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Decision Fatigue in Low-Value Prostate Cancer Screening

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Abstract

Background: Low-value prostate-specific antigen (PSA) testing is common yet contributes substantial waste and downstream patient harm. Decision fatigue may represent an actionable target to reduce low-value urologic care. Our aim was to determine whether low-value PSA testing patterns by outpatient clinicians are consistent with decision fatigue.

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Methods: Outpatient appointments for adult men without prostate cancer were identified at a large academic health system from 2011–2018. We assessed the association of appointment time with PSA testing likelihood, stratified by patient age and appropriateness of testing based on clinical guidelines. Appointments included those scheduled between 8:00AM and 4:59PM, with noon omitted. Urologists were examined separately from other clinicians.

Results: In 1,581,826 outpatient appointments identified, median (IQR) patient age was 54 (37–66) years, 1,256,152 (79.4%) were white, and 133,693 (8.5%) had family history of prostate cancer. PSA testing would have been appropriate in 36.8% of appointments. Clinicians ordered testing in 3.6% of appropriate and 1.8% of low-value appointments. Appropriate testing was most likely at 8:00AM (reference group). PSA testing declined through 11:00AM (OR 0.57; 95% CI, 0.50–0.64) and remained depressed through 4:00PM ($p<.001$). Low-value testing was overall less likely ($p<.001$) and followed a similar trend, declining steadily from 8:00AM (OR 0.48; 95% CI, 0.42–0.56) through 4:00PM ($p<.001$; OR 0.23; 95% CI, 0.18–0.30). Testing patterns in urologists were noticeably different.

Conclusions: Among most clinicians, outpatient PSA testing behaviors appear consistent with decision fatigue. These findings establish decision fatigue as a promising, actionable target for reducing wasteful and low-value practices in routine urologic care.

Lay Summary:

Decision fatigue causes poorer choices to be made with repetitive decision-making. This study used medical records to investigate whether decision fatigue influenced clinicians' likelihood of ordering a low-value screening test (PSA) for prostate cancer. In over 1.5 million outpatient appointments by adult men without prostate cancer, the chances of both appropriate and low-value PSA testing declined as the clinic day progressed, with a larger decline for appropriate testing. Testing patterns in urologists were different from other clinicians. Thus, outpatient PSA testing behaviors appear consistent with decision fatigue among most clinicians and interventions may reduce wasteful testing and downstream patient harms.

Precis:

This retrospective cohort study of 1,581,826 outpatient appointments spanning 2011–2018 at a large academic health system in the United States is the first study to examine the influence of decision fatigue on value-stratified healthcare behaviors, specifically low-value PSA testing in prostate cancer screening. Outpatient PSA testing behaviors among most clinicians appear to be consistent with decision fatigue, establishing decision fatigue as a promising, actionable target for reducing wasteful and low-value practices in routine urologic care.

Keywords

clinical decision-making; early detection of cancer; health care costs; health services research; physicians; prostate-specific antigen; prostatic neoplasms

1. INTRODUCTION

Low-value testing and treatment, that in which the harms outweigh the benefits or no net health benefit is provided, contributes up to \$226 billion annually in wasteful health care spending.¹ Prior studies have shown that low-cost services ordered in high volume, including prostate-specific antigen (PSA) testing, account for 93% of services and 65% of costs associated with low-value care.² Low-value PSA testing is common and constitutes up to 56% of tests ordered for early detection of prostate cancer (PCa).³ PSA guidelines differ on many fronts,^{4–8} but common themes around inappropriate testing do emerge. Examples of low-value PSA testing supported by multiple guidelines include PCa screening performed in younger patients without risk factors,^{9, 10} in men with a life expectancy of less than 10 years,^{11, 12} or with a between-test interval of less than two years in those with low prior PSA results.^{3, 13, 14} Harms of low-value PSA testing include financial waste, increased likelihood of additional testing, and detection of low-risk PCa.⁶ Additionally, patients report problems with mental health, urinary symptoms, and sexual function as a result of false-positive PCa screening results and associated downstream procedures.^{6, 15–18}

Decision fatigue, a concept described by behavioral economists, may help to explain the current abundance of low-value PSA testing. Behavioral economics differs from traditional economics by acknowledging that people do not always act rationally.^{19, 20} This framework may allow for a more accurate characterization of human behavior in non-ideal, real-world circumstances. Traditional economic theory suggests that an informed individual will make the same, rational choice each time a decision is required if circumstances remain unchanged.¹⁹ Conversely, decision fatigue describes the phenomenon in which repetitive decision-making progressively leads to less favorable and less consistent choices as finite cognitive resources deplete.^{19, 21–24}

The likelihood of decision fatigue is increased by several antecedents, nearly all of which are commonly found in clinical settings. These include high decision volume, high decision complexity, repetitive decisions, and concurrently self-regulating one's attention or emotions.²² Recent studies have found support for decision fatigue in physician behaviors correlated with time of day, such as breast and colorectal cancer screening.²⁵ However, no prior study of decision fatigue in health care has attempted to discern its distinct influences on appropriate and low-value behaviors, nor have any compared specialists to other clinicians. Moreover, the contribution of decision fatigue to the current excess of low-value PSA testing administered has yet to be examined.

PSA testing is ubiquitous and performed by a wide variety of clinicians outside of urology, with 34% of men aged 50+ and 40% of men aged 70+ receiving a PSA test in the prior year as of 2018.²⁶ The vast majority of tests occur in outpatient clinics with over half ordered by the patient's primary care physician.²⁷ Therefore, understanding the role of decision fatigue in PSA testing practices is of great importance to a broad range of clinicians aiming to increase value in their practices.

This study evaluated whether low-value PSA testing patterns by outpatient clinicians are consistent with decision fatigue. The primary outcome of interest was the proportion of

PSA tests ordered throughout the day that were appropriate or low-value, and whether temporal trends in testing appeared to be consistent with decision fatigue. We also explored differences in testing patterns by clinician specialty, focusing primarily on non-urology clinicians (henceforth “clinicians”) and secondarily on their urologist colleagues.

2. METHODS

2.1 Setting and Participants

This retrospective cohort study consisted of outpatient appointments in a large academic health system from July 2011-June 2018. All appointments involving men over the age of 18 without a previous PCa diagnosis were initially included. Final analyses were conducted on the subset of appointments scheduled between 8:00 AM and 4:59 PM, as the majority fell between these hours in preliminary investigations (Figure 1). This study was approved by the sponsoring university’s institutional review board.

2.2 Data

Data were queried from the hospital’s enterprise data warehouse. Patient characteristics of interest at time of appointment included age, race, ethnicity, Charlson Comorbidity Index, family history of PCa, and prior PSA testing. Clinician characteristics included gender, practice specialty, medical school graduation date, and medical school rank. Specialty designations were identified and stratified as “clinicians” (physicians from family medicine, general surgery, internal medicine, medicine subspecialties, surgical subspecialties, and other specialties, as well as advanced practice clinicians) or “urologists”. Appointment characteristics included the scheduled day, time, length, and type of appointment which included new, return, procedure, urgent, and other. Appointment times were grouped by hour, with 12:00 PM omitted due to low appointment volume. Appointments with missing data were included in the analyses, with a separate “Missing” category assigned as applicable. Appointment time was selected as the primary measure due to it being the best available option, as alternate metrics such as the order of appointment occurrence and lateness in the clinic schedule were not able to be reliably determined within our dataset. This method of using appointment time is validated in numerous previously published works.^{25, 28–31}

2.3 Outcome Measures

Each outpatient appointment was categorized by whether ordering a PSA test would have been appropriate or low-value. We then identified whether or not a PSA test was actually ordered and reported testing rates as a fraction of all appointments, not patients, identified. Low-value PSA testing was defined based on five major societal guidelines^{4–8} and our previously published work³ as occurring in patients meeting any of the following criteria: 1) men younger than 40 years; 2) men younger than 45 years without risk factors (i.e. African American race or family history of prostate, breast, or ovarian cancer); 3) men older than 75 years; 4) men with a life expectancy less than 10 years. This definition was consistent such that a low-value test in this study would also be considered low-value by each guideline statement during all or the majority of the study period. Of note, here we utilized the updated 2018 USPSTF guidelines as opposed to the 2012 version, as the Grade

D recommendation of the latter would have categorized all PSA tests as low-value.^{6, 32} Life expectancy was calculated using a previously validated methodology combining age and comorbidities.³³ Life expectancy was deemed less than 10 years for men aged 70–75 with 2+ comorbidities, 60–69 with 3+ comorbidities, 50–59 with 4+ comorbidities, or 45–49 with 5+ comorbidities. Additionally, repeat PSA testing was considered low-value if a prior test was conducted within 24 months and was <1 ng/mL, or within 12 months and was 1–4 ng/mL.³⁴

2.4 Statistical Analysis

The primary outcome measure was the percentage of PSA tests ordered throughout the day stratified by whether the test was appropriate or low-value, and whether temporal trends in testing appeared to be consistent with decision fatigue. Given the complex nature of appointments specifically focused on PSA testing and PCa diagnoses, we suspected that patterns among urologists may be distinct from other specialties. Preliminary analyses suggested this to be the case. Therefore, urologists were omitted from the primary analysis which was conducted on the remaining non-urology clinicians (“clinicians”), with a secondary analysis focused on urologists alone. Of note, sensitivity analyses (not shown) examined clinicians in the multiple specialty groupings specified previously and the patterns of testing observed were consistent across these groups. To present a more focused message, we chose to display these results within the broader category of non-urology clinicians. Both models were stratified by patient age at appointment as under 55 (< 55) or over 55 (>55) years. This threshold was chosen as it is the age at which current AUA and USPSTF guidelines begin supporting the use of PSA screening for PCa in the context of shared decision-making.^{8, 35} Further, a prior study using these data found that roughly half of patients fall on either side.³⁶

Descriptive statistics of patient, clinician, and appointment characteristics were stratified by the appropriateness of ordering a PSA test within each appointment. Each appointment was treated independently due to the structure of the dataset, thus we did not assign multiple appointments to a single patient. Wilcoxon rank sum tests were applied for quantitative variables, and chi-squared tests were applied for categorical variables. The association of appointment time with likelihood of an appropriate or low-value PSA test order was evaluated using logistic generalized estimating equation models and interaction terms, adjusted for clinician and appointment characteristics, for all outpatient appointments. Generalized estimating equation methods are able to account for longitudinal repeat measures and clustered measurements in data such as these.³⁷ This modeling technique allowed us to account for possible unknown correlations at a specified level, which we chose to set as the clinic site level. In preliminary analyses clustering at the clinician level was also explored, with results largely unchanged (data not shown). Spline effects were included for appointment time. Robust sandwich estimators were applied to compute standard errors, *P* values, and 95% confidence intervals, accounting for within-clinic dependencies. All analyses were conducted in R (version 3.6.0).

3. RESULTS

3.1 Study Population

Figure 1 is a heatmap of raw PSA testing frequency plotted by appointment day and time grouped to the hour. Most tests were ordered during weekday appointments scheduled between 8:00 AM and 4:00 PM, and tests were notably infrequent during the 12:00 PM lunch hour. These observations guided us to limit the analyses to these hours and omit noon from the models.

Characteristics of 1,581,826 outpatient appointments subsequently identified within the study period for men without PCa are summarized in Table 1. Median (IQR) patient age at appointment was 54 (37–66) years, with 54% under age 55. The vast majority were white with no family history of PCa and no prior PSA test on record. Nearly all appointments were return visits (65.5%) or new patients (27.3%), with most scheduled for more than 15 minutes. Missing data in variables of interest was minor, with all variables complete except for patient race (3.1% missing), clinician specialty (12.7% missing), and appointment type (0.1% missing).

Guideline-based assessments of all outpatient appointments revealed that a PSA test order would have been considered appropriate during 36.8% and low-value during 63.2% (Table 1). Clinicians actually ordered a PSA test in 2.4% of appointments, consisting of testing during 3.6% of appropriate and 1.8% of low-value appointments. Of note, these testing rates are among appointments, of which multiple can belong to any single patient. Therefore, they must be interpreted with caution when compared to other studies where individual patients are the unit of measure.

3.2 Appointment Time and PSA Testing Among Clinicians

We observed an overall decline in PSA testing rates as outpatient appointments progressed throughout the day ($p < .001$, Figure 2). This decline was present in both appropriate and low-value settings ($p < .001$), but with a proportionately larger impact seen when testing was appropriate ($p = .043$). Similar trends were observed when stratifying patients by age, though the disparity in odds by appropriateness was less pronounced in patients over age 55.

Table 2 shows the results of regression models for key appointment characteristics. At all appointment times, the odds of ordering an appropriate test were higher than those of a low-value test (all $p < .001$). Relative to an 8:00 AM appointment, the odds of clinicians ordering an appropriate PSA test declined to a nadir odds ratio of 0.57 (95% CI, 0.50–0.64) at 11:00 AM and, despite minor fluctuation, remained low throughout the afternoon. Relative to appropriate testing at 8:00 AM, the odds of a low-value test began at 0.48 (95% CI, 0.42–0.56) and declined steadily to 0.23 (95% CI, 0.18–0.30) by end of day. The rate of decline observed in the odds of appropriate PSA testing throughout the day was similar to but significantly greater than that observed in low-value testing ($p = .043$). Any testing was about half as likely in appointment types other than a new patient visit, while odds of any testing more than doubled when scheduled appointment duration exceeded 15 minutes. Longer visits likely represent a larger proportion of new patients or annual wellness checks, where testing is more common.

3.3 PSA Testing Among Urologists

Urologists ordered PSA tests during a considerably larger proportion of appointments, testing during 9.8% of visits compared to 2.4% by other clinicians. This comprised of testing during 13.8% of appointments where it was appropriate (vs. 3.6%) and 7.4% where it was low-value (vs. 1.8%). However, the ratio of appropriate to low-value testing by urologists was 1.87 compared to 2.06 by other clinicians.

Patterns of PSA testing observed in urologists differed from those in other clinicians, prompting their omission from the primary analysis (Figure 3). A similar decline in both appropriate and low-value testing was observed in the morning hours, however testing rates rebounded throughout the afternoon and were no different at 4pm ($p=.841$ and $p=.376$, respectively). This was most pronounced in appointments for patients under age 55. For patients over 55, a unique pattern with somewhat less variation in appropriate testing was observed.

4. DISCUSSION

Among a sample of over 1.5 million outpatient appointments in a large academic health system, we observed a substantial decline in clinicians' likelihood of ordering PSA tests when it would be both appropriate and low-value as the clinic day progressed. Specifically, clinicians were most likely to order a PSA test at the beginning of the day, with odds declining then leveling off by midday. Though trends were similar, a proportionately greater decline in odds of PSA testing was observed in appointments where it was appropriate versus low-value. Urologists, however, displayed a pattern of testing distinct from other clinicians which warrants further investigation. Overall rates of PSA testing were lower than expected, likely reflecting the inclusion of all health system encounters regardless of the purpose of the visit. Taken together, these findings indicate that PSA testing behaviors in most clinicians are consistent with decision fatigue.

Decision fatigue refers to the phenomenon by which repetitive decision-making progressively leads to less favorable and less consistent choices as finite cognitive resources deplete.^{19, 21–24} Put another way, it is difficult to make decisions in sequence and doing so progressively impairs executive function which may negatively impact subsequent decision-making ability.^{23, 24} The concept first gained wide attention in a study which found that judges were more likely to deny parole requests later in the day, with odds dropping to nearly zero at the end of a courtroom session but replenishing following a break.³⁸ The act of denying a parole request represents a safer and less complicated option than approving it, which judges seemed to increasingly fall back on as decision fatigue accrued. This concept of a default option can also be applied to PSA testing decisions and is an important factor to consider, as no established criteria currently exist to measure decision fatigue or its influence. Regardless of the exact degree of impact that decision fatigue may play in low-value PSA testing, interventions which can effectively target it have the potential to greatly reduce wasteful spending and low-value care when the substantial burden of downstream services is also considered.^{2, 39, 40}

To our knowledge, this is the first study to demonstrate the influence of decision fatigue on low-value PSA testing patterns. Recently, evidence of decision fatigue in other clinical scenarios has been accumulating. These include antibiotic prescribing,³⁰ opioid prescribing,^{28, 31, 41} influenza vaccine administration,²⁹ and breast and colorectal cancer screening in primary care settings.²⁵ Polyp detection during colonoscopy procedures and orthopedic surgeons' decisions to schedule surgery appear similarly affected.^{42, 43} Our decision to utilize scheduled appointment time as a primary variable, though not perfect, is supported by the methods in most of these prior published studies.^{25, 28–31} However, no study prior to ours has incorporated value stratification in the target behavior to assess the distinct influence of decision fatigue between appropriate and low-value practices. Further, we are the first to compare the relative influence of decision fatigue on specialists versus other clinicians in delivering a particular aspect of care.

These novel aspects shed new light on the mechanisms by which decision fatigue influences clinicians' screening behaviors. Primarily, we found that appropriate PSA testing was more susceptible to decision fatigue than low-value testing in outpatient settings. A possible explanation is that many clinicians take a default position against routine PSA testing, which may be related to recently shifting guidelines and contradictory positions of professional societies.^{4–8} Thus, deliberate decisions to override this default position and order a PSA test when appropriate may be easier earlier in the day. As decision fatigue accrues, clinicians may increasingly fall back on the default position to not order testing. PSA testing in low-value situations appears less affected by decision fatigue, suggesting other factors might drive these testing decisions. These may include patient factors or a default position by some clinicians to order PSA testing more readily. An alternate hypothesis to consider is that longer visits for new patients or annual physical exams were disproportionately scheduled in the early hours, which might increase the likelihood of PSA testing at those times. However, we suspect this was rare and unlikely to significantly alter our analyses as published work has consistently recommended placing longer visits later in the clinic schedule to optimize clinic workflows and patient wait times.^{44–46}

Manipulating defaults is a behavioral economics strategy that could be mobilized to combat decision fatigue. Defaults harness the status quo bias, or the aversion to change, inherent in human decision making. The default option is the one initially presented to a decision-maker and carries significant weight in the decision's outcome regardless of whether it is objectively the best option.^{47–49} This is the mechanism behind the general effectiveness of opt-out programs compared to opt-in alternatives, as sticking with the default choice presented requires less effort than actively opting for an alternative.⁴⁷ Published examples applying defaults have shown them to be effective in increasing rates of adult organ donation, influenza vaccination, and generic medication prescription.^{50–52}

Defaults are a powerful target for intervention as they likely play a large role in low-value care resulting from decision fatigue.⁴² A PSA testing decision is an opt-in scenario and the default position among most clinicians may be "do not test". That is, when faced with the complex and cognitively taxing process of deciding whether or not a given patient should receive a PSA test, clinicians most often fall back on the default position and opt to forego testing. Both appropriate and low-value decisions appear to be subject to this default,

as evidenced by the temporal decline in both testing types seen in the current study. As clinicians accumulate decision fatigue throughout the day, their decision-making appears to become more heavily reliant on the default position and PSA testing rates subsequently decline regardless of testing appropriateness.

Urologists displayed a different pattern of PSA testing which may be better explained by behaviors and factors other than decision fatigue. There is inherently less randomness in PSA testing for patients being seen by a urologist. These patients likely have more reasons to be screened, prompting the initial urology referral from their physician, even if a PSA test is ultimately not appropriate. Additionally, specialists may maintain a different default position than most other clinicians or be less likely to revert to it. Evidence suggests that the influence of default positions is reduced for those with strongly held preferences.^{50, 53} In the case of urologists, a closer familiarity with the literature surrounding PSA testing and more impassioned views regarding its value may be producing this effect.

Our findings represent an important step forward in identifying actionable targets to reduce low-value practices in cancer screening, but inherent limitations must be considered. This study was conducted at a single academic institution with below average patient diversity, and as such our results may not be generalizable to other practice models, patient demographics, or geographic regions. Furthermore, the retrospective observational nature of this study entails the usual limitations, such as potential susceptibility to unmeasured confounding factors. However, we adjusted for patient, clinician, and appointment characteristics to mitigate this risk, though not all variables were ideal. Appointment time and duration, for example, relied on the time the visit was scheduled for and was unable to factor in the actual time the visit began and ended. Lateness in the clinic schedule has been shown to contribute to low-value outpatient practices and thus must be adequately accounted for in future analyses.⁴¹ Appointment type was limited to general categories and lacked granular detail such as whether a visit was for an annual physical exam. If clinicians preferentially scheduled these earlier in the day it could have produced a bias that was unaccounted for in our analyses, though evidence suggests this scheduling pattern is not the norm.^{44–46}

Additionally, the shifting nature of PSA testing guidelines in recent years may have caused our study's definition of low-value testing to be incongruent with actual practice guidelines during some aspects of the study period. This risk was intentionally mitigated by choosing a definition which was consistently considered low-value across five separate guideline statements. Due to structural limitations in the dataset we also needed to treat each appointment as unique, meaning that multiple appointments and PSA tests could have potentially belonged to a single patient without our knowledge. This may have impacted the PSA value assessments based on repeat testing interval, though any effect was likely limited within the large sample size. Further, the generalized estimating equation methods we employed are appropriately designed to handle repeat measures in data such as these.

Decision fatigue is an important addition to the relatively slim repertoire of known factors driving low-value care. Our findings—namely, support for decision fatigue's influence on PSA testing decisions by most clinicians—provide an actionable target for novel strategies

to reduce waste in urologic care. Efforts targeted specifically at alleviating decision fatigue may benefit by leveraging other concepts in the behavioral economics playbook.^{54, 55} With careful design, these initiatives may be able to reduce low-value PSA testing practices without requiring undue effort by the overburdened clinicians who are already struggling to make appropriate PSA testing decisions.

Clinical decision support, which has been effective in reducing low-value care in other overused diagnostic tests,^{56, 57} is one promising solution. Implemented into the electronic medical record, a clinical decision support tool aimed at improving value in PSA ordering could synthesize patient data and guideline statements to generate tailored default positions unique to the patient being seen. As with any clinical decision support, careful design would be essential to avoid generating alert fatigue even as decision fatigue is curtailed.⁵⁸ Further studies will be necessary to determine if such a tool will be equally effective in specialists such as urologists, whose PSA testing practices may be explained to a greater degree by factors other than decision fatigue.

In conclusion, outpatient PSA testing rates declined and remained depressed as the clinic day progressed in a pattern that is consistent with clinician decision fatigue. This effect was seen in both appropriate and low-value testing scenarios, with appropriate testing affected to a significantly greater degree. PSA testing behaviors among urologists were distinct from those of other clinicians, indicating that factors other than decision fatigue may better explain temporal variations in care delivered by specialists. These findings establish decision fatigue as a promising and actionable target for reducing wasteful spending and low-value practices. Future studies should further investigate the role of defaults in the PSA testing practices of specialists compared to other clinicians. Interventions aimed at improving value in PSA testing might employ clinical decision support, which can be effective in the setting of decision fatigue.^{29, 58}

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Figure 1. Distribution of Outpatient Appointments Resulting in a PSA Test Order

Heatmap shows the absolute number of PSA tests ordered during outpatient appointments from July 2011-June 2018, stratified by day and hour of appointment. Appointment times are grouped to the start of the hour (e.g., those scheduled at 8:00 AM, 8:15 AM, and 8:30 AM, etc. were grouped to 8:00 AM).

Figure 2. Clinicians' Trends in PSA Testing Likelihood by Appropriateness

Graphs show the adjusted odds of a PSA test being ordered by appropriateness and hour of outpatient appointment (A), stratified by patient age as ≤ 55 (B) and >55 (C) years. Clinicians includes physicians from family medicine, general surgery, internal medicine, medicine subspecialties, surgical subspecialties, and other specialties, as well as advanced practice clinicians. Urologists are presented separately in Figure 3. Appointment times are grouped to the start of the hour. Appropriateness of PSA testing was determined for each appointment based on patient characteristics and clinical guidelines. Models were adjusted for clinician sex, medical school rank, medical school graduation year, specialty, and appointment type, scheduled duration, and day of week. Odds ratios and confidence intervals were found through spline effects.

Figure 3. Urologists' Trends in PSA Testing Likelihood by Appropriateness

Graphs show the adjusted odds of a PSA test being ordered by appropriateness and hour of outpatient appointment with a urologist (A), stratified by patient age as ≤ 55 (B) and >55 (C) years. Appointment times are grouped to the start of the hour. Appropriateness of PSA testing was determined for each appointment based on patient characteristics and clinical guidelines. Models were adjusted for clinician sex, medical school rank, medical school graduation year, specialty, and appointment type, scheduled duration, and day of week. Odds ratios and confidence intervals were found through spline effects.

Table 1.

Patient and Appointment Characteristics by Appropriateness of PSA Testing

Patient Characteristics	Appropriateness of PSA Testing, No. (%) ^{a,b,c}		
	All Appointments (n = 1581826)	Low Value (n = 999104)	Appropriate (n = 582322)
Age, median (IQR), y	54 (37–66)	42 (31–67)	58 (52–65)
55	851805 (53.8)	618811 (61.9)	232994 (40.0)
>55	729721 (46.1)	380293 (38.1)	349328 (60.0)
Race/Ethnicity			
White, non-Hispanic	1256152 (79.4)	781277 (78.2)	474875 (81.5)
Black, non-Hispanic	31152 (2.0)	21761 (2.2)	9391 (1.6)
Hispanic	140803 (8.9)	97548 (9.8)	43255 (7.4)
Asian	36324 (2.3)	24675 (2.5)	11649 (2.0)
Other	68437 (4.3)	43802 (4.4)	24635 (4.2)
Missing	48658 (3.1)	30041 (3.0)	18617 (3.2)
Charlson Comorbidity Index^d			
0	720223 (45.5)	408540 (40.9)	311683 (53.5)
1	258838 (16.4)	107814 (10.8)	151024 (25.9)
2	162193 (10.3)	77434 (7.8)	84759 (14.6)
3	440272 (27.8)	405316 (40.6)	34956 (6.0)
Family History of PCa			
No	1447833 (91.5)	920796 (92.2)	527037 (90.5)
Yes	133693 (8.5)	78308 (7.8)	55385 (9.5)
Prior PSA Level (ng/mL)			
0–1	148237 (9.4)	79138 (7.9)	69099 (11.9)
1–2	73498 (4.6)	37659 (3.8)	35839 (6.2)
2–3	31948 (2.0)	17642 (1.8)	14306 (2.5)
3–6	32043 (2.0)	18821 (1.9)	13222 (2.3)
6	12254 (0.8)	7401 (0.7)	4853 (0.8)
No Prior Test	1283546 (81.1)	838443 (83.9)	445103 (76.4)
Appointment Characteristics			
Clinician Specialty			
Non-urology ^e	1352213 (85.5)	860035 (86.1)	492178 (84.5)
Urology	29122 (1.8)	18320 (1.8)	10802 (1.9)
Missing	200191 (12.7)	120749 (12.1)	79442 (13.6)
Appointment Type			
New	431493 (27.3)	264079 (26.4)	167414 (28.7)
Return	1036650 (65.5)	661443 (66.2)	375207 (64.4)
Procedure	37088 (2.3)	22580 (2.3)	14508 (2.5)
Urgent	41523 (2.6)	27893 (2.8)	13630 (2.3)

Patient Characteristics	Appropriateness of PSA Testing, No. (%) ^{a,b,c}		
	All Appointments (n = 1581826)	Low Value (n = 999104)	Appropriate (n = 582322)
Other	33776 (2.1)	22539 (2.3)	11237 (1.9)
Missing	996 (0.1)	570 (0.1)	426 (0.1)
Scheduled Duration, min			
15	523593 (33.1)	312945 (31.3)	210648 (36.2)
16–30	734782 (46.5)	480557 (48.1)	254225 (43.7)
>30	323151 (20.4)	205602 (20.6)	117549 (20.2)

Abbreviations: IQR, interquartile range. PCa, prostate cancer. PSA, prostate-specific antigen.

SI conversion factor: To convert PSA to micrograms per liter, multiply by 1.0.

^a Appropriateness of PSA testing was determined for each appointment based on patient characteristics and clinical guidelines. Actual rates of testing varied and are reported in the text.

^b Percentages may not sum to 100 due to rounding.

^c All between-group differences were significant at $P < 0.001$.

^d Greater numbers indicate more comorbidities.

^e Includes physicians from family medicine, general surgery, internal medicine, medicine subspecialties, and surgical subspecialties, as well as advanced practice clinicians. Urologists are presented separately.

Table 2.

Adjusted Odds of a PSA Test Order by Appropriateness and Clinician Specialty

Characteristic ^a	Adjusted OR (95% CI)	
	Clinicians ^b	Urologists
Appointment Type		
New	1 (reference)	1 (reference)
Return	0.56 (0.33, 0.95)	0.32 (0.18, 0.56)
Procedure	0.66 (0.53, 0.81)	1.02 (0.74, 1.40)
Urgent ^c	0.37 (0.27, 0.50)	NA
Other	0.51 (0.31, 0.83)	1.10 (0.69, 1.74)
Scheduled Duration, min		
15 mins	1 (reference)	1 (reference)
16–30 mins	2.01 (1.54, 2.62)	0.72 (0.48, 1.07)
>30 mins	2.35 (1.55, 3.58)	1.06 (0.83, 1.35)
Appointment Hour ^{d,e}		
Appropriate		
8 AM	1 (reference)	1 (reference)
9 AM	0.81 (0.74, 0.88)	0.91 (0.77, 1.08)
10 AM	0.65 (0.58, 0.72)	0.83 (0.60, 1.16)
11 AM	0.57 (0.50, 0.64)	0.77 (0.49, 1.22)
1 PM	0.59 (0.50, 0.70)	0.76 (0.50, 1.16)
2 PM	0.63 (0.53, 0.75)	0.82 (0.62, 1.09)
3 PM	0.63 (0.54, 0.74)	0.92 (0.71, 1.19)
4 PM	0.59 (0.48, 0.72)	1.04 (0.70, 1.54)
Low Value		
8 AM	0.48 (0.42, 0.56)	0.75 (0.47, 1.21)
9 AM	0.40 (0.34, 0.48)	0.61 (0.39, 0.96)
10 AM	0.34 (0.28, 0.41)	0.48 (0.31, 0.76)
11 AM	0.30 (0.25, 0.37)	0.38 (0.24, 0.60)
1 PM	0.30 (0.24, 0.37)	0.30 (0.19, 0.47)
2 PM	0.29 (0.24, 0.36)	0.33 (0.20, 0.54)
3 PM	0.27 (0.22, 0.33)	0.41 (0.23, 0.73)
4 PM	0.23 (0.18, 0.30)	0.54 (0.29, 1.02)

Abbreviations: CI, confidence interval. NA, not applicable. OR, odds ratio. PSA, prostate-specific antigen.

^aOdds modeled for all appointments except where specified by appropriateness. Characteristics adjusted for in models but omitted from this table include clinician sex, medical school rank, medical school graduation year, specialty, and appointment day of week.

^bIncludes physicians from family medicine, general surgery, internal medicine, medicine subspecialties, and surgical subspecialties, as well as advanced practice clinicians. Urologists are presented separately.

^cNo OR available for urologists due to inadequate number of urgent appointments.

^d Appointment times are grouped to the start of the hour (e.g., those scheduled at 8:00 AM, 8:15 AM, 8:30 AM, etc. were grouped to 8:00 AM) with noon omitted.

^e Adjusted ORs represent the relative odds of a PSA test being ordered for each additional hour after 8 AM, with 8 AM for appropriate encounters set as the reference for both groups. ORs and confidence intervals for hour of appointment were found through spline effects.

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