	11.17	0.99%/yr (–1.97, 4.05)	–6.12%/yr (–11.81, –0.06)	–6.68%/yr (–6.95, –6.42)	–3.17%/yr (–4.60, –1.71)	321	9.93	359	9.01	25.1%		–2.13%/yr (–2.31, –1.96)		
Age group (yr)															
45–54	2.42	2.87	0.50%/yr (–0.47, 1.49)	2.12%/yr (1.24, 3.01)	2.70%/yr (1.53, 3.89)	1.54%/yr (1.13, 1.91)	614	2.91	709	3.39	12.2%		2.29%/yr (1.73, 1.85)		
55–69	14.70	16.73	–0.80%/yr (–1.63, 0.03)	1.53%/yr (0.07, 3.02)	4.40%/yr (3.93, 4.87)	0.98%/yr (–0.32, 1.55)	5218	17.38	5856	18.71	33.6%		1.53%/yr (1.25, 1.82)		
70	44.86	44.09	–1.90%/yr (–3.33, –0.44)	0.01%/yr (–1.85, 1.90)	1.94%/yr (1.90, 1.97)	–0.61%/yr (–1.12, –0.06)	6835	42.70	8531	44.60	52.4%		0.63%/yr (0.28, 0.98)		

EAPC = estimated annual percentage change in rates; SEER = Surveillance, Epidemiology, and End Results.

Rates are per 100 000 person years. The combined sum of the burden among all races may not add up to the total burden among all cases, as statistics for Alaskan natives, native Americans, and other race/ethnicities are not included as race-specific categories. The annual burden (numbers of cases) during the observed period is not provided, as these numbers are based on SEER data and not extrapolated to the entire US population.