Association Between Online Information Seeking and Guideline Adherence in Breast and Prostate Cancer Screening

by
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A thesis submitted to the faculty of the Rollins School of Public Health at Emory University in partial fulfillment of the requirements for the Masters of Science in Public Health in the Department of Health Policy and Management.

Atlanta, Georgia
2017

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2015

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An abstract of

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Abstract

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Using 2012 – 2014 data on health information seeking, we analyzed the association between online information seeking and guideline concordance in breast and prostate cancer screening. No statistically significant association was found between online information seeking and guideline concordance, after adjusting for potentially confounding influences. We decomposed the differences in screening rates between online information seekers and non-seekers to gauge the effect of online information seeking on screening decisions at individual-level. The effect of online information seeking differed by gender. These findings can be used to tailor approaches to accurately inform patients on cancer screening and to provide higher quality of preventive care.

Acknowledgment

The author would like to thank his Committee Chair, Joseph Lipscomb, PhD, and committee members, Christopher Filson, MD MS, Peter Joski, MSPH, and Silke von Esenwein, PhD, for all their help and guidance. The author would also like to thank his fellow MSPH classmates for support and assistance.

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Chapter I. Introduction

Although recommendations for cancer screening often vary across different organizations, most guidelines consistently incorporate informed decision-making (IDM) as a required element. Emphasizing the importance of a fully-informed patient is an acknowledgement of the potential benefits and harms of cancer screening (e.g., overdiagnosis and overtreatment). To satisfy the requirements of informed decision making, patients must be aware of their individual risks of cancer and discuss benefits and harms of screening with their physicians. [1] Research shows that patients who received information were found to be more satisfied in their decision making than those who did not receive information. [2]

Though guidelines have highlighted the value of informed decision-making related to cancer screening, studies have shown that a low proportion of patients are aware of the potential harms of cancer screening and that patients often overestimate benefits and underweight potential risks and errors. [3-8] To address this, various interventions at clinic sites have been employed to raise awareness among patients before they receive cancer screening. Though results were mixed, some studies have shown such interventions can increase patient perception about potential harms of screening and facilitate discussion between physicians and patients. [9-13] However, little is known regarding this issue from the patients' perspective; that is, how they acquire information and how their behaviors affect screening decisions. In the case of hormone replacement therapy for menopause, women utilized information from the Internet, as well as other sources, to become fully confident in their choices. [14]

In order to more clearly characterize the patient-centered issues surrounding informed-decision making, we performed a study that examined the relationship between online information-seeking and receipt of cancer screening among men and women potentially eligible for breast and prostate cancer screening, respectively. In addition, as African-American race is an established risk factor for worsened prostate and breast cancer mortality, we examined whether there were differences in online information-seeking based on race, and whether there were any interactions between race, online information-seeking, and receipt of cancer screening. We hypothesize that online information seeking would likely increase screening for the recommended age groups, and likely decrease screening for the non-recommended age groups. Findings from this work may point the way to interventions to identify gaps in online information-seeking and potentially optimize cancer screening among those as greatest risk for death from breast and prostate cancer.

Chapter II. Literature Review

In this chapter, we summarize controversies around breast and prostate cancer screening, interventions at clinic sites and their limitations in raising awareness in the general population, online information-seeking, and disparities in breast and prostate cancer screening among different ethnic groups and geographic regions.

Breast & Prostate Cancer

Breast and prostate cancer are cells in the breast and the prostate gland growing out of control. [15-16] Breast and prostate cancer are the most commonly diagnosed non-cutaneous cancer among women and men, respectively. Specifically, about 1 in 7 men develop prostate cancer during their lifetimes, and 1 in 8 women develop breast cancer, and each is the (gender-specific) second leading cause of cancer deaths behind lung cancer. [15-16] Risk factors include age, race, family history, inherited genes such as BRCA1 and BRCA2, and dietary factors, among others. [15-16]

However, though the overall number of deaths may be high, the overall death rates (i.e., deaths/1,000 diagnosed) for both cancers are generally low. In the case of prostate cancer, the introduction of prostate cancer screening with prostate-specific antigen (PSA) testing resulted in a stage migration, where many men were diagnosed with—and treated for—small, slow-growing tumors unlikely to results in cancer-specific death. [17] For various reasons, the post-PSA screening era heralded a nearly 20% decrease in prostate cancer mortality rates. [18] For breast cancer, better treatment, higher screening rates, and increased awareness attributed to a decrease in death rates from breast cancer among younger population. [15-16]

Questionable Benefits for Prostate Cancer Screening

The prostate-specific antigen (PSA) blood test is a commonly used test to screen for prostate cancer. Two notable clinical trials, the Prostate, Lung, Colorectal, and Ovarian Cancer Screening Trial study (PLCO) and the European Randomized Study of Screening for Prostate Cancer (ERSPC), observed over time whether PSA tests had an impact on reducing prostate cancer mortality. [19, 20] The PLCO study, which was conducted in the United States, found no reduction in prostate cancer mortality [19], though it is important to acknowledge considerable contamination in the control arm. [21] The ERSPC study, which was done in Europe, found a decrease in mortality of approximately 1 death per 1000 men for only the age group of 55 to 69 years. [19, 20]

Breast Cancer Screening – A Clearer Picture?

Compared to PSA testing, breast cancer screening has been shown to provide benefits for women aged 50-74. A randomized clinical trial by Kalager et. al showed that breast cancer mortality reductions in the screening group of 7.2 deaths per 100,000 person-years. [22] However, they also found that only a third of the total reduction in mortality, 2.4 deaths per

100,000 person-years, could be attributed to screening alone. This reduction is also only for women aged 50 to 69 years; for women between the ages of 20 to 49 years, they found that there is no significant difference between non-screening and screening groups. [23]

Guidelines and Harms of Prostate and Breast Screening

Based on the mixed survival results from the PLCO and ERSPC trials, combined with concerns related to harms of prostate biopsies and overtreatment, in 2012 the United States Preventive Services Task Force (USPSTF) recommended against routine prostate-specific antigen (PSA) testing for all men with average risk, regardless of age. [24, 25] In addition, for breast cancer screening, the USPSTF recommended that women under the age of 50 make individual decisions for obtaining mammograms based on personal risks and preferences and suggested that women consult their physicians to understand the risks associated with screening. [24, 25] The USPSTF recommends against routine screening because of uncertainties and harms from screening results.

A recent study has estimated that up to 80% of positive PSA test results are false-positives. [26] For breast cancer, a study estimated that 99% of positive mammogram results for women between the ages of 30 and 39 are false-positives. [27] Most people who have positive test results undergo additional testing and biopsies, which could lead to additional costs of $1,500 to $3,000, psychological harms and anxiety, and could cause side effects such as bleeding, infection, and urinal difficulties. [28-31] Despite the harms, studies have found that 29% of women under 40 have received a mammogram and that more than half of men with little to no risk for prostate cancer receive a PSA test. [32, 33]

Low Awareness of Current Guidelines and Harms of Screening

Because of the potential harms of screening, the USPSTF and other organizations also strongly recommend informed decision-making. [24, 25] IDM can be described as an individual's voluntary and consistent decision made based on his or her preferences and values after "understanding the disease or condition being addressed and what the clinical service involves, including its benefits and risks." [1] The key conditions for IDM regarding cancer screening are patients' adequate knowledge about cancer screening and participation in the decision-making process. Although evidence-based screening guidelines are publicly available, the awareness and accurate knowledge of these guidelines among the general population is low. A study showed that less than a quarter of patients accurately know about the USPSTF guidelines and that most believe screening is always a good idea. [5-8] Correspondingly, many are not aware of the risks of substantial harms from screening. [5]

Interventions to Raise Cancer Screening Awareness

Ideally, screening decisions should be made after patients fully understand the benefits and harms of screening and should also reflect patients' values and preferences. It is thus critical that physicians and patients adequately discuss cancer screening. Numerous researchers have studied interventions aimed at effectively raising awareness, increasing knowledge about cancer screening, and promoting discussion between physicians and patients. [9-12] Studies have mainly focused on interventions that utilize decision aids, such as questionnaires, visual aids, and counseling, during clinic visits. After exposure to screening awareness interventions such as decision aids or questionnaires, patients are found to be more knowledgeable about the benefits and harms of screening and are more likely to discuss their screening decisions with their physicians. [9-12]

While these educational tools seem to be a key to prompting informed decision making, a low proportion of physicians use decision aids for their patients. [34, 35] In one study, only 10% of physicians reported using educational tools with their patients. [36] Physicians cite lack of time, competing health demands of the patients, and malpractice fears as their main reasons to avoid using the aids. [35] There are also differences in guideline adherence by physician specialty. Primary care physicians are more aggressive about testing than urologists for men older than 50; gynecologists are far more likely than internal or family medicine physicians to recommend breast cancer screening to women under 50. [37, 38] Also, besides the limitations and variations in physician factors, there are mixed study results about the actual impact on screening decisions. McCormack et al. found that although interventions raised awareness that PSA test is a decision to be made, these interventions did not have an impact on the screening decision. [39]

Online Information Seeking

These limitations and uncertainties in IDM interventions point to the importance of identifying influential information sources beyond the one-on-one clinic encounter that are initiated and sought after by patients. Johnson (1997) defines information seeking as "the purposive acquisition of information from selected information carriers." [40] A study has reported that the Internet is the most important source of information for patients, second to physicians. [41] Data from the Health Information National Trends Survey (HINTS) also show that 70% of the health information seekers first go to the Internet to search for cancer-related information. Online information seeking by patients about cancer and screening significantly influence discussions between physicians and patients that follow recommended guidelines.

Patients who seek information online are found to be more knowledgeable about cancer screening. [42-44]

Another reason why this paper seeks to examine the association between online information seeking and cancer screening, besides the prevalence of the Internet use, is that the Internet is a source that an individual has to actively engage with to receive information. Other sources such as television and radio can merely expose individuals to cancer-related information without their will. While studies have shown that these information "scanning" activities do have some influence on awareness of IDM and screening decisions, deliberate seeking has more influence on individuals' screening decisions and preventive behaviors than mere exposure. [42, 44] Since a condition to fulfill IDM is for patients to actively participate in the decision-making process, examining the impact of online information seeking is more imperative.

Individual Factors Regarding Cancer Risk and Information Seeking

One major risk factor for both breast and prostate cancer is ethnicity. [15, 16] African American men are more likely to get prostate cancer than non-Hispanic white men, and African American women under the age of 50 are more likely to get breast cancer than their counterparts. There are seemingly mixed study results regarding the African American population's perception of breast and prostate cancer risk and information seeking behaviors. Studies have found that African American men had insufficient information and no awareness on higher prostate cancer risk for their ethnicity, the role of family history as a risk factor for prostate cancer, or the controversy about PSA tests. [45, 46] Kelly et. al found that the likelihood of seeking cancer-related information was positively associated with being female, older age (55-64 vs. 40 -44), and African American (compared with white). [44]

A higher propensity for African Americans to seek cancer-related information than their counterparts may be due to multiple factors. African Americans are found to have more distrust in the medical system and to have a lack of access to medical services. [45, 47] Specifically, for prostate cancer, African American men are reluctant to discuss prostate cancer with other people in fear of threats to their male sexualities. [45, 48] These factors have seemed to contribute to African American men using the Internet as their source of information. Song et al. have found that the Internet is a significant predictor of prostate cancer screening for African American men. [48]

Information Seeking and Cancer Screening

The prevalence and influence of online information have prompted researchers to study factors that precipitate online health information seeking and how this behavior affects patients' health-related decisions. Shim et al. (2006) found that online information seeking is positively associated with cancer screening decisions for those recommended for screening according to the American Cancer Society's guidelines, namely people aged 40 and above. [49]

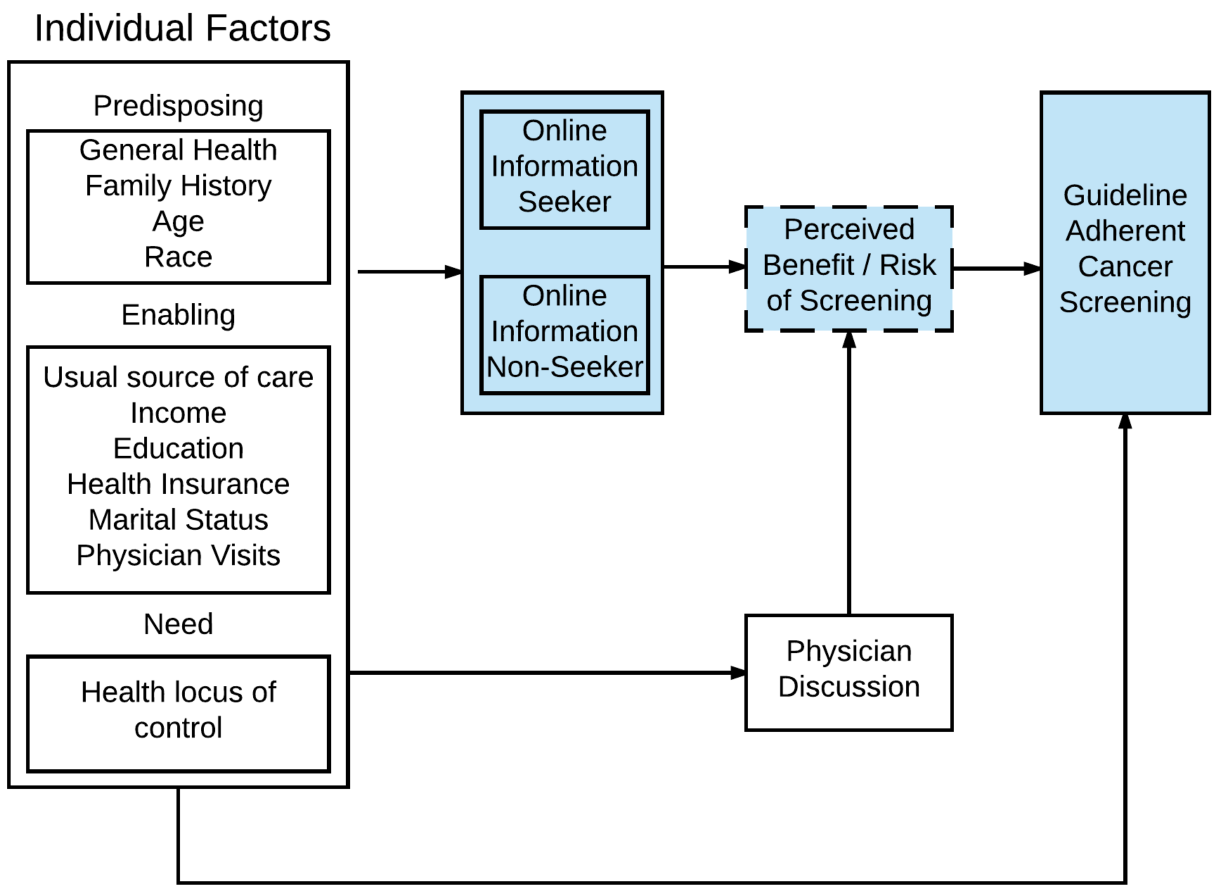
However, no study has yet examined whether online information seeking is associated with breast and prostate cancer screening rates for the population in which screening is not recommended according to the USPSTF guideline – that is, men in all ages and women under 50. If people were adherent to screening guidelines, one would expect to see a lower rate in cancer screening for younger age groups among those who seek information online compared to non-seekers. Therefore, the purpose of this paper is to examine if online information seeking is positively associated with guideline-adherent breast and prostate cancer screening.

Chapter II. Methods

Conceptual Framework

To frame the inquiry about the relationship between an individual's online information seeking behavior and the likelihood that cancer screening decisions will be guideline concordanct, this study uses the Andersen Behavioral Model for Health Care Utilization and the Health Belief Model. [50, 51] Five key constructs are incorporated from the Health Belief Model to explain why an individual decides to receive cancer screening. [51] Perceived benefit of screening is an individual's belief in the efficacy of cancer screening to reduce the risk of cancer. Perceived susceptibility to cancer is one's opinion on the likelihood of getting cancer. Self-efficacy, in this study, is defined as one's perceived ability to search health-related information on the Internet, and cue to action is an internal or external catalyst to receiving cancer screening. [51] The health locus of control is one's perceived control over the likelihood of having cancer. This framework utilizes these key constructs from the Health Belief Model to explain how individuals decide to seek information online about cancer and cancer screening.

The framework then utilizes Andersen's categories of contextual and individual characteristics to identify the factors that confound the focal relationship between online information seeking and cancer screening. The Andersen Behavioral Model describes three types of factors that affect health services use: predisposing, enabling, and need-related characteristics. [50] Predisposing factors are demographic or social factors that influence one's propensity to use health services. Enabling factors are those, such as income or transportation, that directly facilitate or enable health services utilization. Need factors consist of perceived need for health services by patients and evaluated need by physicians. This framework identifies characteristics at both the individual and contextual level that may confound the association between online information seeking behavior and cancer screening rates. [50]



Focal Relationship

The focal relationship is online information seeking and its association with breast and prostate cancer screening. Published studies suggest that people's attitudes about screening change when they learn of the uncertainties and risks of screening and that this leads to a decrease in screening rate. [52, 53] Individuals for whom screening is not recommended are less likely to be screened after learning about the harms. On the other hand, individuals for whom screening is guideline-recommended are more likely to be screening after learning about the benefits.

Perceived Screening Benefit / Risk: Mediator

The construct *perceived screening benefit* acts as a mechanism through which online information seeking is positively associated with the likelihood of guideline-adherent cancer screening. The Health Belief Model defines perceived benefit as an individual's assessment of the efficacy derived from engaging in a health-promoting behavior to decrease the risk of disease. [51] Multiple studies have shown that people are generally not aware of the harms of screening. [8, 22] Thus when individuals learn of the uncertainties and risks of cancer screening, their knowledge of and preferences for cancer screening may change greatly. [52, 54 – 56] After learning about the medical uncertainties from the Internet, their perceived benefit of screening will decrease. [52] On the other hand, for individuals who are guideline-recommended, their perceived benefit of screening will increase after learning about screening benefits online.

Physician Discussion: Moderator

Physician discussion is an interaction term since patients are reminded of potential threats from cancer and their perceived benefit and risk of screening in discussions with their physicians. [57, 58] Physician discussion serves as an external source of information that impacts patients' perceived benefit and risk of screening.

Confounders to the Focal Relationship

Confounders in this study include some individual-level characteristics classified by the Andersen Model.

<u>Predisposing Characteristics</u>

Demographic confounding characteristics consist of age, race, and family history. Younger age is positively associated with Internet usage rate. [59] Past studies have also shown that older age is negatively associated with online information seeking. [59 – 64] Race is also a confounder, since minority individuals are less likely to go through screening than non-Hispanic

White individuals despite higher cancer incidence among minority populations. [65 – 68] Family history of cancer is also positively associated with both screening and information seeking since one's perceived risk of cancer and screening decisions are heavily influenced by family's cancer history. [59-64, 69]

Enabling Characteristics

Income, education, health insurance, and usual source of care are potential enabling factors. Usual source of care is a particular doctor, nurse, or health professional that an individual sees most often. [70] These factors are all positively associated with online information seeking and breast and prostate cancer screening. [34, 60-63, 68-70] Self-efficacy in the current context is one's belief in being able to successfully find cancer-related information online. [51] If individuals find it difficult to access and find the appropriate information on the Internet, they will either go to another source or not seek information at all.

Need Characteristics

Health locus of control refers here to one's perception of his or her ability to control the likelihood of cancer. [71] People who believe that they can control their illness are more likely to use the Internet to find relevant information more frequently. [72]

Dataset

This analysis will use three years of cross-sectional data, 2012 to 2014, from the Health Information National Trends Survey (HINTS). HINTS is a nationally representative, cross-sectional survey that is administered by the National Cancer Institute and has been conducted since 2003. It has been conducted annually since 2011. The target population is all adults aged 18 years or older in the civilian non-institutionalized population of the United States. HINTS is administered via mail to households in English and Spanish. The survey collects information on the public's health-related behavior, perception, knowledge, and status of health-related information and is administered via mail to households.

HINTS samples are drawn in two stages. The first stage randomly selects addresses from the United States Postal Service file, while the second stage selects an adult with the next birthday in each chosen household. For 2014, the sample size is 3,677 respondents, and the overall household response rate is 34.44%.

Measures

Breast and prostate cancer screening. Female respondents to HINTS were asked if and when they received their most recent mammogram. Because the conventional timeframe for breast cancer screening is two years, respondents who answered that they received their last mammogram in the past two years will be classified as screeners. Male respondents were asked if they ever received a PSA test. Respondents who answered that they received a PSA test will be classified as screeners. A dichotomous variable will be created for each analytic sample to categorize the individuals as screeners or non-screeners.

Online information seeking. The construct of online information seeking will be assessed using measures of how people search for health-related information. Respondents were asked if they used the Internet to find health-related information in the past 12 months. They were also asked which source they went to first when they most recently looked up health-related information. Respondents will be categorized as (1) online information seekers if they answered yes to using the Internet to find information and reported using the Internet as their primary source of information the last time they looked up health-related information, or (2) non-seekers if they answered no to using the Internet or reported using any other source than the Internet in the most recent time they looked up health-related information.

Perceived cancer susceptibility. Respondents were asked about their perception of their susceptibility to getting cancer in their lifetime. A categorical variable will be created to classify responses as very unlikely, unlikely, neither, likely, or very likely, in accordance with response categories in the dataset.

Predisposing characteristics. Age and household size will be self-reported continuous variables. The dataset originally categorized participants as Hispanics, non-Hispanics Whites, non-Hispanics Blacks, non-Hispanic Indian, non-Hispanic Asian, non-Hispanic Native Hawaiian, and non-Hispanic multi-races. Individuals who identified themselves as non-Hispanic Whites or non-Hispanic Blacks will be included in the study due to small sample sizes for other ethnicities. Family cancer history will be dichotomously classified as yes or no.

Enabling characteristics. Socio-economic status will be measured with categorical variables for income and education. The dataset originally included nine income categories: $0 - $9,999, $10,000 - $14,999, $15,000 - $19,999, $20,000 - $34,999, $35,000 - $49,999, $50,000 - $74,999, $80,000 - $99,999, $100,000 - $199,999, and ≥ $200,000. In this study, individuals will be categorized into five income categories: $0 - $14,999, $15,000 - $34,999, $35,000 - $49,999, $50,000 - $99,999, and ≥$100,000. The educational categories available in HINTS are < 8 years, 8 – 11 years, high school graduate, vocational school, some college, college graduate, and postgraduate. Education will now be classified into four levels (i.e., less than high school, high school graduate, vocational and some college, and college graduate or more). Respondents were asked if they had any type of health insurance at the time when the survey was taken, with response choices of either yes or no. Thus, a dichotomous variable will be created to indicate whether the individual has health insurance. Respondents were asked if there is a particular doctor, nurse, or health professional that they see most often. A dichotomous variable of usual source of care (USOC) will be created to classify respondents into those who answered yes and those who answered no. Respondents were also asked how difficult it was for them to find health-related information they needed. Based on the HINTS response categories (strongly agree, somewhat agree, somewhat disagree, and strongly disagree), a 4-level categorical variable indexing self-efficacy will be defined.

Need characteristics. Individuals were likewise asked if they strongly agreed, somewhat agreed, somewhat disagreed, or strong disagreed that there is not much they can do to lower their chances of getting cancer. This provides the basis for a 4-level variable measuring the individual's health locus of control.

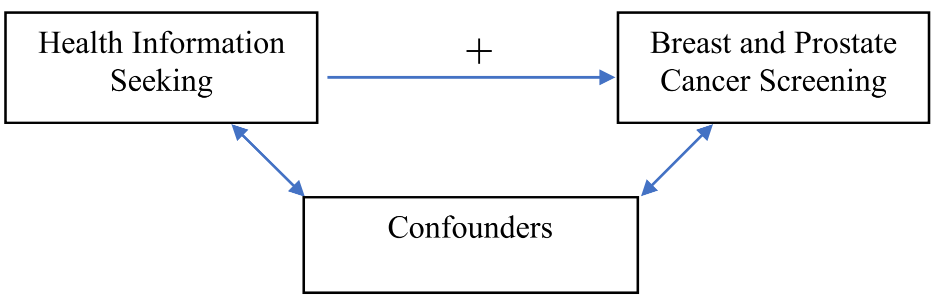
Construct	How measures are coded	Hypothesized relationship with Guideline-Adherent Screening
Breast / Prostate Cancer Screening	**Cancer Screening.** Using self-reported result, respondents will be categorized as: • Screeners • Non-screeners	Breast / prostate cancer screening is the dependent variable.
Online information seeking	**Online information seeking**. Using reported use of the Internet for cancer-related information, respondents will be categorized as: • Seekers • Non-seekers	As people seek cancer-related information online, the likelihood of guideline-adherent cancer screening will increase.
Health insurance status	**Health insurance**. Respondents will be categorized as: • Any kind of insurance • No insurance	Having health insurance will increase the likelihood of cancer screening
Age	**Age**. Age will be a continuous variable.	Screening rate will increase as age increases.
Race / Ethnicity	**Race/ethnicity**. Respondents will be classified into 2 race/ethnic groups: • Non-Hispanic White • Non-Hispanic Black	Screening rate will be lower for the non-Hispanic Blacks than the non-Hispanic Whites.

Marital Status	**Marital Status**. Respondents will be categorized into 2 levels: • Living with a partner • Single	Screening rate will be higher for those who live with a partner.
SES	**Income**. Respondents will be categorized into 5 income ranges: • \$0 to \$14,999 • \$15,000 to \$34,999 • \$35,000 to \$49,999 • \$50,000 to \$99,999 • \$100,000 and above **Education**. Respondents will be categorized into 4 educational levels: • Less than HS • HS graduate • Some college • College graduate or more	Higher education and income level will be positively associated with screening rate.
Family cancer history	**Family history**. Respondents will be categorized as: • Yes • No	People with family cancer history will have higher cancer screening rates than people with no family cancer history.
Usual source of care	**Usual source of care**. Respondents will be categorized as: • Yes • No	People with a usual source of care will have a higher rate of screening than people with no usual source of care.
Health Locus of Control	**Locus of control**. Respondents were asked about their control over chance of cancer. Respondents will be categorized as: • Strongly agree • Somewhat agree • Somewhat disagree • Strongly disagree	People with higher locus of control will have higher rates of cancer screening.

Number of Physician Visits	**Physician Visits**. Respondents were asked how many times they visited their physicians in the past 12 months.	People who visit their physicians more often will more likely get screened.
Physician discussion	**Physician discussion**. Respondents were asked whether doctors told them they could choose to have screening or not. Respondents will be categorized as: • Yes • No	Individuals who are guideline-recommended whose physician had discussed cancer screening with them will more likely go through screening. Individuals who are not recommended will less likely go through screening.

Research Question and Hypothesis

H1: There is a positive association between online information seeking and guideline-adherent breast and prostate cancer screening after controlling for predisposing, enabling, and need characteristics.



Analytic Strategy

There are two analytic samples in this study. Within the breast cancer sample, there are two groups: One group recommended for mammogram and the other group not recommended for mammogram based on age criteria by the USPSTF guideline. The prostate cancer sample will have one group, the non-recommended group, since the USPSTF guideline recommends against routine PSA regardless of age. Both samples will be constructed using data from 2012 to 2014 because the USPSTF guideline for prostate cancer were released in 2012 and the guidelines for breast cancer had been released in 2009.

Descriptive statistics were calculated for variables of interest for the total sample stratified by gender. Subsequently, there are two analytic samples in this study: male and female. Within the female sample, there are two groups: One group recommended for cancer screening (50 years ≤ age ≤ 75 years) and the other group not recommended for screening based on age criteria by the USPSTF guideline (< 50 years). For the male sample, there is only one group not recommended for screening since the guideline recommends against screening regardless of age. Both samples are constructed using data from 2012 to 2014 because the USPSTF guideline for prostate cancer were released in 2012 and the guidelines for breast cancer had been released in 2009.

The analysis first uses a multivariable logistic regression model to assess the first hypothesis about a positive association between online information seeking and USPSTF guideline-adherent breast and prostate cancer screening. The key independent variable is online information seeking and the key dependent variable is guideline-adherent breast and prostate cancer screening. Covariates in the conceptual framework will be included to adjust for confounding relationships. The analysis then uses the Peters-Belson approach to provide an additional perspective on the performance of the multivariable regressions in accounting for observed differences in guideline adherence between information seekers and non-seekers. The Peters-Belson (P-B) approach, also known as the Blinder-Oaxaca decomposition, has been used in economics to look at unexplained variation in outcome variables among different groups such as wage differences between whites and blacks. [73] In terms of cancer screening, this analysis aims to use the Peters-Belson method to provide additional insight into the effect of online information seeking between information seekers and non-seekers. The P-B method, as applied here, seeks to investigate (and quantify) the extent to which there is a difference between information seekers and non-seekers in their propensity to engage in guideline screening that remains even after accounting for all observable confounders thought to influence guideline screening. The difference that emerges (measured through %Unexplained statistic) might then be attributable to unmeasured confounders or to a type of residual difference in the behavior of seekers and non-seekers (analogous to the discrimination or social inequality interpretation that arises when P-B is applied examine black-white differences in economic outcomes). [73]

By implication, the %Explained statistic measures the extent to which any differences between the screening behavior of seekers and non-seekers can be well-accounted for by a model including the observable confounding variables. [73] Thus, if the %Explained happened to be 100%, this indicates that the regression model estimated for seekers does a perfectly wonderful job predicting screening behavior for non-seekers. That is, after adjusting for the covariates, seekers and non-seekers essentially behave the same (on average). [73]

To proceed with the Peters-Belson method in the current context, let $\text{Observed}_{\text{seek}}$ and $\text{Observed}_{\text{non-seek}}$ be the screening rates (measured as proportions) for seekers and non-seekers, and define the difference in screening rates between seekers and non-seekers as

$$\Delta \text{ between seeker and non-seeker} = \text{Observed}_{\text{seek}} - \text{Observed}_{\text{non-seek}}$$

Next, we fit a logistic regression model to online information seekers for breast and prostate cancer screening. Estimated covariates are then inserted into the model fitted for non-seekers in order to estimate non-seekers' probability of being screened. [73] Using covariate values from the seeker population to estimate screening in the non-seeker population allows the analysis to estimate the proportion of screening for non-seekers if that non-seeker were a seeker. We can then define $\text{Expected}_{\text{non-seek}}$ as the proportion of non-seekers engaged in screening had they been seekers. The difference in screening rates between seekers and non-seekers can be re-written as

$$\Delta \text{ between seeker and non-seeker} = \text{Observed}_{\text{seek}} - \text{Observed}_{\text{non-seek}}$$

$$= (\text{Observed}_{\text{seek}} - \text{Expected}_{\text{non-seek}}) + (\text{Expected}_{\text{non-seek}} - \text{Observed}_{\text{non-seek}}) \text{ [73]}$$

The difference between the observed proportion and the expected proportion is then the unexplained variation. This difference will be what remains after accounting for the percent explained by the covariates in the model, which can defined as

$$\text{Explained \%} = [(\text{Observed}_{\text{seek}} - \text{Expected}_{\text{non-seek}}) / \Delta \text{ between seeker and non-seeker}] * 100 \text{ [73]}$$

All analyses will be performed in Stata Version 14, and will incorporate sampling weights to account for the complex survey design elements of the data, non-response bias, and sampling bias. To make the results generalizable to the national population, HINTS calibrated the selection weights using data from the American Community Survey and the National Health Interview Survey.

Chapter IV. Results

i. Descriptive Statistics

Table 1 shows PSA screening rates of the final study sample for males and mammography screening rates of the final study sample of females. In the sample, 1,297 (29%) were online information seekers and the rest (N=3,240) were non-seekers. Among men, 1,156 reported receiving a PSA screening (56%). Among women, 1,866 reported receiving a mammogram within last two years (76%). In terms of race, white men had a higher rate of PSA screening than black men by 4%, whereas black women had a higher rate of mammogram than white women by 5%.

Chi-squared results did not differ significantly for most of the covariates between the male sample and the female sample except three covariates: physician discussion, health locus of control, and occupation status. Another notable difference between men and women is that a smaller percentage of single men than men with a partner received PSA screening, whereas a higher percentage of single women than women with a partner received a mammogram within the past two years.

Table 2 presents unadjusted, chi-squared results for the focal relationship. For groups recommended for mammogram, the focal relationship was statistically significant; for non-recommended mammogram group, the p-value was 0.0501. For mammogram, the screening rate was higher than the non-screening rate for both online information seekers and non-seekers. For PSA, a higher percentage of information seekers got screened.

ii. Regression Results

Using multivariable logistic regression, odds ratios were calculated to test the hypothesis that online information seeking is positively associated with guideline concordance in mammogram and PSA screening. No statistically significant relationship was found between online information seeking and guideline-adherent breast and prostate cancer screening (Table 3). This may be due to various reasons; online information seekers may be more risk averse, which could imply a greater propensity to be screened, or they may have easier access to screening than non-seekers. The interaction between online information seeking and physician discussion was not statistically significant for all three groups as well.

Among the covariates in the model, education level was statistically significant for the PSA sample. Men with higher education were more likely to receive PSA while the parallel relationship for women getting mammography did not hold. Two additional factors that distinguished men from women are physician discussion and number of physician visits in the past 12 months. Men who had a discussion about PSA screening with their physicians were significantly more likely to receive PSA screening. However, having a higher number of physician visits did not correlate with a significantly higher odds of getting screened. For women, mammogram discussion with their physicians did not significantly impact the odds of receiving mammogram but a higher number of physician visits was significantly associated with higher odds of getting screened.

The propensity for mammography screening among recommended, compared with non-recommended, women varied according to several factors. For recommended women, having a usual source of care and higher income were also significantly associated with higher odds of receiving a mammogram. Black female in the recommended age group were significantly less likely to receive a mammogram. With respect to health status, recommended women with better health were more likely to receive a mammogram. Regarding occupational status, recommended women with full-time employment were more likely to receive a mammogram.

Table 4 presents statistics on regression diagnostics. The Hosmer-Lemeshow test statistic showed that the PSA and non-recommended mammogram models fit very well. However, the test statistic for the recommended mammogram group was low. The c-statistic, the area under the curve, supplements the Hosmer-Lemeshow test statistics and shows that recommended mammogram model performs well along with other models. Reasons for the low Hosmer-

Lemeshow test statistic for the recommended mammogram group is not certain, but may be due to sampling weights.

iii. Decomposition Results

To estimate the extent to which there are unmeasured differences between seekers and non-seekers that account for differences in seeker and non-seeker screening behavior, we conducted a decomposition analysis on seekers and non-seekers. We used the Peters-Belson approach to decompose the differences in screening rates between seekers and non-seekers into two parts: one explained by the covariates in the model and the other unexplained by the covariates, which could be attributed to other (unmeasured) differences between online information seekers and non-seekers. The results of the decomposition analysis for the logistic regression model are reported in Table 5. The unadjusted differences in screening rates between seekers and non-seekers are significantly different for all three groups. The largest difference in screening rates between seekers and non-seekers was among men, 9.9%, followed by non-recommended women and recommended women. Overall, it appears that most of the differences in screening rates between seekers and non-seekers are explained by the estimated coefficients. For men, two thirds of the difference are explained by the estimated coefficients. For women, higher percentage of differences, 82.95% for the non-recommended and 85% for the recommended, are explained by the estimated coefficients.

iv. Sensitivity Analysis

Previous guidelines, such as the ACS guideline until 2008, have recommended PSA to men aged 50 and over. To account for differences among guidelines by multiple organizations and the time it takes for guidelines to reach general audience, a sensitivity analysis was conducted on men. Men aged 40-49 years were classified as non-recommended and 50-75 years as recommended. Same logistic regression model was conducted on the re-classified men. The results showed that recommended male seekers were 2.07 times more likely to receive PSA than recommended male non-seekers, a statistically significant estimate (Table 6). For the non-recommended population, male seekers were 1.12 times more likely to receive PSA than non-seekers, which is consistent with the main analysis.

Table 1. Descriptive Statistics

	Male (N=2,067)			Female (N=2,470)		
	Not Screened (N=911)	Screened (N=1,156)		Not Screened (N=604)	Screened (N=1,866)	
	(%)	(%)	P-value	(%)	(%)	P-value
Age (mean, SD)	49.94 (0.28)	57.86 (0.39)		52.51 (0.62)	55.49 (0.27)	
General Health						
Excellent	45	55	0.0597	22	78	0.1217
Very Good	46	54		25	75	
Good	54	46		28	70	
Fair	58	42		30	70	
Poor	63	37		43	57	
Guideline						
Recommended				23	77	0.0008
Non-recommended				34	66	
Physician Discussion						
Yes	12	88	<0.0001	27	73	0.9541
No	85	15		27	73	
Race						
White	51	49	0.7854	25	75	0.7077
Black	50	50		27	73	
Marital status						
Single	59	41	0.0046	25	75	0.0163
Living with a partner	48	52		31	69	
Education						
< High School	69	31	<0.0001	35	65	0.0024
HS Graduate	63	37		30	70	
Some College	47	53		30	70	
College or more	41	58		18	73	
Income*						
< $14,999	71	29	0.0014	35	65	<0.0001
$15,000 - $34,999	52	48		35	65	

\$35,000 - \$49,999	54	45		31	69	
\$50,000 - \$99,999	48	52		21	79	
≥\$100,000	43	57		13	87	
Occupation Status						
Full-time Employ	55	45	0.0020	26	74	0.6648
Else	43	57		27	73	
Family Cancer History						
Yes	49	51	0.0214	24	76	0.0173
No	51	49		33	67	
Usual Source of Care						
Yes	45	55	0.0001	22	78	<0.0001
No	64	36		40	60	
Health Insurance						
Yes	48	52	0.0038	23	77	0.0003
No	62	38		39	61	
# of Physician Visit in the Past Year						
None	67	33	0.0001	62	38	<0.0001
1 time	53	47		26	74	
2 times	45	55		24	76	
3 times	39	61		18	82	
4 times	51	49		25	75	
≥5 times	44	56		17	83	
Year of survey						
2012	50	50	0.8690	27	73	0.2156
2013	52	48		24	76	
2014	51	49		30	70	
Health Locus of Control						
Strongly Agree	64	36	0.0024	34	66	0.1763
Somewhat Agree	59	41		30	70	
Somewhat Disagree	51	49		27	73	
Strongly Disagree	44	56		23	77	

Percentages in parentheses

Table 2. Chi-Squared Results for the Focal Relationship

	Male			Female					
	Not Recommended (N=2,067)			Not Recommended (N=656)			Recommended (N=1,814)		
	Not Screened (N=911)	Screened (N=1,156)		Not Screened (N=388)	Screened (N=1,426)		Not Screened (N=1,063)	Screened (N=542)	
	(%)	(%)	P-value	(%)	(%)	P-value	(%)	(%)	P-value
Online Information									
Seeker	42.6	57.4	0.0014	28.0	72.0	0.0501	17.6	82.4	0.0306
Non-seeker	53.8	46.2		39.6	60.4		24.9	75.1	

Table 3. Logistic Regression Results

		PSA (N=1,714)	Mammogram (N=2,014)	
		Not Recommended (N=1,714)	Not Recommended (N=554)	Recommended (N=1,460)
Seeker		1.64 [0.83, 3.25]	1.29 [0.54, 3.05]	1.17 [0.64, 2.15]
Age		1.10* [1.07, 1.13]	1.20* [1.03, 1.41]	1.06* [1.02, 1.10]
General Health				
	Excellent	0.64 [0.13, 3.17]	1.19 [0.11, 12.60]	5.86* [1.55, 22.13]
	Very Good	0.62 [0.14, 2.71]	1.41 [0.13, 15.20]	4.41* [1.38, 14.14]
	Good	0.55 [0.13, 2.36]	2.39 [0.24, 24.19]	2.94 [0.85, 10.15]
	Fair	0.70 [0.12, 4.03]	2.72 [0.27, 27.42]	2.15 [0.68, 6.84]
	Poor	Ref	Ref	Ref
Physician Discussion				
	Yes	37.03* [21.48, 63.83]	0.74 [0.46, 2.23]	0.77 [0.48, 1.24]
Race				
	Black	0.70 [0.33, 1.46]	0.82 [0.68, 3.22]	0.40* [0.22, 0.75]
Marital status				

Single	1.30 [0.62, 2.70]	0.97 [0.36, 2.65]	0.83 [0.51, 1.36]
Education			
HS Graduate	1.70 [0.68, 4.25]	0.22 [0.022, 2.32]	0.81 [0.33, 2.01]
Some College	4.24* [2.10, 8.60]	0.51 [0.072, 3.61]	0.53 [0.22, 1.29]
≥ College	3.74* [1.51, 9.25]	0.86 [0.10, 7.36]	0.62 [0.20, 1.99]
Income			
\$15,000 - \$34,999	1.30 [0.51, 3.31]	3.20 [0.90, 11.36]	0.79 [0.42, 1.49]
\$35,000 - \$49,999	1.64 [0.53, 5.08]	1.70 [0.40, 7.28]	1.07 [0.50, 2.27]
\$50,000 - \$99,999	1.77 [0.50, 6.28]	2.17 [0.32, 14.98]	2.60 [0.91, 7.38]
≥\$100,000	1.70 [0.52, 5.51]	3.12 [0.32, 30.43]	5.38* [1.47, 19.67]
Occupation Status			
Full-time Employ	0.81 [0.45, 1.43]	0.87 [0.24, 3.19]	1.34 [0.76, 2.35]
Family Cancer History			
No	0.97 [0.69, 1.22]	0.87 [0.41, 1.33]	0.98 [0.68, 1.41]
Usual Source of Care (USOC)			
Yes	0.88 [0.46, 1.67]	1.26 [0.69, 2.96]	1.65* [1.04, 2.62]
Health Insurance			
No	0.97 [0.41, 2.28]	0.55 [0.18, 1.73]	0.71 [0.45, 1.12]
# of Physician Visit in the Past Year			
1 time	1.04 [0.27, 3.95]	5.93* [1.65, 21.32]	6.87* [3.16, 14.95]
2 times	1.35 [0.54, 3.39]	3.80* [1.27, 11.39]	9.96* [4.38, 22.64]
3 times	1.84 [0.68, 4.97]	5.49* [1.11, 27.09]	8.74* [3.92, 19.50]
4 times	0.94 [0.30, 2.94]	3.23 [0.99, 10.49]	7.16* [2.74, 18.71]
≥5 times	1.49 [0.50, 4.38]	9.67* [2.68, 34.83]	12.11* [4.90, 29.89]
Health Locus of Control			
Strongly Agree	0.52 [0.16, 1.68]	1.90 [0.37, 9.65]	0.90 [0.36, 2.28]
Somewhat Agree	0.78 [0.39, 1.56]	0.95 [0.36, 2.53]	0.84 [0.48, 1.48]
Somewhat Disagree	0.88 [0.50, 1.56]	1.00 [0.49, 2.03]	0.83 [0.53, 1.31]
Strongly Disagree	Ref	Ref	Ref
Interaction Between Physician Discussion and Online Information Seeking	1.65 [0.49, 5.66]	1.01 [0.22, 4.65]	0.74 [0.29, 1.91]

95% CI in brackets, * P < 0.05.

Table 4. Logistic Regression Diagnostics

	PSA (N=1,714)	Mammogram (N=2,014)	
	Not Recommended (N=1,714)	Not Recommended (N=554)	Recommended (N=1,460)
Hosmer-Lemeshow Goodness of Fit Test	0.9198	0.9621	0.0127
c-statistic	0.9234	0.7754	0.7681

Table 5. Decomposition Results

	Male		Female			
	Not Recommended		Not Recommended		Recommended	
	Coefficient	In % of Δ	Coefficient	In % of Δ	Coefficient	In % of Δ
Δ	0.099		0.088		0.060	
Explained Part	0.069	66.67%	0.073	82.95%	0.051	85%
Unexplained Part	0.030	33.33%	0.015	17.05%	0.0086	15%

Table 6. Sensitivity Analysis

	Male	
	Not Recommended (N=656)	Recommended (N=1,814)
	Odds ratios	Odds ratios
Seeker	1.12 (0.79)	2.07* (0.62)

Chapter V. Discussion

i. Summary Findings

All odds ratios in the logistic regression models for three groups, non-recommended PSA and recommended and non-recommended mammograms, were statistically insignificant at $\alpha=0.05$ level for the hypothesized association of online information seeking and guideline-adherent cancer screening. Although the USPSTF recommendation against prostate cancer screening is stronger than its recommendation of individual-based decision for mammogram, the odds ratio for male online seekers (1.64) was the highest among the three groups (though still not significant, with $p = 0.27$).

There were significant differences between genders. Men who had discussion with their physicians were significantly more likely to receive a PSA test, but the number of physician visits did not increase the chance of receiving a PSA test. Women, on contrast, were not significantly influenced by physician discussion but were more likely to receive a mammogram with an increase in the number of physician visits. Men with higher education were also increasingly more likely to receive a PSA test, whereas education level was not significantly associated with receiving a mammogram for women.

These findings indicate that the importance of factors may vary by gender. For women, the key factor influencing mammogram may be access to screening. Women recommended for mammogram who have better health status, are white, have higher income, have a usual source of care, and visited their physicians more often were significantly more likely to receive a mammogram. Results for non-recommended women, although to a lesser degree, followed a similar pattern. Regarding PSA, our analyses identify two types of men most likely to be screened: those with high locus of control who actively seek preventive services, and men whose source of information is solely their physicians.

Additional analyses also hint at differences in the effect of online information seeking on cancer screening by gender. The Peters-Belson decomposition results showed that a larger portion of the difference in PSA screening rates are unexplained by covariates in the model, compared to differences in mammogram rates. This indicates that individual factors play a larger role in screening decisions for women than men.

Overall, the analyses suggest that a tailored approach to provide accurate information to at-risk individuals may be required based on individual factors and risk levels. To navigate patients through screening decisions, physicians should discuss with their patients and confirm that patients have accurate information. This study has several limitations. Mammogram and PSA screenings are self-reported in HINTS, and therefore may be subject to error. In addition, the intensity of information seeking cannot be determined. There may be differences in effects of online information seeking among those who frequently search information online and those who search only when necessary.

Despite these limitations, this study examined whether at-risk individuals can contribute to cancer screening decisions based on information acquired online. Internet is a major source of health information, in addition to physicians, and it is crucial to assess what effect patients' information seeking has on their medical decisions. Although the hypothesized association was found to not be statistically significant, we found factors relevant to individuals' decisions to seek information online and to receive cancer screening. These findings can be used to identify individuals who may need interventions and consultation to assess their risk levels and to make screening decisions. The variation in screening rates due to online information seeking was found to be statistically insignificant, but the result showed differences in gender. This finding can inform physicians on how to initiate screening discussions with their patients. This study also examined whether patients are guideline-concordant in those circumstances when screenings are not recommended. To provide higher quality care, accurate cost and benefit measurement, based on correct information and risk assessment, is required before screenings are conducted.

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