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Original Article

Race-insurance disparities in prostate patients' magnetic resonance imaging biopsies and their subsequent cancer care: a New York State cohort study

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Abstract: For organ-confined prostate cancer, socioeconomic factors influencing Magnetic Resonance Imaging (MRI)-guided biopsy utilization and downstream prostate cancer patients' care are unknown. This retrospective, observational cohort study used the New York Statewide Planning and Research Cooperative System (SPARCS) billing-code driven database to examine the impact of prostate patients' socioeconomic characteristics on prostate cancer care defined as initial biopsy, 2-month post-biopsy cancer diagnoses, and within 1-year cancer-related intervention, controlling for other risk factors. From 2011-2017, the population studied (n = 18,253) included all New York State-based, male, residents aged 18 to 75 without a prior prostatectomy receiving a first-time biopsy; 760 such patient records in 2016 were removed due to data quality concerns. Major exposures included patient age, race, ethnicity and insurance. The major outcome included receipt of MRI biopsy versus standard biopsy and for these sub-populations, subsequent 2-month post-biopsy metastatic versus non-metastatic prostate cancer diagnosis and within 1-year prostate cancer treatment (prostatectomy with or without radiation versus prostatectomy-only) were compared using dichotomous (primary) and time-to-event (secondary) endpoints. Of 17,493 patients with a first-time prostate biopsy, 3.89% had MRI guided biopsies; of the 17,128 patients with no pre-biopsy cancer diagnosis, the subsequent prostate cancer diagnosis rate was 42.59%. For 6,754 non-metastatic prostate cancer patients with 1-year follow-up, 1,674 (24.79%) received surgery (with or without radiation) and 495 (7.33%) received radiation-only. Holding other factors constant, multivariable regression models identified that race-insurance was a primary predictor of MRI-guided biopsy use. Compared to commercially insured White patients, Black patients across all insurance categories received MRI-guided biopsies less frequently; Commercially insured and self-pay Black patients also had increased chance of prostate cancer diagnosis. Across all insurers, Black patients had lower likelihood of prostatectomies. In contrast, Black and White patients with government insurance were more likely to have within 1-year radiation-only treatments versus commercially insured White patients. Thus, across the prostate cancer care continuum, race-insurance affected prostate cancer-related service utilization. Future research should evaluate the generalizability of these New York State findings.

Keywords: Prostate cancer, prostate MRI, prostate biopsy, health disparities, race, insurance, New York

Introduction

Although MRI-guided biopsies have greatly improved traditional prostate cancer diagnosis [1], the variability in MRI-guided biopsy utilization has not been evaluated across socioeconomic status (SES) patient subgroups. In previous MRI vs. non-MRI guided biopsies comparisons, it is known that MRI guidance has increases detection rates for clinically significant cancers [2], improved risk-assessment for confirmatory biopsies [3], enhanced prediction of Gleason Scores when upgrading from biopsy to radical prostatectomy [4] and reduced overdiagnosis [5].

Unfortunately, pre-biopsy MRIs are expensive. Using a private insurance database, the MRI-guided biopsy median cost ($4,396) was more than twice the standard TRUS-only biopsy cost

($1,869); imaging being the major driver of the expense [6]. Despite higher costs, prostate MRI-guided biopsies have been recommended given substantial diagnostic benefits. The American Urological Association (AUA) guidelines state that "... current evidence now supports its [MRI-guided biopsy's] use in men at risk of harboring prostate cancer who have not undergone a previous biopsy" [7].

Despite these AUA clinical guidelines, insurance coverage has varied widely for MRI-guided prostate cancer biopsies. A recent insurance provider survey reported that only 9 out of 81 (11.1%) private payors provided coverage for a prostate MRI without a prior biopsy [8]. In metropolitan areas, private insurance had substantial geographic variability in MRI-guided biopsy utilization. Additionally, payor-specific insurance-related coverage barriers for novel MRI-based biopsy techniques were previously reported [9].

The impact of patients' socioeconomic status [SES] and related patient characteristics upon MRI-guided prostate biopsy use and post-biopsy prostate cancer care has not yet been studied. Although differential center-based rates for MRI-guided versus traditional biopsy rates have been previously published [10], these studies did not evaluate for any SES-related interactions with insurance (i.e., a race and insurance interaction effect). Thus, for a diverse prostate patient population, a current gap in knowledge exists as to whether there are SES-related effects of MRI-guided versus standard prostate biopsy on differential prostate cancer diagnosis and subsequent treatment. To-date, the only publication analyzing race-only differences have been done in a single-center [11]. Evaluating for health disparities, this multi-center study examined the factors impacting prostate patients' utilization of guideline-recommended prostate cancer care.

Methods

Design

This retrospective cohort study utilized the New York Statewide Planning and Research Cooperative System (SPARCS) de-identified database to assess for SES variations in prostate MRI-guided biopsy use. SES differences in post-biopsy prostate cancer diagnoses and treatments were evaluated by biopsy type. After holding other risk factors such as patient comorbidities constant, this study's hypotheses evaluated for age, race, ethnicity, or insurance disparities in: (1) initial prostate biopsy as classified by either MRI-guided versus non-MRI, standard TRUS biopsy; (2) post-biopsy prostate cancer diagnosis classified as non-metastatic versus metastatic prostate cancer; and (3) post-diagnosis subsequent prostate cancer treatment (classified by radiation and/or surgical interventions). The study specifically evaluated race-insurance disparities for prostate cancer patients for the following pre-established hypotheses:

- $H(0)_1$: For adult patients <75 years old who received an initial MRI-Guided biopsy vs. a non-MRI guided biopsy in the state of NY between 2010-2017, there will be no difference in patient risk characteristics as defined by age, race/ethnicity, source of payment, or Elixhauser Comorbidity Scores/components; additionally, there is no disparity in race-insurance subgroups in the use of MRI-guided biopsies after controlling for possible confounding factors including age, ethnicity, or Elixhauser Comorbidity Scores/components.

- $H(0)_2$: For adult patients <75 years old who received an initial MRI-Guided biopsy vs. a non-MRI guided biopsy in the state of NY between 2010-2017, there will be no difference in initial diagnosis of non-metastatic prostate cancer within 2 months of initial biopsy adjusting for age, race/ethnicity, source of payment, or Elixhauser Comorbidity Scores/components; additionally, variable interactions (e.g. race-insurance) with subsequent diagnosis of non-metastatic prostate cancer will be evaluated while holding other characteristics constant.

- $H(0)_3$: For non-metastatic prostate cancer patients <75 years old in the state of NY between 2010-2018 who received a diagnostic MRI-Guided biopsy vs. a non-MRI guided biopsy, there will be no difference in initial surgery and/or radiation within 1-year of initial biopsy adjusting for age, race/ethnicity, source of payment, or Elixhauser Comorbidity Scores/components; additionally, variable interactions (e.g. race-insurance) with subsequent, within 1-year prostate cancer treatments will be evaluated while holding other characteristics constant.

This study's protocol is available online at: https://commons.library.stonybrook.edu/dou-articles/1/.

Population

From January 2011 to December 2017, the study included New York State adult (age ≥18 years) receiving first-time prostate cancer care; these generally included male, NY state residents with no prior prostate cancer diagnosis or treatment history, surviving their initial prostate biopsy encounter. Exclusion criteria were based upon AUA prostate cancer screening guideline recommendations (patients aged >75 were excluded) and non-NY state residents (due to potential loss to follow-up). When NYS SPARCS reporting transitions occurred in 2016, reporting abnormalities were identified and due to data completeness concerns, 2016 SPARCS biopsy records were excluded (**Appendix B**). Additionally, SPARCS records with unknown or missing SES variables were excluded (**Figure 1**).

Using literature-based definitions, patient records that had a prostate MRI within 3-months prior to their initial biopsy were identified as "MRI-guided biopsies". SPARCS data elements combined with billing codes (e.g., ICD-9, ICD-10, and CPT codes) were used to identify patients' risk-factors, diagnoses, treatments, and outcomes (**Appendix A**). Comparing patients with an initial prostate MRI-guided versus non-MRI guided biopsy, these patients' risks characteristics included age, Elixhauser Comorbidity Index Score [12] and sub-components, ethnicity, race, insurance coverage, morbid obesity, smoking/tobacco, family prostate cancer history, and history of irradiation treatments (**Table 1**). As SPARCS included New York State-only encounters, New York residents may have traveled to another state (e.g., Massachusetts General's Cancer Center) for their post-biopsy prostate cancer care. To avoid any loss-to-follow-up, newly diagnosed prostate cancer patients without any post-biopsy follow-up encounters were excluded (n = 372).

Intervention and endpoints

The intervention studied was the use of MRI-guided versus non-MRI-guided prostate biopsy. For these two patient cohorts, the primary outcome evaluated was the prostate cancer metastatic and non-metastatic diagnosis rates within 2-months post-biopsy which was defined dichotomously (presence/absence of cancer). Secondary outcomes included 1-year post-biopsy intervention rates sub-classified by radiation therapy with or without surgery for non-metastatic cancer patients. Within the first post-biopsy year, these endpoints were evaluated dichotomously (presence/absence of treatment) and as time-to-first-event endpoints (e.g., time to first treatment or censored at last SPARCS follow-up date if without treatment); these endpoints were compared between biopsy sub-types.

Statistical analysis

To evaluate the potential risk factors associated with MRI-guided biopsy utilization, Monte Carlo simulation Chi-square tests with exact *P*-values were used for categorical variables and Wilcoxon rank sum tests were used for continuous variables [13]. Bivariate screening identified eligible risk factors for multivariable modeling ($P \leq 0.01$) [14]. For dichotomous endpoints, multivariable logistic regression models identified the impact of MRI-guided biopsy holding other risk factors constant [13]. For endpoints with more than two categories, multivariable multinomial logistic regression investigated the impact of MRI-guided biopsy.

Protocol-driven significance levels for model-eligible variables was conservatively pre-established at $P<0.01$; however, all *P*-values are reported to facilitate independent interpretations. Each multivariable logistic regression model's variable specific odds ratios are reported with 99% confidence intervals listed in **Figures 2-4**. Complete modeling results are presented in the online-only **Appendix E**. Statistical analyses were performed using SAS 9.4 (SAS Institute Inc., Cary, NC).

For time-to-event endpoints, Fine-Gray models evaluated for the MRI-guided biopsy impact as a cause-specific prognostic factor; cumulative incidence functions (CIFs) described time-to-event endpoints with death as a competing risk event [15].

To rank order each risk factor's relative importance, C-index comparisons were used; for these comparisons, explanatory variables were removed one-at-a-time to build a set of endpoint-specific comparison models. As a com-

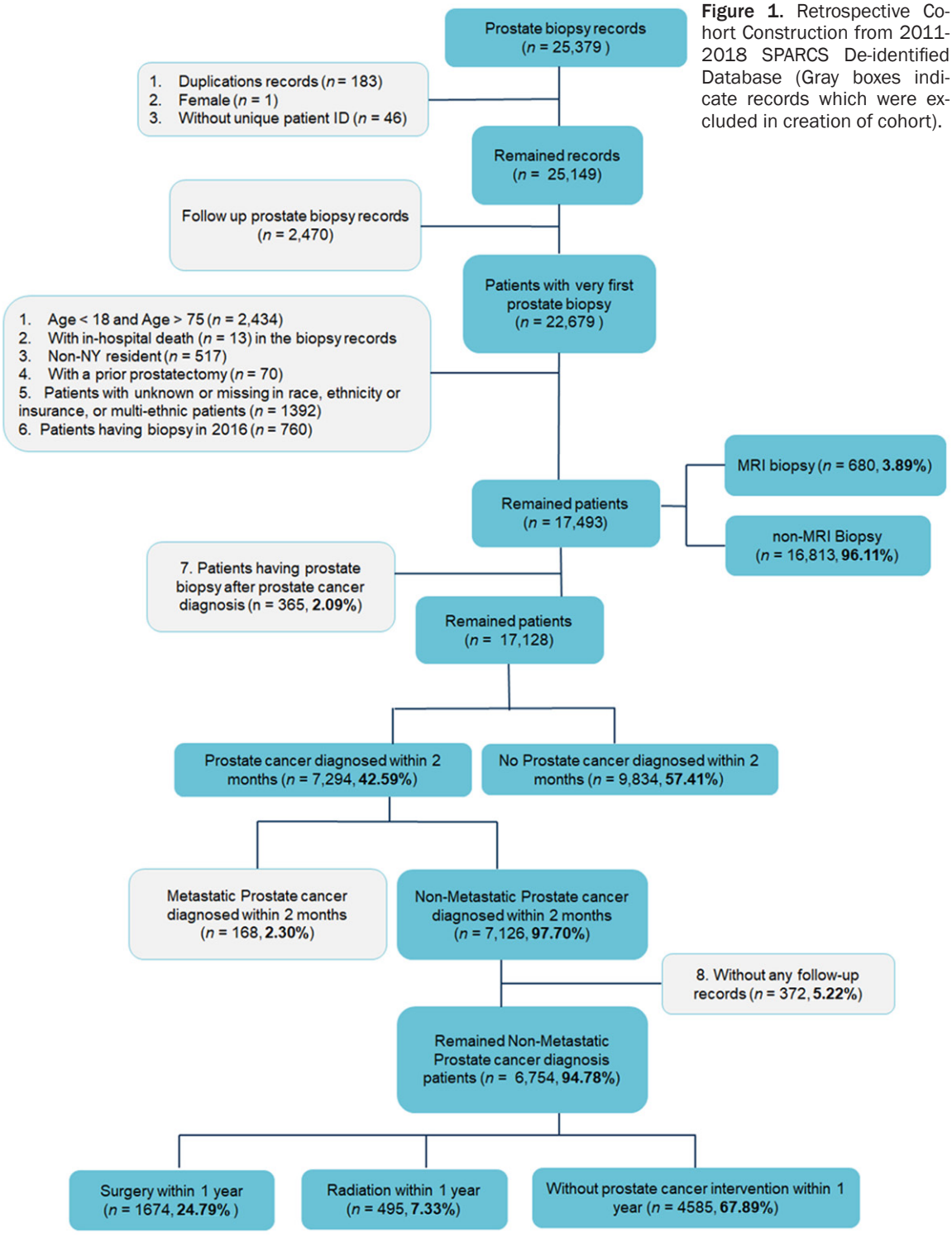

Figure 1. Retrospective Cohort Construction from 2011-2018 SPARCS De-identified Database (Gray boxes indicate records which were excluded in creation of cohort).

monly reported multivariable model-based performance metric, the c-index calculates the area under the "receiver operating characteristic curve". As a model's predictive power improves, the c-index becomes closer to the value of 1.0. To investigate SES interactions, the multivariable models' predictive power using the two race and insurance variables separately versus a combined race-insurance variable were compared using c-index com-

Table 1. Descriptive table of patients' characteristics, risk factors, comorbidity score, and index of comorbidities by initial biopsy type

Variable	Level	Total (N = 17493)	MRI Biopsy (N = 680)	Non-MRI Biopsy (N = 16813)	*P*-value*
Patients' characteristics at the time of Initial Prostate Biopsy					
Age		63.00±10.00	65.00±9.50	63.00±10.00	<.0001
Age Categories	18 to 54	2420 (13.83%)	67 (2.77%)	2353 (97.23%)	<.0001
	55 to 64	7369 (42.13%)	241 (3.27%)	7128 (96.73%)	
	65 to 75	7704 (44.04%)	372 (4.83%)	7332 (95.17%)	
Race	Black	4832 (27.62%)	75 (1.55%)	4757 (98.45%)	<.0001
	Other	4193 (23.97%)	125 (2.98%)	4068 (97.02%)	
	White	8468 (48.41%)	480 (5.67%)	7988 (94.33%)	
Ethnicity	Hispanics	1988 (11.36%)	35 (1.76%)	1953 (98.24%)	<.0001
	Non-Hispanics	15505 (88.64%)	645 (4.16%)	14860 (95.84%)	
Insurance	Commercial	8633 (49.35%)	360 (4.17%)	8273 (95.83%)	<.0001
	Government	7193 (41.12%)	302 (4.20%)	6891 (95.80%)	
	No Payment	1667 (9.53%)	18 (1.08%)	1649 (98.92%)	
Risk factors at the time of Initial Prostate Biopsy					
Smoking/Tobacco	No	16126 (92.19%)	651 (4.04%)	15475 (95.96%)	0.0004
	Yes	1367 (7.81%)	29 (2.12%)	1338 (97.88%)	
Morbid Obesity	No	17140 (97.98%)	673 (3.93%)	16467 (96.07%)	0.0615
	Yes	353 (2.02%)	7 (1.98%)	346 (98.02%)	
Family History of Prostate Cancer	No	17470 (99.87%)	680 (3.89%)	16790 (96.11%)	0.2340
	Yes	23 (0.13%)	0 (0.00%)	23 (100.00%)	0.2606
Personal History of Irradiation	No	17470 (99.87%)	680 (3.89%)	16790 (96.11%)	0.6214
	Yes	23 (0.13%)	0 (0.00%)	23 (100.00%)	
Elixhauser Score		0.00±0.00	0.00±0.00	0.00±0.00	0.2606
Significant Elixhauser Comorbidities Sub-Components at the time of Initial Prostate Biopsy					
Hypertension, uncomplicated		3316 (18.96%)	45 (1.36%)	3271 (98.64%)	<.0001
Hypertension, complicated		226 (1.29%)	1 (0.44%)	225 (99.56%)	0.0080
Chronic pulmonary disease		568 (3.25%)	6 (1.06%)	562 (98.94%)	0.0004
Diabetes w/o chronic complications		1066 (6.09%)	11 (1.03%)	1055 (98.97%)	<.0001
Renal failure		278 (1.59%)	2 (0.72%)	276 (99.28%)	0.0074
Solid tumor w/out metastasis		1016 (5.81%)	55 (5.41%)	961 (94.59%)	0.0095
Alcohol abuse		600 (3.43%)	8 (1.33%)	592 (98.67%)	0.0010

*For categorical variables, *P*-values were based on Chi-squared test with exact *P*-value from Monte Carlo simulation; for continuous variable, *P*-value was based on Wilcoxon rank sum test. Note: For continuous variable, median ± IQR were reported.

parisons [16-18]; final combined race-insurance groupings were selected to optimize the model's predictive power.

Human subjects research ethics and evidence-based medicine standards

As summary SPARCS reports only were received, this project (IRB2020-00534: SPARCS Prostate Cancer Care, Dr. Shroyer-Principal Investigator) was classified by the Stony Brook University's Committee on Human Subjects Research (CORIHS) office to be "not human subjects research" under the Common Rule or FDA regulations on November 19, 2020. As the evidence-based medicine standard for observational studies, this research was designed per STROBE requirements [19] (**Appendix D**).

Results

Intervention: MRI-guided biopsy

From January 2011 to December 2017, a total of 17,493 patient records were stratified into MRI-guided (3.9%; n = 680) vs. non-MRI (96.1%; n = 16,813) biopsy subpopulations.

Ranked Explanatory Patient Factors	OR (99% CI)	C-Index
1. Race-Insurance Groupings		0.6522
Black-Commercial vs. White-Commercial	0.34 (0.22-0.25)	
Black-Government vs. White-Commercial	0.21 (0.12-0.35)	
Black-No Pay vs. White-Commercial	0.10 (0.03-0.31)	
Other-Commercial vs. White-Commercial	0.63 (0.43-0.91)	
Other-Government vs. White-Commercial	0.55 (0.35-0.86)	
Other-No Pay vs. White-Commercial	0.33 (0.14-0.77)	
White-Government vs. White-Commercial	1.01 (0.77-1.32)	
White-No Pay vs. White-Commercial	0.18 (0.04-0.82)	
2. Uncomplicated Hypertension	0.33 (0.22-0.51)	0.7021
3. Age	1.3 (1.1-1.54)	0.7099
4. Ethnicity	0.48 (0.3-0.78)	0.7125
5. Solid Tumor without Metastasis	1.68 (1.15-2.46)	0.7132

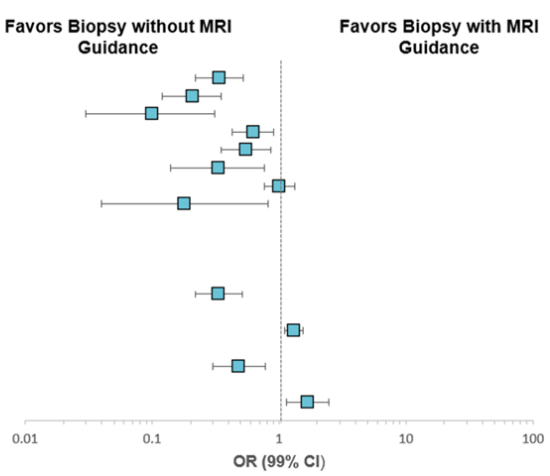

Figure 2. Top factors associated with MRI-Guidance for initial prostate biopsy. Note: This figure only presents the top factors identified. To review this final model's complete listing of predictive variables, please see **Appendix Table E1**.

Ranked Explanatory Patient Factors	OR (99% CI)	C-Index
1. Elixhauser Comorbidity Score	1.08 (1.06-1.10)	0.5804
2. Race-Insurance Groupings		0.5839
Black-Commercial vs. White-Commercial	1.32 (1.15-1.51)	
Black-Government vs. White-Commercial	1.15 (0.99-1.34)	
Black-No Pay vs. White-Commercial	1.72 (1.39-2.12)	
Other-Commercial vs. White-Commercial	0.77 (0.66-0.90)	
Other-Government vs. White-Commercial	0.81 (0.68-0.96)	
Other-No Pay vs. White-Commercial	0.68 (0.53-0.86)	
White-Government vs. White-Commercial	0.98 (0.86-1.11)	
White-No Pay vs. White-Commercial	0.79 (0.57-1.09)	
3. Age	1.30 (1.22-1.38)	0.5862
4. Smoking/Tobacco Use	1.18 (1.01-1.39)	0.5974
5. Prostate Biopsy Type (MRI vs. No-MRI Guidance)	1.35 (1.10-1.66)	0.5975

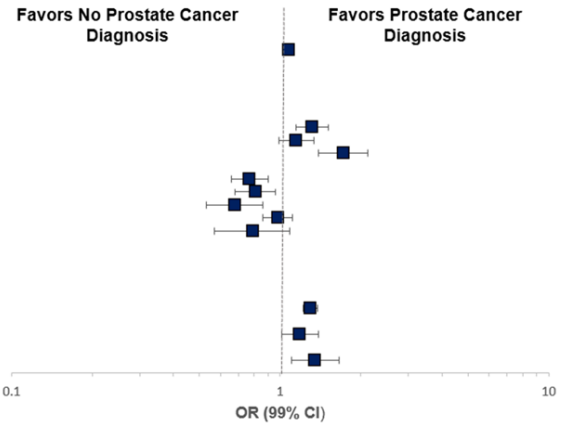

Figure 3. Top factors associated with prostate cancer diagnosis within 2-months of initial prostate biopsy. Note: This figure only presents the top factors identified. To review this final model's complete listing of predictive variables, please see **Appendix Table E2**.

Based on bivariate comparisons, factors associated with MRI-guided prostate biopsy utilization included: age, race, ethnicity, insurance, race-insurance combinations, and smoking/tobacco use; all P≤0.01. Although the Elixhauser Comorbidity Score was not significant (P = 0.2606), several Elixhauser variable's sub-components had documented MRI-guided biopsy associations (**Table 1**).

Using a multivariable regression model (**Figure 2**), the combined race-insurance variable was identified as the most important predictor of MRI-based biopsy. Compared to White commercially insured patients, Black and Other races (defined as non-White, non-Black patients) with self-pay, commercial insurance, or government insurance had a lower chance of using MRI-guided biopsies. Other top predictors of MRI-guided biopsy use included age (by decile), ethnicity (Hispanic vs. non-Hispanic), and selected Elixhauser comorbidities (hypertension with or without complications and solid tumor without metastasis). Older patients had greater odds of receiving MRI-guided biopsies vs. younger patients, while Hispanics were less likely than non-Hispanics to receive MRI-guidance. All variable-specific odds ratio (OR) details with 99% confidence intervals and *P*-values have been reported in **Figure 2**.

Ranked Explanatory Patient Factors	OR (99% CI) Radiation vs. No Treatment	OR (99% CI) Surgery vs. No Treatment	C-Index
1. Race-Insurance Groupings			0.5166
Black-Commercial vs. White-Commercial	1.08 (0.67-1.75)	0.63 (0.49-0.81)	
Black-Government vs. White-Commercial	1.66 (1.08-2.25)	0.47 (0.35-0.63)	
Black-No Pay vs. White-Commercial	0.97 (0.50-1.90)	0.66 (0.47-0.94)	
Other-Commercial vs. White-Commercial	0.98 (0.56-1.72)	0.75 (0.57-0.98)	
Other-Government vs. White-Commercial	1.21 (0.73-2.01)	0.52 (0.37-0.72)	
Other-No Pay vs. White-Commercial	0.76 (0.28-2.03)	0.58 (0.36-0.93)	
White-Government vs. White-Commercial	1.63 (1.11-2.41)	0.97 (0.77-1.21)	
White-No Pay vs. White-Commercial	0.39 (0.06-2.52)	0.91 (0.51-1.63)	
2. Age	1.34 (1.08-1.66)	0.61 (0.54-0.68)	0.5284
3. Prostate Biopsy Type (MRI vs. No-MRI Guidance)	2.11 (1.32-3.38)	1.17 (0.82-1.67)	0.5294
4. Elixhauser Comorbidity Score	1.07 (1.02-1.12)	0.96 (0.93-1.00)	0.5339

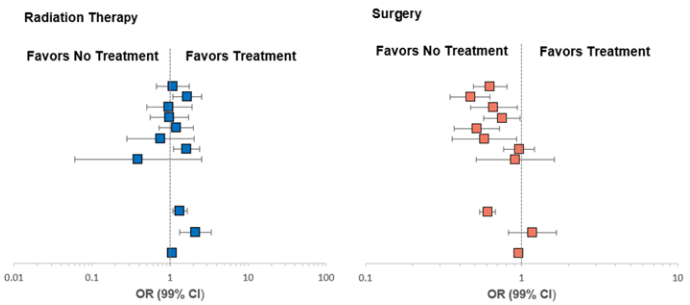

Figure 4. Top factors associated with prostate cancer intervention within1-year of initial prostate biopsy. Note: This figure only presents the top factors identified. To review this final model's complete listing of predictive variables, please see **Appendix Table E3**.

Primary endpoint: post-biopsy 2-month prostate cancer diagnosis

Based on univariate comparisons, all variables of interest (prostate biopsy type, age, ethnicity, race, insurance, race-insurance, Elixhauser scores and smoking/tobacco) were significantly associated with 2-month, post-biopsy non-metastatic prostate cancer diagnosis (P<0.001) (**Figure 3**); these were included as multivariable model-eligible variables.

In the multivariable model, MRI-guided prostate biopsy patients were more likely than non-MRI guidance prostate biopsy patients to receive a prostate cancer diagnosis. Based on C-index comparisons, Elixhauser score was the top predictor; patients with higher Elixhauser scores were more likely to be diagnosed with non-metastatic prostate cancer within 2-months of initial biopsy. Race-insurance was also an important, top predictor; Black-self pay, and Black-commercially insured patients had an increased probability of 2-month, post-biopsy, prostate cancer diagnosis compared to White, commercially insured patients. Other race patients with self-pay, government insurance, or commercial insurance were less likely to have 2-month post-biopsy prostate cancer diagnosis as compared to White, commercially insured patients. Other top predictors included older age (deciles) and smoking/tobacco use. All variable-specific odds ratio (OR) details with 99% confidence intervals and *P*-values have been reported in **Figure 3**.

Secondary endpoint: post-biopsy initial treatment within 1-year

Among the examined variables, seven (age, race, insurance, race-insurance, MRI-guided prostate biopsy type, Elixhauser score and family history of prostate cancer) were univariate significant predictors (P<0.005) of initial prostate cancer intervention as defined by surgery and/or radiation within 1-year of initial prostate biopsy. Given that race-insurance categories consistently had better model performance as compared to race and insurance categories separately, this interaction variable was selected for multivariable modeling to predict 1-year prostate cancer interventions, along with the other four variables meeting the pre-established multivariable modeling screening criteria.

Among patients diagnosed with non-metastatic prostate cancer, intervention was stratified by type (radiation vs. surgery), where patients having prostate cancer surgery with or without radiation treatment were classified in the surgery category. The top-ranked predictor for 1-year intervention was race-insurance. Differences across race-insurance groupings for intervention were most dramatic when comparing prostate cancer surgery (with or without radiation treatment) and radiation-only treatment to patients that received neither intervention. Across all three insurance categories (commercial, government, and self-pay), both Black patients and other race patients were

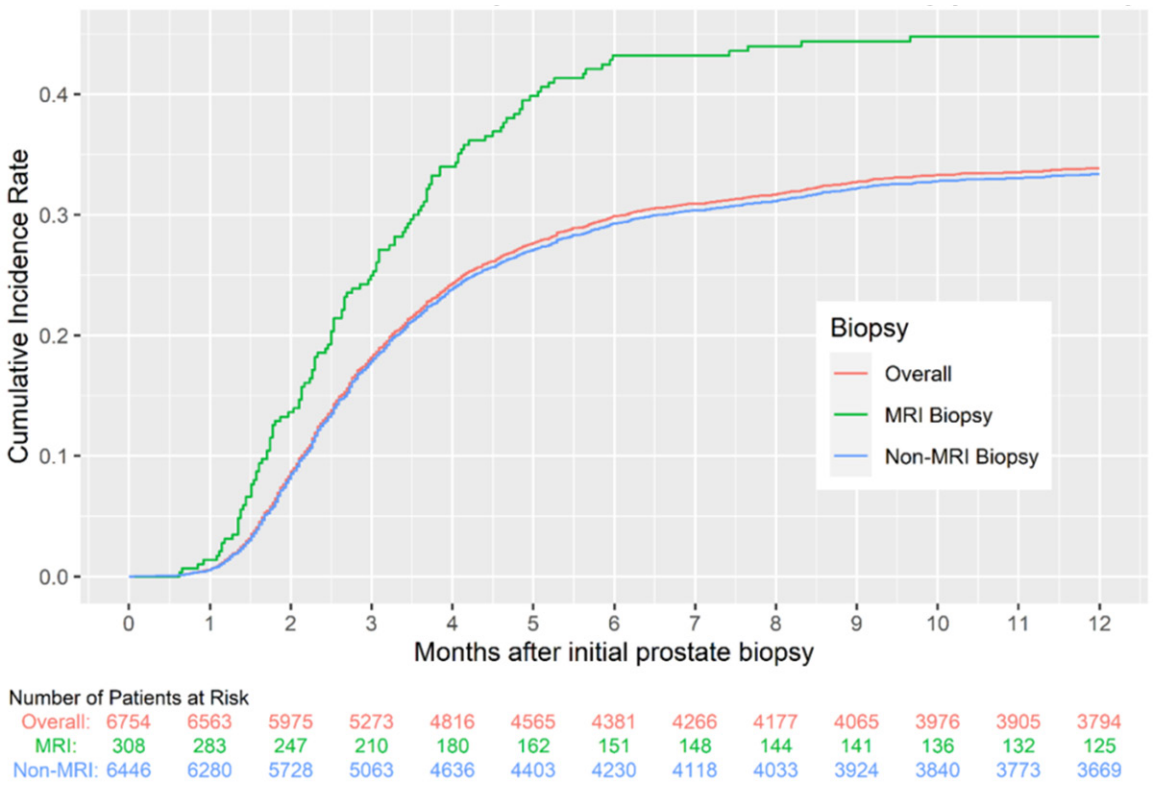

Figure 5. Cumulative incidence of initial prostate cancer intervention by prostate biopsy type.

less likely to receive prostate cancer surgery compared to White-commercially insured patients. White patients who were governmentally insured or had no insurance were as likely as White, commercially insured patients to receive prostate cancer surgery (**Figure 4**).

In contrast to 1-year post-biopsy surgery findings (i.e., for surgical patients with or without radiation therapy), these same race-insurance categories did not predict post-biopsy 1-year radiation-only treatment. For radiation-only treatment, Black or White patients with government insurance were more likely to receive radiation-only treatment compared to White-commercially insured patients. Older patients (by age decile) were also more likely to receive radiation-only treatment vs. no intervention and less likely to receive surgical treatment (with or without radiation) vs. no intervention. Hence, patient age appeared to influence post-diagnosis prostate cancer treatment decisions.

Interestingly, MRI-guided biopsies were predictive of receiving post-biopsy 1-year radiation-only treatments as compared to no treatment; however, patients with MRI-guided biopsies had no difference in their likelihood of receiving post-biopsy 1-year surgical procedures (with or without radiation) as compared to no treatment. Based upon higher Elixhauser scores, patients with more complex, comorbidity profiles were more likely to undergo radiation-only treatment though they were not more likely to receive post-biopsy 1-year surgery (with or without radiation) versus no treatment.

Secondary endpoint: time from initial biopsy to initial post-biopsy intervention within 1-year

The cumulative incidence for post-biopsy, 1-year initial prostate intervention is graphically displayed, stratified by MRI-guided vs. no-MRI guided biopsy (**Figure 5**), hazards ratios (HR) with 99% confidence intervals for this analysis provided in **Table 2**. Starting from 1-month post-biopsy, at any given time point, MRI-guided biopsy patients had greater cumulative incidence rates for prostate cancer interventions (surgery and/or radiation), P = 0.0003.

According to AUA guideline requirements for age [20], a sensitivity analysis was run for ini-

Table 2. Estimated Hazard Ratios of explanatory variables and their 99% Confidence Intervals (CI) for time to initial prostate cancer intervention within 1-year after initial prostate biopsy among patients diagnosed with non-metastatic prostate cancer based on a multivariable Fine-Gray model

Variable	Levels	Hazard Ratio with 99% CI	*P*-value*
Prostate Biopsy Type	MRI-Biopsy vs. Non-MRI Biopsy	1.42 (1.11, 1.82)	0.0003
Age	Unit = 10	0.76 (0.70, 0.82)	<.0001
Race-Insurance Categories	Black-Commercial vs. White-Commercial	0.72 (0.60, 0.87)	<.0001
	Black-Government vs. White-Commercial	0.70 (0.57, 0.85)	
	Black-No Pay vs. White-Commercial	0.76 (0.58, 1.00)	
	Other-Commercial vs. White-Commercial	0.85 (0.69, 1.04)	
	Other-Government vs. White-Commercial	0.68 (0.54, 0.87)	
	Other-No Pay vs. White-Commercial	0.72 (0.49, 1.06)	
	White-Government vs. White-Commercial	1.06 (0.90, 1.25)	
	White-No Pay vs. White-Commercial	0.90 (0.57, 1.40)	
Family History of Prostate Cancer	Yes vs. No	1.21 (0.85, 1.71)	0.1632

*P-values were type-3 *P*-values from multivariable Fine-Gray model.

tial prostate biopsy patients with ages between 55 and 69 (n = 11,688). Of these, there were 4,827 patients diagnosed with prostate cancer within 2-months post-biopsy; 4,482 were diagnosed with non-metastatic prostate cancer patients of whom, 1212 (27.0%) had surgery (with or without radiation treatment) and 289 had radiation-only treatment within 1-year post-biopsy. Using these AUA guideline-eligible patients, the MRI-guided biopsy and Black race-related impacts had the same directionality within multivariable models, as reported above (**Appendix C**).

Discussion

As novel findings, this New York statewide, multi-center study documented that SES-related disparities had substantial impact upon New York State residents' pre-biopsy MRI utilization, 2-month post-biopsy prostate cancer diagnosis, and 1-year post-biopsy intervention (surgery and/or radiation) rates. Based on these results, the most important predictor of an MRI-guided prostate biopsy was the interaction between race-insurance. To-date, only one other single-center study [11] evaluated race and insurance differences for MRI-fusion biopsies. It found that rates for MRI-TRUS Fusion biopsies were utilized at lower rates for Black race (OR: 0.32, 95% CI: 0.21-0.51, P<0.001) and Medicaid patients (OR: 0.42, 95% CI: 0.20-0.86, P = 0.018) compared to White patients. However, this study did not examine the interaction between race-insurance or compare post-biopsy diagnoses and the subsequent treatments received.

Across all insurance groupings, Black patients had reduced likelihood of MRI-guided biopsy compared to White commercially insured patients; independent of insurance coverage, all other race (defined as non-White, non-Black) patients similarly received less MRI-guided biopsies. Also, self-pay White patients received MRI-guided biopsies less commonly than White, commercially insured patients; thus, the combined impact of race-insurance was an important breakthrough.

Compared to White commercially insured patients, Black patients (independent of their insurance coverage) had increased chance of post-biopsy prostate cancer diagnosis but White patients with government insurance or self-pay had no difference in the likelihood of their post-biopsy cancer diagnosis. Other races patients reported lower post-biopsy prostate cancer diagnosis likelihood across all insurance categories. Compared to White patients, moreover, Black patients with prostate cancer had lower chance of prostate cancer surgery independent of insurer. Across the continuum of prostate cancer-related care encounters, therefore, the importance of race-insurance was a critical discovery.

Our observations are consistent with the finding that, nationally, Black men have the highest incidence of prostate cancer diagnosis [21]. Our data also builds on trends studied at

single-institution centers such as Hoge et al. which find that Black patients utilized MRI technology such as MRI-TRUS Fusion biopsies at lower rates (22.5% = 41/182) than White patients (51.5% = 225/437) [11]. Previous studies also documented that Black men were less likely to undergo radical prostatectomies and more likely to be treated conservatively [22].

Using 2011-2017 SPARCS records, a very small percentage (3.94%; n = 17,128) of initial prostate biopsies were performed using MRI-guidance. Compared to other studies, this MRI-guided biopsy rate appears comparable for this emerging technology [23]. Addressing a sub-set of these same research questions, Liu et al. examined the Truven MarketScan records from 2012-2015, reporting a 1.7% MRI-guided biopsy rate for first time (naïve) prostate biopsies performed, a rate substantially lower than SPARCS 3.94%; when stratified by the year of biopsy, their 6-month post-biopsy follow-up cancer detection rates or subsequent treatment rates were not associated with pre-biopsy MRI usage among biopsy-naïve patients [10]. These private insurance findings are inconsistent with our NYS SPARCS results, where MRI-guided biopsies increased rates for 2-month post-biopsy cancer detection, with increased rates of 1-year post-cancer diagnosis radiation treatments without corresponding increases in prostatectomy rates. Analyzing a private insurer's database, this study was inherently limited; the combined race-insurance impacts upon MRI-guided biopsy utilization or subsequent prostate care could not be examined.

Interestingly, age impacted MRI-guided biopsy utilization as well as definitive treatment choice. In our bivariate analysis, age was significantly associated with MRI-guidance utilization ($P<0.0001$). A smaller percentage of patients aged 18 to 54 had MRI-guided biopsies compared to patients aged 55 to 64. The largest proportion of patients who had an MRI-guided biopsy were those aged 65-75 (4.83% = 372/7704). In subsequent multivariable regression models, age (in deciles) was found to be a top explanatory variable across all prostate cancer-related endpoints; Older patients were more likely to receive an MRI-guided biopsy, more likely to have a prostate cancer diagnosis within 2-months of biopsy, and more likely to have a prostate cancer intervention within 1-year of biopsy. When intervention is stratified into radiation and surgery, older patients were more likely to receive radiation vs. no intervention and less likely to receive surgery vs. no intervention.

As with all observational studies, this SPARCS database analysis had several inherent limitations. The coding used to identify MRI-guided biopsies may be imperfect; however, the coding classifications used represent the current literature-based definition of pre-biopsy, prostate MRIs [6, 10, 24]. Moreover, as a billing database, SPARCS lacks clinically relevant, pathology-based risk factors like tumor size or Gleason scores to optimally risk-stratify prostate cancer sub-populations. Finally, these NYS SPARCS findings may not be representative of non-NYS populations.

Conclusion

Addressing an existing knowledge gap, the combination of race and insurance had a substantive and pervasive impact upon prostate patients MRI-guided biopsy utilization and their post-biopsy subsequent prostate cancer care received. In New York State, MRI-guided prostate biopsy rates were lower for Black patients as compared to all other races. Independent of insurance status, Black patients more commonly had post-biopsy prostate cancer diagnoses, but less likely to receive any post-cancer diagnosis intervention within 1-year as compared to White commercially insured patients.

Future research should build upon these findings by analyzing electronic medical record databases to evaluate for a race-insurance impact holding other tumor-related characteristics (e.g., tumor size) constant as well as examining the impact of SES-related patient characteristics over time. To appraise this NYS-based study's broader-based generalizability, confirmatory analyses should be performed using other state, regional or national databases.

Given that these SES-related prostate cancer care disparities may be exacerbated by the recent COVID-19 pandemic, a unique research opportunity now exists to evaluate for an SES-

COVID-19 interaction. Pending these findings, strategies may be identified to proactively address these race-insurance disparities by means of enhanced outreach, monitoring, and follow-up programs-improving future prostate cancer patients care, equitably for all.

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Disclosure of conflict of interest

None.

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Appendix A. Data element definitions and billing codes

Procedure	ICD-9	ICD-10	CPT	Comments
Prostate Needle Biopsy (Open or Closed)	60.11, 60.12	0VB03ZX, 0VB04ZX, 0VB07ZX, 0VB08ZX, 0VB00ZX	55700, 55705, 55706	Criteria met with any ONE ICD-9 code, ICD-10 code, or CPT code
MRI Guidance	88.95	BV33Y0Z or BV33YZZ or BV33ZZZ	72195 or 72196 or 72197 or 76376 or 76377	Any ONE additional code (ICD-9, ICD-10 OR CPT) satisfies criteria given: 1. Must have code 55700 FIRST 2. Must be within 3-months of biopsy
Prostate Cancer Surgery Codes	60.3, 60.4, 60.5, 60.62, or 60.69	0VT00ZZ, 0VT04ZZ, 0VT07ZZ, or 0VT08ZZ	55810, 55812, 55815, 55840, 55842, 55845, 55866	Criteria met with only ONE ICD-9 code, one ICD-10 code, or one CPT code
Prostate Cancer Radiation Codes	92.30, 92.31, 92.32, 92.33, 92.39, 92.20, 92.23, 92.28, 92.27, 92.22, 92.24, 92.25, 92.26, 92.21, 99.85, 92.29, 17.69, 92.41	DV20DZZ, DV20HZZ, DV20JZZ, DV1097Z, DV1098Z, DV1099Z, DV109BZ, DV109CZ, DV109YZ, DV10B7Z, DV10B8Z, DV10B9Z, DV10BBZ, DV10BB1, DV10BCZ, DV10BYZ, 3E0N304, 3E0N704, 3E0N804, DV000ZZ, DV001ZZ, DV002ZZ, DV003Z0, DV003ZZ, DV004ZZ, DV005ZZ, DV006ZZ, DVY07ZZ, DVY08ZZ, DVY0CZZ, DVY0FZZ, DVY0KZZ	77373, 77385, 77386, 77424, 77425, 77520, 77522, 77523, 77525, 77600, 77605, 77610, 77615, 77620, 77770, 77771, 77772, 77778, 77371, 77372, 77373, 77401, 77402, 77403, 77404, 77406, 77407, 77408, 77409, 77411, 77412, 77413, 77414, 77416, 77418, 77423, 77424, 77425, 77520, 77522, 77523, 77525, 77781, 77782, 77783, 77784, 77785, 77786, 77787, 0395T, G0173, G0251, G0339, G0340, G6003, G6004, G6005, G6006, G6007, G6008, G6009, G6010, G6011, G6012, G6013, G6014, G6015, G6016	Any ONE ICD-9, ICD-10, or CPT satisfies criteria
Prostate Cancer Diagnosis	ICD-9	ICD-10		Comments
Non-Metastatic Prostate Cancer Diagnosis Codes	185, 233.4	C61, D07.5		Presence of any ONE these characteristic codes defines a prostate cancer diagnosis (non-metastatic vs. metastatic)
Metastatic Prostate Cancer Diagnosis Codes	198.5, 198.82, 196.2, 196.6	C79.51, C79.82, C77.2, C77.5		
Patient Risk Factor Codes	ICD-9	ICD-10		Comments
Smoking/Tobacco	649.03	O99.339		Presence of any ONE these characteristic codes defines a patient risk factor
Morbid Obesity	649.13	O99.21		
Family History of Prostate Cancer	V16.42	Z80.42		
Personal History of Prostatic Dysplasia	V13.89	Z87.430		
Personal History of Irradiation	V15.3	Z92.3		

Appendix B: Exclusion of SPARCS 2016 data

Data from 2016 was excluded from this project due to billing data quality concerns. As shown in the tables, there was an apparent lack of SPARCS prostate biopsy records in 2016 for both MRI-guided and non-MRI guided initial biopsies in both inpatient and outpatient settings.

Frequency table for patients' very first prostate biopsy by year

Year of prostate biopsy	Total	MRI Biopsy	Non-MRI Biopsy
2011	3553	21 (0.59%)	3532 (99.41%)
2012	3064	22 (0.72%)	3042 (99.28%)
2013	2771	59 (2.13%)	2712 (97.87%)
2014	2608	79 (3.03%)	2529 (96.97%)
2015	2127	136 (6.39%)	1991 (93.61%)
2016	760	54 (7.11%)	706 (92.89%)
2017	3370	363 (10.77%)	3007 (89.23%)
Total	18253	734	17519

Frequency table patients' very first prostate biopsy for inpatient vs. outpatient by year

Year of prostate biopsy	Total	Inpatient	Outpatient
2011	3553	164 (4.62%)	3389 (95.38%)
2012	3064	151 (4.93%)	2913 (95.07%)
2013	2771	121 (4.37%)	2650 (95.63%)
2014	2608	127 (4.87%)	2481 (95.13%)
2015	2127	114 (5.36%)	2013 (94.64%)
2016	760	101 (13.29%)	659 (86.71%)
2017	3370	125 (3.71%)	3245 (96.29%)
Total	18253	903	17350

Appendix C: Sensitivity analysis of all outcomes based on AUA guideline requirements for age

According to AUA guideline requirements for age, initial prostate biopsy patients with age <55 and ≥70 were further excluded for sensitivity analysis. There were 11688 patients remained with initial prostate biopsy. There were 4827 patients diagnosed with prostate cancer within 2 months post-biopsy. Among 4482 non-metastatic prostate cancer diagnosed patients, there were 1212 (27.04%) patients having surgery and 289 (6.45%) patients with radiation as the initial intervention within 1 year post-biopsy, while 2981 (66.51%) patients without any intervention within 1 year post-biopsy. The variables included in the multivariable regression models in sections 3.1-3.5 were kept in the multivariable regression analysis in this part, regardless the significance of the variables in univariate analysis.

C.1 Sensitivity analysis of MRI prostate biopsy

The variables included in the multivariable regression model in were used in the model shown in **Table C1.1** for sensitivity analysis. In **Table C1.1**, age, ethnicity, race-insurance categories, Hypertension, uncomplicated, and Solid tumor w/out metastasis were significantly associated with having MRI biopsy among patients with age met with AUA guideline requirements. The results were same as the model in **Appendix Table E1**. **Table C1.2** shows the rank of importance of significant explanatory variables. Race-Insurance is still the most important significant explanatory variable.

Table C1.1. Factors associated with having MRI prostate biopsy based on a multivariable logistic regression model using Elixhauser comorbidities

Variable	Levels	Odds ratio (99% CI)	*P*-value*
Age	Unit = 10	1.55 (1.10, 2.19)	0.0009
Ethnicity	Hispanics vs. Non-Hispanics	0.53 (0.3, 0.94)	0.0044
Race-Insurance Categories	Black, Comm. vs. White, Comm.	0.31 (0.18, 0.53)	<.0001
	Black, Govt vs. White, Comm.	0.18 (0.08, 0.36)	
	Black, No Pay vs. White, Comm.	0.1 (0.03, 0.39)	
	Other, Comm. vs. White, Comm.	0.68 (0.45, 1.04)	
	Other, Govt vs. White, Comm.	0.52 (0.29, 0.92)	
	Other, No Pay vs. White, Comm.	0.31 (0.11, 0.87)	
	White, Govt vs. White, Comm.	1.07 (0.77, 1.48)	
	White, No Pay vs. White, Comm.	0.16 (0.03, 1)	
Smoking/Tobacco	Yes vs. No	0.6 (0.3, 1.2)	0.0569
Hypertension, uncomplicated	Yes vs. No	0.34 (0.2, 0.58)	<.0001
Hypertension, complicated	Yes vs. No	0.27 (0.01, 8.21)	0.3222
Chronic pulmonary disease	Yes vs. No	0.2 (0.03, 1.29)	0.0262
Diabetes w/o chronic complications	Yes vs. No	0.48 (0.17, 1.34)	0.0672
Renal failure	Yes vs. No	0.82 (0.07, 9.38)	0.8311
Solid tumor w/out metastasis	Yes vs. No	1.63 (1.02, 2.62)	0.0073
Alcohol abuse	Yes vs. No	0.61 (0.21, 1.82)	0.2482

*P-value was based on type 3 test of multivariable logistic regression.

Table C1.2. Rank of the explanatory variables in the multivariable logistic regression model for MRI Biopsy among patients with initial prostate biopsy

Rank of the importance of explanatory variables	C-index*
Race-Insurance	0.645208
Hypertension, uncomplicated	0.705725
Age	0.715771
Ethnicity	0.717182
Solid tumor w/out metastasis	0.718917

*C-index was based on multivariable logistic regression model built by eliminating one explanatory variable at each time.

C.2 Sensitivity analysis of prostate cancer diagnosis within 2-months after initial prostate biopsy

The same variables included in the multivariable regression model were used for sensitivity analysis of having prostate cancer diagnosis within 2 months after initial prostate biopsy. The results in **Table C2.1** were same as the model in **Appendix Table E2** except for Smoking/Tobacco, though the *P*-value of Smoking/Tobacco is approaching the significant level. **Table C2.2** shows the rank of importance of significant explanatory variables.

Table C2.1. Factors associated with prostate cancer diagnosis within 2 months after initial prostate biopsy based on a multivariable logistic regression model

Variable	Levels	Odds ratio (99% CI)	*P*-value*
Prostate Biopsy Type	MRI Biopsy vs. Non-MRI Biopsy	1.37 (1.06, 1.75)	0.0013
Race-Insurance Categories	Black, Comm. vs. White, Comm.	1.32 (1.12, 1.55)	<.0001
	Black, Govt vs. White, Comm.	1.24 (1.03, 1.48)	
	Black, No Pay vs. White, Comm.	1.68 (1.31, 2.14)	
	Other, Comm. vs. White, Comm.	0.75 (0.63, 0.9)	
	Other, Govt vs. White, Comm.	0.79 (0.64, 0.99)	
	Other, No Pay vs. White, Comm.	0.72 (0.54, 0.96)	
	White, Govt vs. White, Comm.	0.96 (0.82, 1.12)	
	White, No Pay vs. White, Comm.	0.7 (0.48, 1.03)	
Age	Unit = 10	1.19 (1.04, 1.36)	0.0006
Ethnicity	Hispanics vs. Non-Hispanics	1.1 (0.92, 1.32)	0.1568
Elixhauser Comorbidities Score	Unit = 1	1.09 (1.06, 1.11)	<.0001
Smoking/Tobacco	Yes vs. No	1.2 (0.99, 1.46)	0.0137

**P*-value was based on type 3 test of multivariable logistic regression.

Table C2.2. Rank of the explanatory variables in the multivariable logistic regression model for prostate cancer diagnosis among patients with initial prostate biopsy

Rank of the importance of explanatory variables	C-index*
Elixhauser Comorbidities Score	0.566667
Race-Insurance Categories	0.567948
Prostate Biopsy Type	0.587440
Age	0.587651

*C-index was based on multivariable logistic regression model built by eliminating one explanatory variable at each time.

C.3 Sensitivity analysis of prostate cancer initial intervention within 1-year after initial prostate biopsy

The variables included in the multivariable regression model were used in the model shown in **Table C3.1** for sensitivity analysis of initial prostate cancer intervention within 1 year after initial prostate biopsy. In **Table C3.1**, age, race-insurance categories, and Elixhauser score were significantly associated with having initial prostate cancer intervention among patients with age met with AUA guideline requirements. The results were same as the model in **Appendix Table E3** except for prostate biopsy type. Prostate biopsy type was not significantly associated with having initial intervention within 1-year post-biopsy for a smaller patient population. **Table C3.2** shows the rank of importance of significant explanatory variables.

Table C3.1. Factors associated with prostate cancer initial intervention within 1 year after initial prostate biopsy based on a multivariable logistic regression model

Variable	Levels	Radiation Odds ratio (99% CI)	Surgery Odds ratio (99% CI)	*P*-value*
Race-Insurance Categories	Black, Comm. vs. White, Comm.	1.11 (0.63, 1.96)	0.63 (0.48, 0.84)	<.0001
	Black, Govt vs. White, Comm.	1.81 (1.06, 3.08)	0.48 (0.34, 0.68)	
	Black, No Pay vs. White, Comm.	1.23 (0.58, 2.6)	0.62 (0.41, 0.94)	
	Other, Comm. vs. White, Comm.	0.88 (0.43, 1.79)	0.75 (0.54, 1.03)	
	Other, Govt vs. White, Comm.	1.11 (0.56, 2.21)	0.53 (0.36, 0.8)	
	Other, No Pay vs. White, Comm.	1.09 (0.39, 3)	0.54 (0.31, 0.95)	
	White, Govt vs. White, Comm.	1.53 (0.92, 2.53)	0.89 (0.68, 1.17)	
	White, No Pay vs. White, Comm.	0.3 (0.02, 4.18)	0.82 (0.41, 1.66)	
Prostate Biopsy Type	MRI Biopsy vs. Non-MRI Biopsy	1.54 (0.78, 3.05)	1.22 (0.81, 1.84)	0.1724
Age	Unit = 10	1.34 (1.08, 1.66)	0.61 (0.54, 0.68)	<.0001
Family History of Prostate Cancer	Yes vs. No	0.88 (0.26, 3)	1.25 (0.71, 2.19)	0.5464
Elixhauser Comorbidities Score	Unit = 1	1.09 (1.04, 1.16)	0.96 (0.92, 1)**	<.0001

*P-value was based on type 3 test of multivariable logistic regression. **Odds ratio (99% CI) is 0.959 (0.917, 1.004).

Table C3.2. Rank of the explanatory variables in the multivariable multinomial logistic regression model for initial prostate cancer intervention within 1-year after initial prostate biopsy among patients diagnosed with non-metastatic prostate cancer

Rank of the importance of explanatory variables	C-index*
Age	0.49623
Race-Insurance Categories 1	0.51857
Elixhauser Comorbidities Score	0.52050

*C-index was based on multivariable multinomial logistic regression model built by eliminating one explanatory variable at each time.

C.4 Sensitivity analysis of time to initial prostate cancer intervention within 1-year after initial prostate biopsy

The variables included in the multivariable Fine-gray model were used in the model shown in **Table C4.1** for sensitivity analysis of time to initial prostate cancer intervention within 1-year post-biopsy. In **Table C4.1** prostate biopsy type and race-insurance categories 1 were significantly associated with having initial prostate cancer intervention among patients with age met with AUA guideline requirements. The results were same as the model in Main text **Table 2** except for age. But the *P*-value of age is approaching the significant level. **Table C4.2** shows the rank of importance of significant explanatory variables.

Table C4.1. Estimated HRs of explanatory variables and their 99% CIs for time to first prostate cancer intervention among patients diagnosed with non-metastatic prostate cancer within 2 months after initial prostate biopsy based on multivariable Fine-Gray model

Variable	levels	Hazard Ratio with 99% CI	*P*-value*
Prostate Biopsy Type	MRI-Biopsy vs. Non-MRI Biopsy	1.36 (1.01, 1.84)	0.0087
Age	Unit = 10	0.87 (0.73, 1.03)	0.0344
Race-Insurance Categories	Black, Comm. vs. White, Comm.	0.73 (0.59, 0.90)	<.0001
	Black, Govt vs. White, Comm.	0.69 (0.54, 0.88)	
	Black, No Pay vs. White, Comm.	0.75 (0.55, 1.02)	
	Other, Comm. vs. White, Comm.	0.82 (0.64, 1.05)	
	Other, Govt vs. White, Comm.	0.68 (0.50, 0.93)	
	Other, No Pay vs. White, Comm.	0.72 (0.46, 1.13)	
	White, Govt vs. White, Comm.	0.99 (0.81, 1.21)	
	White, No Pay vs. White, Comm.	0.80 (0.46, 1.38)	
Family History of Prostate Cancer	Yes vs. No	1.18 (0.78, 1.80)	0.2980

**P*-values were type-3 *P*-values from multivariable Fine-Gray model.

Table C4.2. Rank of the explanatory variables in the multivariable Cox PH model for time to first prostate cancer intervention among patients diagnosed with non-metastatic prostate cancer within 2 months after initial prostate biopsy

Rank of the importance of explanatory variables	C-index*
Race-Insurance Categories 1	0.5425
Prostate Biopsy Type	0.5642

*C-index was Harrell's Concordance Statistic from multivariable Cox-PH model built by eliminating one explanatory variable at each time.

Appendix D: STROBE checklist

STROBE Statement-Checklist of items that should be included in reports of *cohort studies*

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	6
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7
Data sources/measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7, 8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7, 8
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	
		(*d*) If applicable, explain how loss to follow-up was addressed	
		(e) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study-eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	Report numbers of outcome events or summary measures over time	9-11
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9-11
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done-eg analyses of subgroups and interactions, and sensitivity analyses	11
Discussion			
Key results	18	Summarise key results with reference to study objectives	11-13
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11-14
Generalisability	21	Discuss the generalisability (external validity) of the study results	13, 14
Other information			

Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	NA

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org. *Give information separately for exposed and unexposed groups.

Appendix E: Complete model findings

Table E1. Factors associated with having MRI prostate biopsy based on a multivariable logistic regression model using Elixhauser comorbidities (Sub-figure of **Figure 2**)

Variable	Levels	Odds ratio (99% CI)	*P*-value*
Age	Unit = 10	1.30 (1.10, 1.54)	<.0001
Ethnicity	Hispanics vs. Non-Hispanics	0.48 (0.3, 0.78)	<.0001
Race-Insurance Categories	Black, Commercial. vs. White, Commercial.	0.34 (0.22, 0.52)	<.0001
	Black, Government vs. White, Commercial.	0.21 (0.12, 0.35)	
	Black, No Pay vs. White, Commercial.	0.1 (0.03, 0.31)	
	Other, Commercial. vs. White, Commercial.	0.63 (0.43, 0.91)	
	Other, Government vs. White, Commercial.	0.55 (0.35, 0.86)	
	Other, No Pay vs. White, Commercial.	0.33 (0.14, 0.77)	
	White, Government vs. White, Commercial.	1.01 (0.77, 1.32)	
	White, No Pay vs. White, Commercial.	0.18 (0.04, 0.82)	
Smoking/Tobacco	Yes vs. No	0.71 (0.42, 1.2)	0.0916
Hypertension, uncomplicated	Yes vs. No	0.33 (0.22, 0.51)	<.0001
Hypertension, complicated	Yes vs. No	0.23 (0.01, 5.31)	0.2245
Chronic pulmonary disease	Yes vs. No	0.37 (0.13, 1.1)	0.0183
Diabetes w/o chronic complications	Yes vs. No	0.5 (0.22, 1.13)	0.0277
Renal failure	Yes vs. No	0.52 (0.05, 4.99)	0.4590
Solid tumor w/out metastasis	Yes vs. No	1.68 (1.15, 2.46)	0.0005
Alcohol abuse	Yes vs. No	0.49 (0.19, 1.25)	0.0494

*_P_-value was based on type 3 test of multivariable logistic regression.

Table E2. Factors associated with prostate non-metastatic cancer diagnosis within 2 months after initial prostate biopsy based on a multivariable logistic regression model (Subfigure of **Figure 3**)

Variable	Levels	Odds ratio (99% CI)	*P*-value*
Prostate Biopsy Type	MRI Biopsy vs. Non-MRI Biopsy	1.35 (1.1, 1.66)	0.0002
Race-Insurance Categories	Black, Commercial. vs. White, Commercial.	1.32 (1.15, 1.51)	<.0001
	Black, Government vs. White, Commercial.	1.15 (0.99, 1.34)	
	Black, No Pay vs. White, Commercial.	1.72 (1.39, 2.12)	
	Other, Commercial. vs. White, Commercial.	0.77 (0.66, 0.9)	
	Other, Government vs. White, Commercial.	0.81 (0.68, 0.96)	
	Other, No Pay vs. White, Commercial.	0.68 (0.53, 0.86)	
	White, Government vs. White, Commercial.	0.98 (0.86, 1.11)	
	White, No Pay vs. White, Commercial.	0.79 (0.57, 1.09)	
Age	Unit = 10	1.30 (1.22, 1.38)	<.0001
Ethnicity	Hispanics vs. Non-Hispanics	1.06 (0.92, 1.23)	0.2652
Elixhauser Comorbidities Score	Unit = 1	1.08 (1.06, 1.1)	<.0001
Smoking/Tobacco	Yes vs. No	1.18 (1.01, 1.39)	0.0055

*_P_-value was based on type 3 test of multivariable logistic regression.

Table E3. Factors associated with prostate cancer initial intervention within 1 year after initial prostate biopsy based on a multivariable multinomial logistic regression model (Subfigure of **Figure 4**)

Variable	Levels	Radiation Odds ratio (99% CI)	Surgery Odds ratio (99% CI)	*P*-value*
Race-Insurance Categories	Black, Commercial. vs. White, Commercial.	1.08 (0.67, 1.75)	0.63 (0.49, 0.81)	<.0001
	Black, Government vs. White, Commercial.	1.66 (1.08, 2.55)	0.47 (0.35, 0.63)	
	Black, No Pay vs. White, Commercial.	0.97 (0.5, 1.9)	0.66 (0.47, 0.94)	
	Other, Commercial. vs. White, Commercial.	0.98 (0.56, 1.72)	0.75 (0.57, 0.98)	
	Other, Government vs. White, Commercial.	1.21 (0.73, 2.01)	0.52 (0.37, 0.72)	
	Other, No Pay vs. White, Commercial.	0.76 (0.28, 2.03)	0.58 (0.36, 0.93)	
	White, Government vs. White, Commercial.	1.63 (1.11, 2.41)	0.97 (0.77, 1.21)	
	White, No Pay vs. White, Commercial.	0.39 (0.06, 2.52)	0.91 (0.51, 1.63)	
Prostate Biopsy Type	MRI Biopsy vs. Non-MRI Biopsy	2.11 (1.32, 3.38)	1.17 (0.82, 1.67)	0.0002
Age	Unit = 10	1.34 (1.08, 1.66)	0.61 (0.54, 0.68)	<.0001
Family History of Prostate Cancer	Yes vs. No	0.82 (0.29, 2.31)	1.33 (0.83, 2.13)	0.2195
Elixhauser Comorbidities Score	Unit = 1	1.07 (1.02, 1.12)	0.96 (0.93, 1)**	<.0001

*P-value was based on type 3 test of multivariable logistic regression. **Odds ratio (99% CI) is 0.965 (0.929, 1.002).