

Determinants of participation in prostate cancer screening: A simple analytical framework to account for healthy-user bias

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In Japan at present, fecal occult blood testing (FOBT) is recommended for cancer screening while routine population-based prostate-specific antigen (PSA) screening is not. In future it may be necessary to increase participation in the former and decrease it in the latter. Our objectives were to explore determinants of PSA-screening participation while simultaneously taking into account factors associated with FOBT. Data were gathered from a cross-sectional study conducted with random sampling of 6191 adults in Osaka city in 2011. Of 3244 subjects (return rate 52.4%), 936 men aged 40–64 years were analyzed using log-binomial regression to explore factors related to PSA-screening participation within 1 year. Only responders for cancer screening, defined as men who participated in either FOBT or PSA-testing, were used as main study subjects. Men who were older (prevalence ratio [PR] [95% confidence interval (CI)] = 2.17 [1.43, 3.28] for 60–64 years compared with 40–49 years), had technical or junior college education (PR [95% CI] = 1.76 [1.19, 2.59] compared with men with high school or less) and followed doctors' recommendations (PR [95% CI] = 1.50 [1.00, 2.26]) were significantly more likely to have PSA-screening after multiple variable adjustment among cancer-screening responders. Attenuation in PR of hypothesized common factors was observed among cancer-screening responders compared with the usual approach (among total subjects). Using the analytical framework to account for healthy-user bias, we found three factors related to participation in PSA-screening with attenuated association of common factors. This approach may provide a more sophisticated interpretation of participation in various screenings with different levels of recommendation.

Cancer screening is a secondary prevention measure to reduce cancer mortality and to improve future quality of life. Evidence-based effective screening should be implemented appropriately. Based on extensive evidence, the US Preventive Services Task Force (USPSTF) recommended fecal occult blood test (FOBT), as well as flexible sigmoidoscopy or colonoscopy, for colorectal cancer screening, consistent with other guidelines,^(1–3) while the USPSTF issued a screening recommendation against prostate-specific antigen (PSA) testing, “Do not use PSA-based screening for prostate cancer in all age groups of adult men” in 2012.⁽⁴⁾ Before 2012, most guidelines concluded that there was insufficient evidence to justify routine PSA-based screening and recommended shared decision-making based on appropriate information on the benefits and harms.^(5–7) Likewise in Japan, population-based colorectal cancer screening of FOBT was recommended and conducted nationwide for both men and women aged 40 years or more, following the consensus that the efficacy of FOBT was evident.⁽⁸⁾ On the other hand, although the Japanese Urological Association recommended PSA-based screening,⁽⁹⁾ another

Japanese guideline for prostate cancer screening by a study group supported by the Ministry of Health, Labour and Welfare suggested that PSA-testing should not be recommended for population-based screening programs because its efficacy was unclear.⁽¹⁰⁾ However, PSA-screening was introduced nationwide as opportunistic practice-based or population-based screening, partly because political powers promoted PSA-screening as a cancer-control action for men, which can be harmonized with breast or cervical cancer screening for women (information from several political newsletters). Population-based PSA-screening was conducted as a public service in 68% of Japanese local municipalities in 2010.⁽¹¹⁾ Although other municipalities, including Osaka, did not provide a population-based PSA screening program, residents could receive PSA-testing in practice- or workplace-based screening. Screening testing for both colorectal and prostate cancer has been disseminated worldwide, regardless of different evidence-based effectiveness.^(11,12)

In terms of the participants in these cancer screenings, generally, common factors such as age and socioeconomic

position were associated with participation in a wide range of health behaviors including cancer screening, regardless of considerable heterogeneity across cancer screenings.^(13–15) For example, older age, higher education level, regular checkup experience and family history of cancer were found as determinants of participation in colorectal cancer screening.⁽¹⁵⁾ Of these factors, older age and regular checkup were also significantly associated with PSA-screening participation.⁽¹⁵⁾ Use of lipid-lowering therapy was associated with participation in PSA testing and FOBT.⁽¹⁶⁾ Thus, same variables were observed as factors associated with participation in cancer screening (including FOBT and PSA testing) as for other health behaviors.^(13,16,17) Therefore, previous studies which compared “responders” and “non-responders” for cancer screening participation of FOBT or PSA test separately^(18,19) might only reveal common shared factors related to common health behavior participation. These common factors have been referred to as “healthy-user bias” in the comparative effectiveness research field⁽¹⁶⁾ and are important in our understanding of the nature of health behavior responders.⁽¹³⁾ However, as this bias has not been evaluated in a research field of determinants of health behavior participation, it should be carefully interpreted, especially when we explore determinants of participation in one of the various screening tests that have different features: e.g. level of recommendations or type of modalities. When we analyze multi-types of cancer screening participation simultaneously, we may need an additional analytical framework, following the suggestion by Shrank *et al.*⁽²⁰⁾ that healthy-user bias can be minimized by forming a control group from subjects who received a different preventive service. The principal aim of the comparison between “responders (preferable outcome)” and “non-responders” was to find a way to make “non-responders” into “responders” (and vice versa when a response is not preferable). However, it is not easy to yield a preferable response from non-responders. Furthermore, the availability of resources such as budget and provider capacity is limited. Therefore, we may need to reduce an inappropriate response, e.g. participation in un-recommended cancer screening, among “responders.” From this point-of-view, to analyze cancer screening participation, we used a simple analytical framework to account for healthy-user bias: i.e. only “cancer-screening responders” were used as main study subjects instead of “total subjects (including both responders and non-responders; a usual framework).” The objectives of our study were to provide details of this analytical framework and to explore factors associated with participation in un-recommended screening among men in this framework, because two types of cancer screenings, FOBT and PSA testing, have been conducted worldwide based on different recommendations.

Materials and Methods

Data. A cross-sectional study was conducted from September to November 2011 in Osaka city (population of 2.7 million) to examine overall health outcomes including cancer screening participation among working-age adults.⁽²¹⁾ We randomly sampled 6191 adults aged 25–64 years as of August 1 2011 from the governmental Basic Resident Register database, which includes all Japanese residents. Self-administered questionnaires were distributed and collected by mail. We visited recipients who did not answer at least three times with at least one visit on a weekend or in the evening. For data quality control, missing or inconsistent answers were re-tested by telephone. Three thousand two

hundred and forty-four subjects were available and provided written consent, giving a return rate of 52.4%. Men aged 40–64 years were used as study subjects to examine cancer screening participation. The study was approved by the Ethics Committee of Osaka City University.

Participants were asked if they had had a PSA test as cancer screening within the last year (yes or no); and a FOBT (yes or no). The following factors that were hypothesized to be associated with cancer screening participation were used to present characteristics of study subjects and to explore factors associated with outcome: (i) age (40–49, 50–59, or 60–64 years), (ii) educational attainment (high school or less, technical school or junior college, or university or more), (iii) working status (public or large scale workplace, fewer than 500-employee workplace, not working including retired men, or unemployed), (iv) home ownership (yes or no), (v) marital status (married, or never married/widowed/divorced), (vi) current smoker (yes or no), (vii) health checkup in the last 3 years (yes or no), (viii) Currently receiving medical treatment for major physical diseases (yes or no), (ix) cancer history including past and current status (yes or no), (x) adherence to doctor’s suggestions (yes or no), and (xi) family history of cancer (yes or no).

The question “Please choose which option best describes your attitude as to whether you follow your physician’s suggestions faithfully?” was used to constitute a variable of adherence to doctor’s suggestions. The answer was categorized as “always, usually, sometimes and rarely.” The former two answers were combined as a dichotomized variable (yes or no). Family history for cancer was defined as subjects whose father, mother, brother/sister or spouse had ever had a medical diagnosis of any cancer including colorectal, prostate or other cancers. The definitions of some covariates are shown in the Supporting Information.

Analytical framework to account for healthy-user bias. We used a simple analytical framework using only the “responders” sample to explore determinants of cancer screening participation among cancer-screening responders. The separation of “responders” and “non-responders” is important for conceptualization. “Responders” for cancer screening (at least once) may be likely to participate in all kinds of cancer screening and have common shared factors as stated in the introduction. The difference between “total subjects” analysis (usual method) and “among-responders” analysis is only whether the “non-responders” sample is included in the reference category (counterpart of outcome) or not. For cancer screening participation research, a possible combination of outcome and counterpart with responders’ definition was the case of PSA test versus only FOBT (among “responders” for at least one of either PSA test or FOBT) (Fig. 1). The reason for separating “responders” into outcome and counterpart should be rational: i.e. PSA-based screening was not recommended, regardless of participation in recommended FOBT. To investigate and interpret the applicability and the effectiveness of the framework, we used data from our previous study⁽²¹⁾ as a case of PSA testing and FOBT among men (Fig. 1) according to the population-based cancer screening recommendations.^(1,2,4,8,10,22) “Cancer-screening non-responders” were defined as men who reported no screening participation in either FOBT or PSA testing. PSA-based screening participation (with or without FOBT) was defined as an “un-recommended” participation in cancer screening. Those who reported receiving only a FOBT (without PSA-based screening) were categorized as men receiving “recommended” modality for cancer screening,

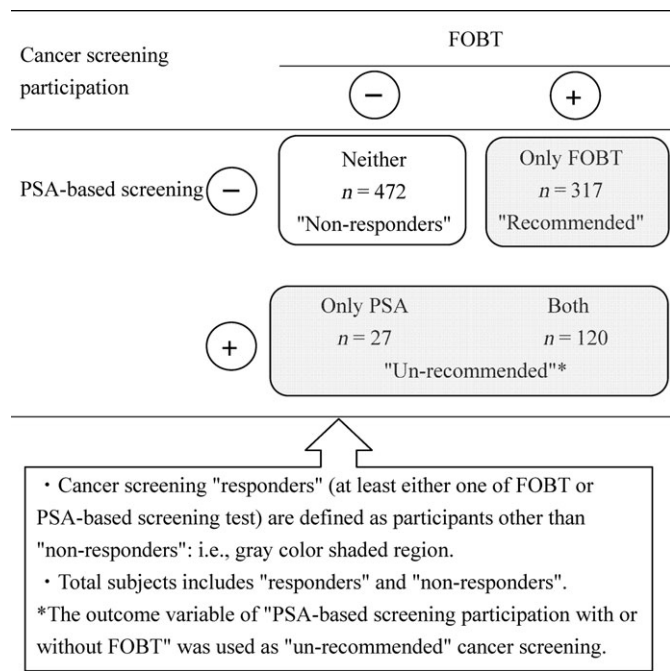


Fig. 1. Analytical sample framework for "total subjects" and "responders" analysis: the case of fecal occult blood testing (FOBT) and prostate-specific antigen (PSA) among men.

because FOBT is an acceptable and recommended screening according to Japanese and worldwide guidelines.^(2,8)

Statistical analyses. Among men aged 40–64 years (*n* = 966), men who had had a diagnosis of colorectal or prostate cancer to date (*n* = 7 for colorectum and *n* = 3 for prostate), or had missing data for FOBT (*n* = 11) or PSA testing (*n* = 18) were excluded. The remaining 936 men were analyzed as total subjects (Fig. 2). In an analytical framework to account for healthy-user bias, only responders for cancer screening (*n* = 464) were analyzed.

Prevalence and 95% confidence interval (CI) for cancer screening participation were calculated based on the *F*-distribution. Chi-square tests were used to compare the difference in cancer screening participation rates according to subjects' characteristics. Log-binomial regression models were used to calculate prevalence ratios (PRs) and 95% CIs for each outcomes, because outcomes such as PSA-based screening participation were more than 10%.⁽²³⁾ In some instances, the models did not converge and we therefore used log-Poisson models, which provide consistent but not fully efficient estimates of the PRs.⁽²⁴⁾ Univariate and multivariate analyses were used to document the crude and adjusted relationship between independent variables and cancer screening status such as PSA-based screening participation. Probability values for statistical tests were two-tailed and *P* < 0.05 was considered statistically significant. All analyses were performed using SAS version 9.2 (SAS Institute, Cary, NC, USA).

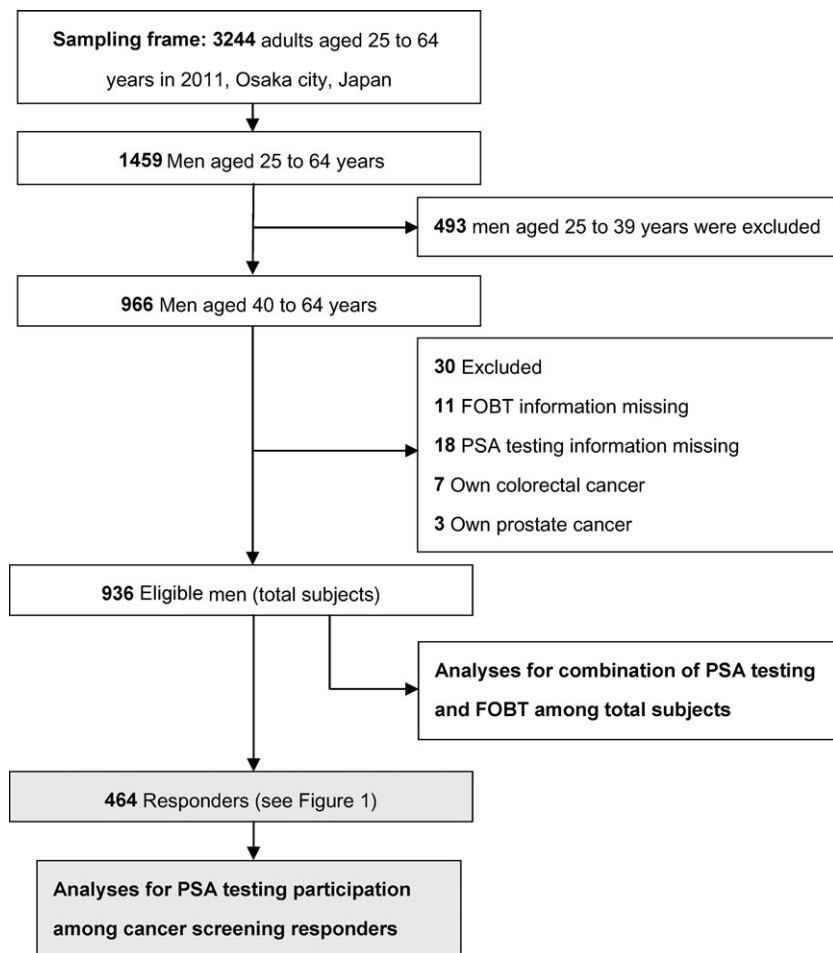


Fig. 2. Flow diagram for selection of analyzed men. FOBT, fecal occult blood testing; PSA, prostate-specific antigen.

Results

Basic characteristics and prevalence of cancer screening participation among “total study subjects” and among “cancer-screening responders” are shown in Tables 1 and S1. 15.7% of men received PSA-based screening (only PSA: 2.9% and both

PSA and FOBT: 12.8%), while 33.9% and 49.6% received only FOBT and at least either one of PSA or FOBT, respectively, among total subjects. 31.7% received PSA-based screening among cancer-screening responders. For PSA testing, the proportion of participation significantly differed for all factors

Table 1. Proportion (%) with 95% confidence interval (CI) of men undergoing screening, according to basic characteristic, among total subjects and among cancer-screening responders

Characteristics	Among total subjects			Among cancer-screening responders		
	No. subjects	Combination of PSA test and FOBT, % (95% CI)			No. responders	PSA test, % (95% CI) (un-recommended)
		PSA test (un-recommended)	Only FOBT (recommended)	At least either one (responders)		
Total	936	15.7 (13.4, 18.2)	33.9 (30.8, 37.0)	49.6 (46.3, 52.8)	464	31.7 (27.5, 36.1)
Age group, years						
40–49	368	9.5 (6.7, 13.0)*	36.7 (31.7, 41.8)	46.2 (41.0, 51.4)	170	20.6 (14.8, 27.5)*
50–59	328	18.9 (14.8, 23.6)	34.8 (29.6, 40.2)	53.7 (48.1, 59.2)	176	35.2 (28.2, 42.8)
60–64	240	20.8 (15.9, 26.5)	28.3 (22.7, 34.5)	49.2 (42.7, 55.7)	118	42.4 (33.3, 51.8)
Education group						
High school or less	481	10.4 (7.8, 13.5)*	29.7 (25.7, 34.0)*	40.1 (35.7, 44.7)*	193	25.9 (19.9, 32.7)*
Technical or junior college	122	20.5 (13.7, 28.7)	27.9 (20.1, 36.7)	48.4 (39.2, 57.6)	59	42.4 (29.6, 55.9)
University (4-years) or more	332	21.7 (17.4, 26.5)	42.2 (36.8, 47.7)	63.9 (58.4, 69.0)	212	34.0 (27.6, 40.8)
Working condition (including workplace)						
Public or large scale† workplace	195	24.1 (18.3, 30.7)*	49.2 (42.0, 56.5)*	73.3 (66.5, 79.4)*	143	32.9 (25.2, 41.2)
Fewer than 500 employees workplace	569	13.5 (10.8, 16.6)	33.2 (29.4, 37.3)	46.7 (42.6, 50.9)	266	28.9 (23.6, 34.8)
Not working including retired men	100	19.0 (11.8, 28.1)	20.0 (12.7, 29.2)	39.0 (29.4, 49.3)	39	48.7 (32.4, 65.2)
Unemployed	71	5.6 (1.6, 13.8)	16.9 (9.1, 27.7)	22.5 (13.5, 34.0)	16	25.0 (7.3, 52.4)
Home owner						
Yes	546	18.9 (15.7, 22.4)*	36.6 (32.6, 40.8)*	55.5 (51.2, 59.7)*	303	34.0 (28.7, 39.6)
No	386	11.1 (8.2, 14.7)	30.1 (25.5, 34.9)	41.2 (36.2, 46.3)	159	27.0 (20.3, 34.7)
Marital status						
Married	600	18.5 (15.5, 21.8)*	39.3 (35.4, 43.4)*	57.8 (53.8, 61.8)*	347	32.0 (27.1, 37.2)
Never married/Widowed/Divorced	336	10.7 (7.6, 14.5)	24.1 (19.6, 29.0)	34.8 (29.7, 40.2)	117	30.8 (22.6, 40.0)
Current smoker						
No	573	18.5 (15.4, 21.9)*	36.0 (32.0, 40.0)	54.5 (50.3, 58.6)*	312	34.0 (28.7, 39.5)
Yes	363	11.3 (8.2, 15.0)	30.6 (25.9, 35.6)	41.9 (36.7, 47.1)	152	27.0 (20.1, 34.8)
Health checkup in the last 3 years						
No	276	4.3 (2.3, 7.5)*	10.1 (6.8, 14.3)*	14.5 (10.6, 19.2)*	40	30.0 (16.6, 46.5)
Yes	655	20.5 (17.4, 23.8)	43.8 (40.0, 47.7)	64.3 (60.5, 67.9)	421	31.8 (27.4, 36.5)
Current medical treatment for physical diseases						
No	653	13.5 (11.0, 16.3)*	33.8 (30.2, 37.6)	47.3 (43.4, 51.2)*	309	28.5 (23.5, 33.9)*
Yes	262	21.4 (16.6, 26.8)	34.0 (28.3, 40.1)	55.3 (49.1, 61.5)	145	38.6 (30.7, 47.1)
Cancer history including past and current status						
No	907	15.0 (12.7, 17.5)*	34.2 (31.1, 37.4)	49.2 (45.9, 52.5)	446	30.5 (26.3, 35.0)*
Yes	28	39.3 (21.5, 59.4)	25.0 (10.7, 44.9)	64.3 (44.1, 81.4)	18	61.1 (35.7, 82.7)
Adherence to doctors' suggestions						
No	232	9.1 (5.7, 13.5)*	34.5 (28.4, 41.0)	43.5 (37.1, 50.2)*	101	20.8 (13.4, 30.0)*
Yes	701	17.8 (15.1, 20.9)	33.8 (30.3, 37.4)	51.6 (47.9, 55.4)	362	34.5 (29.6, 39.7)
Family history of cancer						
No	520	14.4 (11.5, 17.7)	32.3 (28.3, 36.5)	46.7 (42.4, 51.1)	243	30.9 (25.1, 37.1)
Yes	416	17.3 (13.8, 21.3)	35.8 (31.2, 40.6)	53.1 (48.2, 58.0)	221	32.6 (26.4, 39.2)

FOBT; fecal occult blood test; PSA; prostate-specific antigen. The numbers of missing values were 1 for education, 1 for working condition, 4 for home owner, 5 for health checkup, 21 for current medical treatment, 1 for cancer history and 3 for adherence among total subjects; 2 for home owner, 3 for health checkup, 10 for current medical treatment and 1 for adherence among cancer-screening responders. * $P < 0.05$ The * mark was only placed by the first factor of the characteristic. †Five hundred or more employees.

except for family history of cancer among total subjects, although there were relatively fewer significant differences among cancer-screening responders. Regarding total subjects, higher proportions of participation for PSA-based or FOBT screening (combination of PSA test and FOBT) were observed among subjects who were highly educated, owned their home, were married, and did not smoke. Men who were employed in a public or large scale workplace were much more likely to receive cancer screening (all three categories) than those in other working conditions. Men who had recently had a checkup, were currently receiving medical treatment, or adhered to doctors' suggestions were also more likely to receive cancer screening than the opposite categories, except for some cells. Among cancer-screening responders, a higher proportion of PSA screening participation was observed among

subjects who were older, had technical or junior college education, were currently receiving treatment, had a cancer history and adhered to doctors' suggestions.

Table 2 shows the multivariate PRs for PSA-based screening participation among total subjects and among cancer-screening responders. Among total subjects, men with university or more education (PR [95% CI] = 1.64 [1.16, 2.31]), those who had recently had a checkup (PR [95% CI] = 3.87 [2.18, 6.89]) or those with a cancer history (PR [95% CI] = 1.58 [1.02, 2.46]) were significantly likely to be screened, whereas those who were employed in small scale workplace (PR [95% CI] = 0.66 [0.48, 0.92]), or were unemployed (PR [95% CI] = 0.36 [0.15, 0.90]) were less likely to be screened than those who were employed in a public or large scale workplace. However, men with these characteristic categories (which showed significance

Table 2. Multivariate prevalence ratios (PRs) with 95% confidence interval (CI) of men undergoing prostate-specific antigen (PSA) test, according to basic characteristic among total subjects and among cancer-screening responders

Characteristics	No. total subjects/responders	Multivariate model* for PSA test			
		Among total subjects		Among cancer-screening responders	
		PRs (95% CI)	<i>P</i>	PRs (95% CI)	<i>P</i>
Age group, years					
40–49	368/170	1 (reference)		1 (reference)	
50–59	328/176	1.77 (1.18, 2.65)	0.0055	1.72 (1.17, 2.53)	0.0054
60–64	240/118	2.48 (1.59, 3.85)	<0.0001	2.17 (1.43, 3.28)	0.0003
Education group					
High school or less	481/193	1 (reference)		1 (reference)	
Technical or junior college	122/59	1.75 (1.09, 2.82)	0.0208	1.76 (1.19, 2.59)	0.0044
University (4-years) or more	332/212	1.64 (1.16, 2.31)	0.0053	1.23 (0.89, 1.69)	0.2159
Working condition					
Public or large scale† workplace	195/143	1 (reference)		1 (reference)	
Fewer than 500 employees workplace	569/266	0.66 (0.48, 0.92)	0.0143	0.81 (0.60, 1.11)	0.1963
Not working including retired men	100/39	0.98 (0.60, 1.60)	0.9371	1.14 (0.71, 1.82)	0.5836
Unemployed	71/16	0.36 (0.15, 0.90)	0.0295	0.69 (0.32, 1.47)	0.3338
Home owner					
Yes	546/303	1 (reference)		1 (reference)	
No	386/159	0.75 (0.53, 1.05)	0.0967	0.79 (0.57, 1.09)	0.1501
Marital status					
Married	600/347	1 (reference)		1 (reference)	
Never married/widowed/divorced	336/117	1.11 (0.77, 1.59)	0.5722	1.15 (0.82, 1.61)	0.4256
Current smoker					
No	573/312	1 (reference)		1 (reference)	
Yes	363/152	0.80 (0.57, 1.12)	0.1982	0.83 (0.60, 1.15)	0.2715
Health checkup in the last 3 years					
No	276/40	1 (reference)		1 (reference)	
Yes	655/421	3.87 (2.18, 6.89)	<0.0001	1.25 (0.76, 2.04)	0.3743
Current medical treatment for physical diseases					
No	653/309	1 (reference)		1 (reference)	
Yes	262/145	1.08 (0.79, 1.47)	0.6387	0.98 (0.73, 1.32)	0.9148
Cancer history including past and current status					
No	907/446	1 (reference)		1 (reference)	
Yes	28/18	1.58 (1.02, 2.46)	0.0407	1.44 (0.94, 2.22)	0.0974
Adherence to doctors' suggestions					
No	232/101	1 (reference)		1 (reference)	
Yes	701/362	1.57 (1.02, 2.42)	0.0407	1.50 (1.00, 2.26)	0.0499
Family history of cancer					
No	520/243	1 (reference)		1 (reference)	
Yes	416/221	0.93 (0.70, 1.24)	0.6166	1.01 (0.77, 1.33)	0.9176

*Adjusted for listed all variables. †Five hundred or more employees. Boldface indicates statistical significance of *P* < 0.05.

in total subjects) did not retain statistical significance for PSA-based screening participation among cancer-screening responders. For example, PR (95% CI) of recent health checkup was 1.25 (0.76, 2.04), considerably lower than among total subjects. Among both total subjects and cancer-screening responders, men who were older (e.g. PR [95% CI] = 2.17 [1.43, 3.28] for 60–64 years among responders), had technical or junior college education (PR [95% CI] = 1.76 [1.19, 2.59] compared with men with high school or less among responders) and followed doctors' recommendations (PR [95% CI] = 1.50 [1.00, 2.26] among responders) were significantly more likely to be screened for PSA than the reference categories after multivariate adjustment.

Discussion

We applied a simple analytical framework to account for healthy-user bias and found three factors related to participation in an un-recommended PSA-based cancer screening: i.e. older age, technical college or junior college education and adherence to doctors' suggestions were determinants of participation in PSA screening among cancer-screening responders. Although it is often seen that older or highly educated men are more likely to be screened than younger or less educated,^(13,15) the result of adherence to doctors' suggestions may stimulate further discussion.

Prostate-specific antigen-based screening was used more often among men who followed doctors' recommendations than those who did not. Generally, cancer screening, including PSA-based screening, has been promoted by the media, celebrities and local government.^(11,25) Furthermore, not only has there been unthinking endorsement of patient screening by physicians but also a lack of negative feedback indicating that early detection and treatment may result in more harm than benefits and this might increase participation in PSA testing.⁽²⁵⁾ Despite long controversies about the efficacy of PSA-based screening,⁽⁴⁾ it is possible many doctors have not adequately explained the probability that the harm outweighs the benefits,^(22,26) especially in Japan where the urological association recommended PSA-screening⁽⁹⁾ and doctors' consultation hours are very short.⁽²⁷⁾ Promoting discussion between patients and doctors (including consideration of the harm such as overdiagnosis and overtreatment), although we need more time in practice, is required to reduce potentially inappropriate PSA use.

Analytical framework of the study. Socioeconomic factors such as workplace size (including public offices) and unemployment were obtained as determinants of cancer-screening responders (Table S2), although other personal factors including current smoking, following doctors' recommendations and family history were not significantly associated with participation in at least one FOBT or PSA screening. In particular, recent checkup experience was considered as a strongly institutionalized factor, because the Japanese health care system is mainly maintained in large-scale workplaces or public offices where annual employee health checks with cancer screening options are mandatory.⁽²⁸⁾ Financial incentives tend to make health care institutions and the industry support screening.⁽²⁵⁾ Therefore, when we assessed cancer screening participation among total subjects, recent checkup experience was the most influential factor for participation (Table S2). Because this association was considerably attenuated in the analysis among cancer-screening responders (PR [95% CI] for checkup decreased from 3.87 [2.18, 6.89] to 1.25 [0.76, 2.04]), this

attenuation might imply positive utility of the analytical framework to account for healthy-user bias. Although checkup experience was a shared accelerator for both FOBT and PSA test participation, it might not be useful when increasing FOBT and decreasing PSA testing. This analytical approach may enable us to produce a more sophisticated interpretation that could lead to the development of better informed and theory-based interventions to reduce an un-recommended screening use.

In other words, the analytical framework to account for healthy-user bias may be able to meaningfully treat the influence of the common shared factors for cancer-screening responders in different settings. When we examine the combination of two preferable screenings with positive recommendations, e.g. FOBT and mammography among women, the shared factors for cancer-screening responders have positive association with both screenings. In the case of PSA and FOBT, because there are different recommendations for these two screenings, we may need to reduce the influence of the common shared factors by accounting for healthy-user bias. Therefore, interpretation of the results and applicable implications for future intervention of the shared factors should be different according to the status of two screenings in terms of recommendations. Additional application of this analytical framework in other settings should be considered in future.

Limitations. There are several limitations to this study. First, the nature of screening procedures for PSA testing and FOBT is different. Because patient perceptions of FOBT are frequently negative in contrast to the ease of acceptance of the PSA blood test,⁽¹⁵⁾ the utility of "cancer-screening responders" should be interpreted carefully with consideration of the modalities, cost and barriers to access other than recommendations. Second, as it is a cross-sectional study, causal interpretations of the results cannot be established. Participants who attended cancer screening might be more likely to report their adherence to doctors' suggestions and vice versa. Our response rate (52%) was not high, which is an unavoidable feature of such population surveys and may limit the generalization of the study findings. Third, data for cancer screening participation was collected by self-reported questionnaire. According to a study of meta-analysis, sensitivity and specificity of self-reported cancer screening were 0.71 and 0.73, respectively, for PSA testing and 0.82 and 0.78, respectively, for FOBT.⁽²⁹⁾ Fourth, psychosocial variables such as worry, or concern about prostate cancer were not available in the analysis, although these were associated with prostate cancer screening.⁽³⁰⁾ However, socioeconomic positions such as education, which were considered to be highly correlated with the psychosocial factors, could be adjusted.⁽³¹⁾

In conclusion, we found that men who were older, had middle level education and followed doctors' recommendations were more likely to participate in PSA-based cancer screening with attenuated association of common factors, using a simple analytical framework to account for healthy-user bias. This analytical approach and results may provide a more sophisticated interpretation for participation in various screenings with different levels of recommendation.

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Disclosure Statement

The authors have no conflict of interest.

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Supporting Information

Additional supporting information may be found in the online version of this article:

Data S1. Covariates.

Table S1. Proportion (%) with 95% confidence interval of men undergoing screening, according to basic characteristic, among total men.

Table S2. Univariate and multivariate prevalence ratios with 95% confidence interval for each combination of prostate-specific antigen (PSA) test and fecal occult blood testing (FOBT) participation among total men.