INTRODUCTION

Whether to pursue prostate-specific antigen (PSA)-based screening remains a topic of debate. However, there remains substantial agreement between guidelines that testing in certain men is low-value care. Low-value screening increases the risks for overtesting, overdiagnosis, and overtreatment. For example, screening in older men with short life expectancies is low-value because many such patients may not experience the benefit of screening due to the indolent nature and long natural history of most prostate cancers. There have been multiple studies evaluating prevalence of PSA testing in...
older men, but none evaluate low-value PSA practice patterns in younger men.1–3 The Center for Disease Control database identifies that those under the age of 45 have a low risk of prostate cancer. Between the ages of 40 and 49 the incidence is approximately 35 per 100,000 men, and for men below the age of 40, it is less than 1 per 100,000 men.4 In addition to testing in older men, testing for prostate cancer in young men may be another source of low-value care that limits the overall benefits of PSA-based prostate cancer screening. In this study, we sought to identify the prevalence of PSA testing in men younger than is recommended by current evidence-based guidelines.

2 | METHODS

2.1 | Data

Data for this study were extracted from Health Information National Trends Surveys (HINTS) from 2011 to 2014 and 2017. HINTS is a cross-sectional, nationally representative survey series developed through the National Cancer Institute.5 The data collected, via telephone or mailer questionnaire, surveys patients older than 18 regarding knowledge, perceptions, and use of cancer and health-related information. We limited our analysis to male respondents under the age of 70, regardless of age, race, and health status. Respondent factors of interest included if they have ever had a PSA test, age, and race/ethnicity.

2.2 | Analysis

Descriptive statistics of the respondent factors were stratified by whether respondents reported having a PSA test as well as by age group. The association of each factor with history of a PSA test (Y/N) was evaluated respectively for all encounters using multivariate logistic regression models adjusted for patient and provider factors. P values less than 0.05 were considered as statistically significant. All analyses were conducted in SAS (version 9.4).

3 | RESULTS

The combined survey data included 5178 men, with 2393 reporting previous PSA screening. There were 1093 respondents between the ages of 18 and 39, with 78 (7.1%) reporting previous PSA testing (Table 1). Among men under 40, PSA testing was more common among black men (14%) compared to white men (7%), Hispanics (6%), and men of Asian descent (8%). Twenty-two percent and 31% of men aged 40–44 and 45–49, respectively, reported previous PSA screening. The rate of PSA screening increased as age increased. The proportion of black men undergoing PSA screening exceeded that of all other races until the age group of 60–64, where the rate of screening in non-Hispanic white men exceeded all others. Weighted estimates demonstrate that the number of men in the US under the age of 40 undergoing PSA screening is approximately 600,000 to 3.6 million.

Logistic regression results show that as a person moves up in age they are more likely to have had a PSA test (Table 2). For race/ethnicity in the group of men <40, 40–44, and 45–49, when compared to Caucasian men, analysis found no significant increase in risk for exposure to testing. When Black men are analyzed compared to all other races and ethnicities, those under 40 are more than twice as likely to undergo PSA testing. This increase in odds was not significant in ages 40–49.

4 | DISCUSSION

This study demonstrates that numerous young men are exposed to PSA testing even prior to the youngest recommended age. Depending on the professional association, recommendations for initiating PSA testing for men at average risk range from 45 to 55; and, as young as 40 for those with high risk. High risk is typically defined as black men and those with strong family history of prostate cancer (i.e. early diagnosis, multiple family members, etc.).6–8 The indications for PSA testing in the young men of this study are unknown, but testing may be completed in those considered high risk, men with lower urinary tract symptoms, or those requesting testing. Additionally, testing in young men may be done as part of routine testing given the relative low cost, low risk, and ease of ordering in comparison to other cancer screenings (e.g. colonoscopy for colon cancer).

Regression models also demonstrated an increased risk of PSA testing as age increased, which is not surprising given the known increased prevalence of prostate cancer and the cumulative risk of PSA testing exposure as men age. However, black men under the age of 40 were more likely to undergo PSA testing suggesting a disparate exposure to guideline-discordant testing among this group. Significant differences were not demonstrated with white men versus others despite age group; nor, in black men versus others in ages greater than 40.

There are limitations with this study. The nature of cross-sectional analysis does not allow for an estimate of incidence of prostate cancer. Responses were self-reported and were based on recollection of ever having been tested, so are subject to recall bias; however, this self-reporting likely leads to lower estimates than the true rate of testing in young men. The indication for testing is also unknown. It may be that the testing in young men is done among those
TABLE 1 Descriptive statistics of PSA testing history stratified by age and race/ethnicity groups.

| Age group: <40 | Never been tested | Have been tested |
|---------------|-------------------|-----------------|
| Non-Hisp White | 558 (93.5%)       | 39 (6.5%)       |
| Non-Hisp Black or African American | 96 (86.5%) | 15 (13.5%) |
| Hispanic      | 213 (94.2%)       | 13 (5.8%)       |
| Non-Hisp Asian| 79 (91.9%)        | 7 (8.1%)        |
| Other         | 69 (94.5%)        | 4 (5.5%)        |
| Total         | 1015 (92.7%)      | 78 (7.3%)       |

| Age group: 40–44 | Never been tested | Have been tested |
|------------------|-------------------|-----------------|
| Non-Hisp White   | 196 (78.1%)       | 55 (21.9%)      |
| Non-Hisp Black or African American | 38 (73.1%) | 14 (26.9%) |
| Hispanic         | 66 (75.9%)        | 21 (24.1%)      |
| Non-Hisp Asian   | 24 (88.9%)        | 3 (11.1%)       |
| Other            | 21 (77.8%)        | 6 (22.2%)       |
| Total            | 348 (77.9%)       | 99 (22.1%)      |

| Age group: 45–49 | Never been tested | Have been tested |
|------------------|-------------------|-----------------|
| Non-Hisp White   | 205 (68.3%)       | 95 (31.7%)      |
| Non-Hisp Black or African American | 41 (59.4%) | 28 (40.6%) |
| Hispanic         | 67 (69.1%)        | 30 (30.9%)      |
| Non-Hisp Asian   | 30 (90.9%)        | 3 (9.1%)        |
| Other            | 25 (73.5%)        | 9 (26.5%)       |
| Total            | 368 (69.0%)       | 165 (31.0%)     |

| Age group: 50–54 | Never been tested | Have been tested |
|------------------|-------------------|-----------------|
| Non-Hisp White   | 206 (51.5%)       | 194 (48.5%)     |
| Non-Hisp Black or African American | 40 (46.5%) | 46 (53.5%) |
| Hispanic         | 55 (52.9%)        | 49 (47.1%)      |
| Non-Hisp Asian   | 13 (68.4%)        | 6 (31.6%)       |
| Other            | 43 (55.8%)        | 34 (44.2%)      |
| Total            | 357 (52.0%)       | 329 (48.0%)     |

| Age group: 55–59 | Never been tested | Have been tested |
|------------------|-------------------|-----------------|
| Non-Hisp White   | 163 (33.5%)       | 324 (66.5%)     |
| Non-Hisp Black or African American | 30 (30%) | 70 (70%) |
| Hispanic         | 44 (41.9%)        | 61 (58.1%)      |
| Non-Hisp Asian   | 17 (51.5%)        | 16 (48.5%)      |
| Other            | 28 (40%)          | 42 (60%)        |
| Total            | 282 (34.5%)       | 513 (64.5%)     |

| Age group: 60–64 | Never been tested | Have been tested |
|------------------|-------------------|-----------------|
| Non-Hisp White   | 135 (25%)         | 405 (75%)       |
| Non-Hisp Black or African American | 33 (33.3%) | 66 (66.7%) |
| Hispanic         | 34 (40.5%)        | 50 (59.5%)      |
| Non-Hisp Asian   | 10 (55.6%)        | 8 (44.4%)       |

(Continues)
with genitourinary symptoms. Such testing in young men may reflect a misunderstanding of the role of PSA in the management of these symptoms in contrast to its use for the early detection of prostate cancer.6,9 Another limitation of the study is the lack of clinical patient variables available in the HINTS database, as specific family history, patient diagnoses, and physician practice patterns would improve the understanding of why PSA testing is being used inappropriately. Further evaluation using a longitudinal commercial claims and encounter database is planned to validate the prevalence of testing in young men, expand the understanding of inappropriate PSA testing in this group, and characterize the downstream effects that may impact patients as a result of inappropriate testing.

A recent report demonstrated a rising incidence of prostate cancer in young men. Bleyer et al. found a 2% increase in prostate cancer incidence per year since 1990 in men ages 15–40. They also identified worse 5-year survival and more aggressive disease when compared to men diagnosed at age 40 and older [8]. Despite this increase in prostate cancer among this age group, the overall incidence remains less than 1 case per million men and the most likely explanatory factor is increase in PSA screening rates. Despite a slight increase in early diagnoses, the overall low incidence rate suggests that PSA testing in this age group continues to be of low utility.

There is ongoing debate regarding the benefit of PSA screening, especially concerning decreases in prostate cancer specific mortality.8,10,11 Incidence of prostate cancer has correlated with the widespread use of PSA testing since the 1990s, and PSA testing appears to decrease the risk of metastatic disease.4,10 Considering the ongoing debate of the benefits of prostate cancer screening, diagnosis, and treatment in groups of men with the highest incidence of prostate cancer, it is unlikely there is significant benefit from PSA testing in men under the age of 40. Even testing men under the age of 45 likely attributes little value and exposes these men to risks of physical, psychological, and financial harms. This analysis also demonstrated a disproportionate risk of PSA testing in young black men. While awareness of increased risk of prostate cancer in black men is important, this result suggests that young black men may be at a disproportionately higher risk of inappropriate testing.12 Taken together, these data represent an opportunity to improve the value of PSA testing through reducing unnecessary testing in young men.

### TABLE 2

Logistic regression analysis of PSA testing by age and race/ethnicity.

| Race/ethnicity | Never been tested | Have been tested |
|----------------|-------------------|------------------|
| Non-Hisp White | 34 (38.2%)        | 55 (61.8%)       |
| Non-Hisp Black or African American | 25 (33.3%) | 50 (66.7%) |
| Hispanic       | 22 (25.9%)        | 63 (74.1%)       |
| Non-Hisp Asian | 9 (39.1%)         | 14 (60.9%)       |
| Other          | 24 (24.7%)        | 73 (75.3%)       |
| Total          | 172 (21.6%)       | 625 (78.4%)      |

| Age group        | Odds ratio | 95% CI     | p-value |
|------------------|------------|------------|---------|
| 40–44 vs. <40    | 3.61       | (2.62,4.98)| <0.0001 |
| 45–49 vs. <40    | 5.65       | (4.27,7.59)| <0.0001 |
| 50–54 vs. <40    | 11.23      | (8.51,14.81)| <0.0001 |
| 55–59 vs. <40    | 22.28      | (16.93,29.32)| <0.0001 |
| 60–64 vs. <40    | 28.48      | (21.58,37.6)| <0.0001 |
| 65–69 vs. <40    | 43.89      | (32.85,58.63)| <0.0001 |

| Race and ethnicity, non-Hisp Black/African American vs. Other | Odds ratio | 95% CI     | p-value |
|---------------------------------------------------------------|------------|------------|---------|
| <40                                                           | 2.141      | (1.17, 3.93) | 0.0141 |
| 40–44                                                         | 1.38       | (0.71, 2.68) | 0.3421 |
| 45–49                                                         | 1.669      | (0.99, 2.82) | 0.0553 |

5 | DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available at https://hints.cancer.gov/data/download-data.aspx
CONFLICT OF INTEREST
None.

AUTHOR CONTRIBUTIONS
Suzanne M. Lange MD: formal analysis, investigation, methodology, project admin, writing—original draft, writing—review and editing. Jacob P. Ambrose MS: data curation, formal analysis, investigation, software, validation, visualization, writing—review and editing. Michael C. Flynn MD: conceptualization, supervision, writing—review and editing. William T. Lowrance MD MPH MBA: conceptualization, supervision, writing—review and editing. Heidi A. Hanson PhD: conceptualization, data curation, methodology, resources, supervision, visualization, writing—review and editing. Brock B. O’Neil MD: conceptualization, formal analysis, funding acquisition, investigation, methodology, project admin, resources, supervision, visualization, writing—original draft, writing—review and editing.

ETHICAL APPROVAL
Analysis using the Health Information National Trends Survey meets criteria for non-human subjects’ research by the University of Utah institutional review board. This analysis did not require review.

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