Supplementary Online Content

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This supplementary material has been provided by the authors to give readers additional information about their work.

eMethods.

Mediation effects refer to those contributed by an intervening variable within a relationship between the exposure and outcome of interest. [1] In this study, we sought to explain the effects of race on the use of prostate MRI, and specifically how the association can be explained through (1) the effects of race on a hierarchy of clinical and sociodemographic factors and, in turn, on prostate MRI use; and (2) determining whether the association between race and prostate MRI use persist after adjusting for the effects of potential mediators.

We used a generalized approach to mediation under the counterfactual framework. This approach seeks to examine the potential difference in outcomes (Y_i) that would occur if the exposure variable could be changed while other conditions being held constant (i.e., the difference in receipt of prostate MRI if a given patient belonged to the race group conceptualizes as "White" (*x)* versus "Black"*(x')*]. Thus, we aimed to appreciate the average causal effects of race over a population of patients $E(Y_i(x)) – (Y_i(x'))$.[2]

We further sought to decompose the total effects into those contributed by the exposure variable (race) as well as those contributed indirectly by the mediators (a hierarchy of clinical and sociodemographic factors including racialized residential segregation defined by the Index of Concentrations at the Extremes for race).

We evaluated the relationships among these exposure, outcome and potential mediating variables using predictive models using a previously described method and software package (*mma)* which operationalizes several algorithms to estimate mediation effects (Comprehensive R Archive Network (CRAN)). This approach has been applied for mediation analyses, including those examining racial disparity in breast cancer.[3] Based on the binary and categorical nature of the study variables, as well as the possibility of complex hierarchies and nonlinear relationships, we elected to use non-linear approaches. The prediction method employed in the *mma* software utilizes Multiple Additive Regression Trees (MART) an application of gradient tree boosting, an approach that sequentially applies a classification algorithm to a set of data which has been applied in predictive data mining. As described by Yu and Li (mma: An R Package for Mediation Analysis with Multiple Mediators), the *mma* software package integrates several steps to identify potential mediators and estimate mediation effects, as follows[4,5]:

We first identified mediators based on the following conditions: (1) potential mediators must be associated with the exposure variable (race), and (2) must also be associated with the outcome (prostate MRI use). We tested these conditions using chi-square statistics or analysis of variance for categorical and continuous variables, respectively using a significance level (alpha=0.1). The putative sociodemographic and clinical variables were entered simultaneously and tested for meeting the specified conditions of mediation. Based on their associations with race and prostate MRI receipt, SEER region, HRR-level prostate imaging utilization, Medicare-Medicaid dual eligibility, ICE_{race} category, and high area-level poverty met criteria as mediators. In the model comprised of patients whose race was conceptualized as 'Black' and 'Other,' SEER-region, ICErace category, high area-level poverty, and HRR-level prostate cancer imaging utilization met criteria as mediators. Dual Medicaid eligibility did not meet criteria as a mediator but was included as a covariate.

eTable 1. Selection Process for Variables Meeting Conditions for Mediation		
Candidate Mediator Variable	Step 1 *p-value*	Step 2 *p-value*
Race: Black versus White		
SEER Region*	<0.001	<0.001
Dual eligibility for Medicaid*	<0.001	<0.001
ICE_{race} category*	0.005	<0.001
High poverty area*	<0.001	<0.001
HRR-level imaging use*	<0.001	0.037
CAPRA score	0.157	N/A
Race: Black versus Other		
SEER Region*	<0.001	<0.001
Dual eligibility for Medicaid	0.002	0.685
ICE_{race} category*	0.020	<0.001
High poverty area*	0.001	<0.001
HRR-level imaging use*	0.035	<0.001
CAPRA score	0.474	N/A
Step 1: Univariate test of association between variable and outcome (prostate MRI) Step 2: Univariate test of association between variable and predictor (race) *Indicates variable meeting criteria for mediator *Abbreviations*: SEER=Surveillance, Epidemiology and End-Results; ICE=Index of Concentrations at the Extremes; HRR=Hospital Referral Region; CAPRA=Cancer of the Prostate Risk Assessment Score		

We subsequently used the "*med"* argument to generate point estimates for mediation effects using nonlinear methods under the Bernoulli probability distribution. These models assumed independent mediation effects. We reported the direct and indirect association of race with MRI receipt through log-odds and relative effects (%) using 100 bootstrap iterations to accommodate uncertainty of the estimates. The relative effects were calculated as the ratio of indirect or direct effects divided by the total effect. Lastly, we generated figures depicting the direct, indirect, and total effects of the mediators.

eTable 2. Procedure Codes Used to Identify Prostate Imaging Procedures

	Healthcare Common Procedure Coding	International Classification of Diseases, Ninth Revision	International Classification of Diseases, Tenth Revision
Prostate MRI	72195, 72196, 72197	8895	BV33Y0Z, BV33YZZ, BV33ZZZ, BW3GY0Z, BW3GYZZ, BW3GZZZ
Bone scan	78306, 78315, 78102, 78103, 78104	92.14	CP111ZZ, CP11YZZ, CP141ZZ, CP14YZZ, CP151ZZ, CP15YZZ, CP161ZZ, CP16YZZ, CP171ZZ, CP17YZZ, CP181ZZ, CP18YZZ, CP191ZZ, CP19YZZ, CP1B1ZZ, CP1BYZZ, CP211ZZ, CP21YZZ, CP221ZZ, CP22YZZ, CP231ZZ, CP23YZZ, CP241ZZ, CP24YZZ, CP261ZZ, CP26YZZ, CP271ZZ, CP27YZZ
CT abdomen	72191, 72192, 72193, 72194, 74150, 74160, 74170, 74175	88.01	BW2000Z, BW200ZZ, BW2010Z, BW201ZZ, BW20Y0Z, BW20YZZ,BW20ZZZ
Body scan	N/A	92.18	CW1N1ZZ, CW1NDZZ, CW1NFZZ, CW1NGZZ, CW1NLZZ, CW1NSZZ, CW1NYZZ, CW3NYZZ'

eReferences.

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