Perceived Ambiguity about Screening Mammography Recommendations: Association with Future Mammography Uptake and Perceptions

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Abstract

Conflicting expert recommendations regarding cancer screening and prevention are growing in number, visibility, and importance, but their impact are not well understood. In this study, we examined the impact of conflicting recommendations about mammography screening on women's mammography behavior and perceptions. We conducted a secondary analysis of longitudinal data from the 1995 Maximizing Mammography Participation Trial, a large randomized interventional trial examining the effectiveness of patient reminders in increasing mammography utilization among women ages 50 to 79. Using the decision theory concept of ''ambiguity'' as an analytic framework, we tested several predictions about the effects of conflicting recommendations regarding mammography recommendations on behavior, cognitions, and emotions related to mammography screening. We found high perceived ambiguity about mammography recommendations to be associated with both diminished uptake of mammography over time [odds ratio (OR), 0.42; 95% confidence interval (95% CI), 0.23-0.76; $P < 0.0001$] and lower intentions for future mammography (OR, 0.34; 95% CI, 0.20-0.55; $P < 0.0001$). High perceived ambiguity also predicted greater mammography-related worry over time (OR, 2.60; 95% CI, 1.79-3.78; $P < 0.0001$). These findings suggest that conflicting recommendations regarding cancer screening and prevention have important effects, and we discuss the implications of these findings for future research. (Cancer Epidemiol Biomarkers Prev 2007;16(3):458–66)

Introduction

How do people respond to conflicting expert recommendations about cancer screening and prevention? This is a question of growing importance for several reasons. First, the increasingly rapid emergence and diffusion of innovations in the field has expanded the number of interventions of promising but disputable value. At the same time, forces within medicine and society at large have heightened the public visibility and significance of debates over these measures. The rise of the evidence-based medicine movement has stimulated critical examination of both novel and well-established interventions, whereas a growing emphasis upon informed decision making (1-8) has engendered a renewed focus on increasing patients' awareness of scientific uncertainty and conflicts in expert opinion. This awareness has been further magnified by broader sociocultural trends, including the growing influence of health consumerism, information technology, mass media, and the pharmaceutical industry (9, 10).

Given these trends, it is critical to understand the effects of conflicting recommendations in the field of cancer prevention and screening. Relatively little research has been devoted to this question, although it raises serious concerns. Several authors have argued that educating people about scientific controversies surrounding cancer-protective measures might discourage them from pursuing these interventions (7, 11-14). Some studies do lend support to this concern (12, 15-17), although the data are mixed (18-20). Past studies, however, have been limited in number and methodologic strength and have lacked a coherent theoretical framework.

In a previous study (21), we used the concept of ''ambiguity,'' as developed in the decision science literature, as a basis for analyzing potential outcomes of conflicting cancer prevention recommendations. The concept of ambiguity refers to a type of uncertainty distinct from ''risk'' (i.e., the likelihood of future outcomes) and relating specifically to the ''reliability, credibility, or adequacy'' of one's information concerning risks (22). Ambiguity arises from incomplete or conflicting evidence or expert opinion and thus represents a useful concept for studying the effects of conflicting expert recommendations in medicine. For example, people have been found to show ''ambiguity aversion'' (i.e., when ambiguity is high, they pessimistically appraise the risks and benefits of action and avoid decision making; refs. 23-27). Perceived ambiguity about the efficacy of a cancer-protective intervention, then, would be expected to lower perceptions of the intervention's efficacy, reduce interest in the intervention, and increase feelings of vulnerability to adverse outcomes. Ambiguity has also been shown to have important emotional correlates, provoking negative affective responses such as anxiety (28, 29), whereas anxiety itself increases the intensity of ambiguity aversion (30-33). Perceived ambiguity regarding a cancer-protective intervention may thus make people worry more about cancer and the outcomes of adopting the intervention, and this heightened worry, in turn, may make further reactions to ambiguity even more pessimistic.

We previously (21) explored these possibilities using data from the 2003 Health Information National Trends Survey and found that perceived ambiguity about cancer prevention recommendations related to other important cognitive variables (perceptions of cancer risk and preventability and cancer-related worry) in ways consistent with theory-based

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predictions. The cross-sectional nature of this study, however, restricted causal inferences, and relationships between perceived ambiguity and actual cancer-protective behaviors were not explored.

In the study we report now, we attempted to address these limitations. We conducted a secondary analysis of data from the Maximizing Mammography Participation Trial, a prospective randomized trial conducted in 1994 to 1997 and aimed at comparing the effectiveness of patient reminder interventions in increasing mammography screening (34). A secondary aim of the trial was to identify determinants of mammography uptake, and the study collected longitudinal data on several cognitive variables, including perceived ambiguity regarding contradictory mammography recommendations, perceived breast cancer risk, mammography-related worry, and mammography intentions. The trial notably took place during a time of heated scientific debate over mammography screening in women ages 40 to 49, when conflicting recommendations about mammography were being issued by major professional organizations (18, 35-39). This data set thus allowed us to test our previously derived model of the influence of ambiguity perceptions on cognitions, emotions, and behaviors related to cancer screening.

Materials and Methods

Data Source and Study Population. The Maximizing Mammography Participation Trial was conducted at the Group Health Cooperative of Puget Sound, a large nonprofit health maintenance organization in Seattle, WA. Since 1986, the Group Health Cooperative of Puget Sound had used a centralized Breast Cancer Screening Program to coordinate screening services, maintain a database to track mammography use, and mail recommendations to schedule screening examinations when they were due (defined as every 1-2 years, depending on women's age and risk factors; refs. 34, 40).

Study participants were recruited from a random sample of women ages 50 to 79 enrolled in the Breast Cancer Screening Program and meeting the following criteria: (*a*) no history of breast cancer, (*b*) no prior involvement in mammography recruitment studies, (*c*) residence in the regions served by two screening centers, and (*d*) English speaking. Women who received mammograms more recently than their 1- to 2-year due interval were excluded. Of 5,062 eligible women, 3,743 (74%) consented to participate. Further details about the study population and recruitment are reported elsewhere (34).

Study Intervention and Data Collection. At the time of recruitment, participants completed a telephone survey measuring sociodemographic characteristics, cancer screening history, and several cognitive and behavioral factors potentially relevant to breast cancer screening. Following recruitment, study participants received a mailed reminder to obtain a screening mammogram, in accordance with the usual practice of the Breast Cancer Screening Program.

Following the mailed reminder, 1,965 (53%) participants scheduled a mammogram within 2 months, and an additional 13 women disenrolled from the Group Health Cooperative of Puget Sound. The remaining 1,765 (47%) women were then randomized to one of three intervention groups: (*a*) mailed reminder postcard (n = 590), (*b*) reminder telephone call (n = 585), and (*c*) motivational telephone call addressing mammography barriers (n = 590).

Mammography uptake over the 12-month period following study recruitment was ascertained in all 3,743 participants by review of automated health system records documenting completion of a mammogram at the Group Health Cooperative of Puget Sound. At the end of the observation period, all participants were administered a follow-up telephone survey that repeated measurements of several baseline variables. Ninety-nine percent of participants (n = 3,701) completed both questionnaires, had complete data on mammography uptake, and were included in the current analyses.

Measures

Primary outcome variables. Mammography uptake was treated as a three-level ordinal variable: (*a*) early (within the first 2 months of study recruitment); (*b*) late (>2 months after recruitment, and following randomization to the study interventions); and (*c*) never (not during the entire 12-month observation period).

Mammography intentions at baseline were assessed by the question, ''Would you say it is likely or unlikely that you will have a mammogram done in the next 12 months?'' Five-category Likert scale response options ranged from ''very likely'' to ''very unlikely.''

Mammography intentions at 12-month follow-up were assessed by the question, ''Within the next 2 years, is it likely or unlikely that you will get a screening mammogram when it is recommended?'' Five-category Likert scale response options ranged from ''very likely'' to ''very unlikely.''

Mammography-related worry was measured at both baseline and 12-month follow-up using four items: (*a*) ''When you think about having a mammogram, you feel relaxed''; (*b*) ''When you think about the physical discomfort involved, you feel anxious''; (*c*) ''When you think about waiting for the results, you feel anxious''; and (*d*) ''When you think about the radiation associated with mammograms, you feel concerned.'' Response options for all four questions were scored on five-point Likert scales ranging from ''strongly agree'' to ''strongly disagree.'' Exploratory factor analysis (principal components analysis with varimax rotation) of the 23 baseline survey items measuring cancer- and mammography-related cognitions showed strong factor loadings (>0.600) for the first three worry items and moderate loading (0.424) of the fourth item onto a single factor. Scores for these items were therefore averaged (items 2-4 were reverse coded), excluding ''neither agree nor disagree (don't know)'' responses to create composite mammography-related worry scores; individuals responding to fewer than three of the four individual scale items were treated as missing. Baseline mammography-related worry scores ranged from 1 to 4, with median of 2.25 and mean (SD) of 2.26 (0.74), with higher scores indicating higher worry. Follow-up scores ranged from 1 to 4, with median of 2 and mean (SD) of 2.15 (0.76). Cronbach's α was 0.61 and 0.62 for the baseline and follow-up mammography-related worry scales, respectively.

Perceived breast cancer risk was assessed at both baseline and 12-month follow-up using a single item measuring perceived risk in comparative, rather than absolute, terms: ''How would you rate your OWN RISK of getting breast cancer in the next 5 years, compared with other women?'' Responses were scored on a five-category Likert scale ranging from ''much lower'' to ''much higher.'' All further references to perceived cancer risk in our analyses pertain to this construct of comparative risk.

Predictor Variables. Perceived ambiguity about mammography recommendations was assessed at both baseline and 12-month follow-up using a single item asking respondents to compare their attitudes about mammography with those of other women: ''Another woman said she didn't want a mammogram because she felt too confused about the contradictory recommendations she had read or heard about having a mammogram. Would you say this woman is...'' Five-category Likert scale response options ranged from ''just like you'' to ''not at all like you.''

Prior mammography history was ascertained from automated health system records documenting both self-reported past mammography use assessed at the time of women's enrollment in the Breast Cancer Screening Program and

subsequent mammography utilization occurring within the Group Health Cooperative of Puget Sound. Use of the number of prior mammograms as a predictor variable was limited by the age heterogeneity of the study sample because younger women would have had fewer opportunities for mammography than older women. For our purposes, therefore, study participants were categorized as having had either no prior mammograms, or at least one.

Study intervention group (none, reminder postcard, and reminder telephone call) was included as a covariate to account for any potential effect on the outcome variables. Because the two types of telephone calls were previously shown to have equivalent effects on mammography uptake (34), they were collapsed into a single category for this variable.

Sociodemographic factors included age, race, education level, and income, all of which have been shown to be associated with health cognitions and cancer screening behaviors (15, 41-47).

Data Analysis. Univariate and multivariate analyses were done. χ^2 tests were used to examine the relationships between the various predictor variables and mammography uptake and between sociodemographic factors and perceived ambiguity. Ordinal and binary logistic regression analyses were used to examine relationships between baseline perceived ambiguity and each of the primary outcome variables, adjusting for their baseline values and for prior mammography history and sociodemographic characteristics. Continuous scores for the mammography-related worry variable were dichotomized using a median split, so that logistic regression analyses of this outcome variable could be done, in consistent fashion with those of the other categorical variables. The two highest response levels for the baseline and follow-up perceived risk variables were also collapsed to accommodate small cell sizes. Finally, a multivariate logistic regression model including all predictor variables was used to examine their associations with subsequent mammography uptake.

We excluded from analyses individuals with ''don't know,'' ''refused,'' or missing responses to any of the variables. The proportion of excluded data in the study sample exceeded 5% for several individual variables: income (12%), follow-up mammography intentions (11%), and follow-up perceived breast cancer risk (13%). Missing data were also present for more than one of the four mammography-related worry scale items in 7% of the baseline and 17% of the follow-up surveys. Univariate analyses of excluded subjects showed higher perceived ambiguity and lower mammography uptake than in the study population at large, although the differences were not significant, and inclusion of these subjects in multivariate analyses (imputing intermediate values for ''don't know,'' ''refused,'' and missing responses) did not change the statistical significance or magnitude of the relationships between perceived ambiguity and the primary outcome variables.

Predictions. We predicted several associations between higher baseline perceived ambiguity about mammography recommendations and individual cognitive and behavioral variables (Fig. 1), manifesting ''ambiguity aversion.'' Using separate regression models, we tested each of the following potential outcomes of perceived ambiguity:

(*a*) *Lower mammography intentions at baseline*. We chose to model this single cross-sectional association given that behavioral intentions are correlated with, and frequently used as a surrogate for, future health-protective behaviors.

(*b*) *Lower mammography intentions at 12-month follow-up*, controlling for baseline mammography intentions.

(*c*) *Higher perceived breast cancer risk at 12-month follow-up*, controlling for baseline perceived risk.

(*d*) *Higher mammography-related worry at 12-month follow-up*, controlling for baseline mammography-related worry. Although mammography-related worry is distinct from ''cancer worry'' as analyzed in our previous study (21) and other research (48-50), we hypothesized that as another negative affective state, mammography-related worry would be similarly affected by perceived ambiguity.

(*e*) *Lower uptake of mammography by 12-month follow-up*, controlling for all other baseline predictor variables.

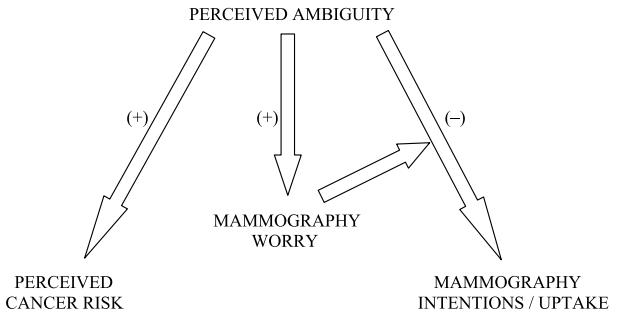

Figure 1. Predicted relationships between perceived ambiguity about mammography screening recommendations, perceived breast cancer risk, mammography-related worry, and mammography intentions and uptake.

We also predicted an additive interaction between baseline perceived ambiguity and mammography-related worry, such that women with higher worry would show greater ambiguity aversion (i.e., a stronger inverse relationship between perceived ambiguity and mammography uptake) than women with low worry.

Results

Descriptive and Univariate Analyses. Most study participants reported White race (91%), at least some college education (93.9%), household income greater than US$30,000 (60%), and at least one prior mammogram (86%). Distributions over time of the cognitive and affective variables are shown in Table 1. Most participants reported a low level of perceived ambiguity about mammography recommendations at both baseline and 12-month follow-up.

Univariate associations between mammography uptake and baseline predictor variables are summarized in Table 2. Notably, 51% of women reporting high perceived ambiguity did not have a mammogram during the observation period compared with 17% of women reporting low perceived ambiguity. Table 3 shows the univariate associations between perceived ambiguity and sociodemographic variables, all of which were significant.

Relationships between Perceived Ambiguity and Mammography Intentions. Consistent with predictions, a significant negative relationship was found between baseline perceived ambiguity and baseline mammography intentions, controlling for sociodemographic variables, prior mammography history, and intervention group (Table 4, Prediction 1 Model). Compared with women reporting the lowest level of perceived ambiguity, women with higher levels of ambiguity had progressively lower odds of intending to obtain a future mammogram (for women indicating the highest level of perceived ambiguity: odds ratio, 0.34; 95% confidence interval, 0.20-0.55).

Covariates significantly associated with baseline mammography intentions included age, prior mammography history, and study intervention, with older age predicting lower baseline mammography intentions, and prior mammography and lack of study intervention predicting higher intentions. There were no significant differences in intentions among women receiving any of the study interventions.

A similar relationship was seen between baseline perceived ambiguity and mammography intentions at 12-month follow-up (Table 4, Prediction 2 Model). Even after controlling for baseline mammography intentions, which had the strongest association with follow-up intentions, perceived ambiguity remained a significant predictor, suggesting that its potential influence on mammography intentions, and thus actual behavior in the even more distant future, persists over time. Compared with women reporting the lowest perceived ambiguity, women with higher levels of ambiguity had lower odds of intending to obtain a future mammogram, although the trend was not linear. The lowest mammography intentions (odds ratio, 0.54; 95% confidence interval, 0.37-0.79) were found in the category of respondents reporting the second highest level of perceived ambiguity.

Relationships between Perceived Ambiguity and Mammography-Related Worry. Consistent with predictions, a significant positive relationship was found between baseline perceived ambiguity and mammography-related worry at the 12-month follow-up, controlling for sociodemographic variables and baseline mammography-related worry (Table 5, Prediction 3 Model). Compared with women reporting the lowest perceived ambiguity, women with higher levels of ambiguity had higher odds of reporting a high level of mammography-related worry, although the association was nonlinear and strongest in the category of respondents with the second highest level of worry (odds ratio, 2.60; 95% confidence interval, 1.79-3.78).

Covariates showing significant associations with mammography-related worry at follow-up included age, race, study intervention, and baseline mammography-related worry, with older age predicting lower mammography-related worry, and non-White race, active study intervention group (reminder postcard), and baseline mammography-related worry each predicting higher mammography-related worry.

Relationships between Perceived Ambiguity and Perceived Breast Cancer Risk. Contrary to predictions, no significant relationship was found between baseline perceived ambiguity and perceived breast cancer risk at the 12-month follow-up, controlling for sociodemographic variables and baseline perceived risk (Table 5, Prediction 4 Model).

Covariates having significant associations with follow-up perceived risk included age, race, prior mammography history, and baseline perceived risk, with older age and non-White race predicting lower subsequent perceived risk, and prior mammography history and baseline perceived risk predicting higher perceived risk.

Table 1. Distribution and percentages of mammography-related cognitions among study participants at baseline and 12-month follow-up (Maximizing Mammography Participation Trial)

Mammography-related cognitions	Baseline, *n** (%)	Follow-up, *n* (%)
Perceived ambiguity		
Lowest	2,794 (75.7)	2,426 (75.6)
Low	509 (13.8)	366 (11.4)
High	313 (8.5)	364 (11.3)
Highest	75 (2.0)	53 (1.7)
Don't know	9 (0.2)	133 (4.0)
Mammography intentions		
Very unlikely	353 (9.8)	131 (4.0)
Somewhat unlikely	275 (7.7)	78 (2.4)
Somewhat likely	572 (15.9)	211 (6.4)
Very likely	2,393 (66.6)	2,878 (87.3)
Don't know	107 (2.9)	49 (1.5)
Mammography-related worry		
Low	1,985 (54.7)	1,685 (51.3)
High	1,641 (45.3)	1,600 (48.7)
Perceived breast cancer risk		
Much lower	913 (25.8)	748 (23.3)
Somewhat lower	1,125 (31.8)	1,022 (31.9)
About the same	1,005 (28.4)	995 (31.0)
Somewhat higher	398 (11.3)	375 (11.7)
Much higher	94 (2.7)	69 (2.1)
Don't know	156 (4.2)	131 (3.9)

*Total sample $N = 3,701$ (decreased and unequal n for individual models due to missing data).

Relationships between Perceived Ambiguity and Future Mammography Uptake

Main effects. As predicted and consistent with the phenomenon of ambiguity aversion, a significant negative relationship was found between baseline perceived ambiguity and actual mammography uptake by 12-month follow-up, controlling for sociodemographic variables, prior mammography history, intervention group, and all baseline cognitive variables (Table 6, Prediction 5 Model). Compared with women reporting the lowest level of perceived ambiguity, women with higher levels of ambiguity had progressively lower odds of obtaining a subsequent mammogram (for women indicating the highest level of perceived ambiguity: odds ratio, 0.43; 95% confidence interval, 0.22-0.84).

Covariates having significant associations with mammography uptake included prior mammography history and baseline mammography intentions. As predicted based on the study design, women in the no-intervention group were significantly more likely to have a mammogram during the study period than women in the active intervention groups, but there were no significant differences in mammography uptake between intervention groups.

Interactions. Contrary to predictions, no significant interaction was found between perceived ambiguity and mammography-related worry in their relationship to mammography uptake.

Discussion

In this prospective longitudinal study, we found evidence of ''ambiguity aversion'' regarding recommendations about mammography screening. Higher levels of perceived ambiguity were associated with both diminished subsequent uptake of mammography, lower mammography intentions at baseline and 12-month follow-up, and higher levels of subsequent mammography-related worry, controlling for the effects of baseline levels of these variables. These findings support our proposed causal model linking perceptions of ambiguity with behavior and are consistent with past research on the outcomes of ambiguity.

Our findings also expand upon data from cross-sectional studies of women's reactions to widely publicized mammography controversies of recent years. Confusion about mammography recommendations has been shown to predict less frequent mammography screening, greater worry about breast cancer and the cost and pain associated with mammography (37), and lower mammography intentions (51). However, other studies (18) have found perceptions of scientific controversy to be unrelated to either past mammography use or perceptions of the importance of mammography. The cross-sectional and retrospective nature of all these studies, however, limited their conclusions.

The major strengths of the current study are its longitudinal design and scope, which allow us to get closer to making causal inferences about the effects of ambiguity perceptions, which seem to be strong even when other important behavioral determinants are accounted for. In the multivariate model including all baseline cognitive variables, perceived ambiguity was significantly associated with mammography uptake, as was mammography intentions, whereas perceived

breast cancer risk was not (Table 6). These findings are particularly striking given the central role of these other cognitive variables in prevailing health behavior theories [e.g., Health Belief Model (52) and Theory of Planned Behavior (53)]. We cannot draw further conclusions about the relative importance or effect sizes for these variables because the reliability of the study measures is unknown, and interrelationships between these variables and other unmeasured factors (e.g., physician recommendation and perceived pros and cons) were not analyzed; however, our preliminary findings suggest that perceived ambiguity deserves greater attention in health behavior research and theory.

The association between perceived ambiguity and mammography in the study population of women ages 50 and older is somewhat surprising, given that the ambiguity at hand involved mammography screening in women ages 40 to 49 only. This suggests ambiguity perceptions influence behaviors even in circumstances where they do not strictly apply. Nevertheless, the public health significance of ambiguity perceptions related to cancer screening controversies remains unclear. At baseline, only 11% of study participants reported feeling confused about contradictory mammography recommendations. This finding is consistent with previous studies that have shown that awareness of controversies concerning mammography does not always lead to confusion or negative attitudes towards screening (19, 36, 37, 39, 51, 54).

Even if people are truly averse to ambiguity, most either may not perceive it, or may discount its relevance due to several factors, including individual personality differences (55, 56). Furthermore, our study and others have found

Table 2. Univariate associations between mammography uptake and predictor variables (Maximizing Mammography Participation Trial)

	Mammography uptake*			Total ‡	*P*	χ^2
	Early	Late	Never †			
Age					0.001	18.43
50-59	427 (28.1)	797 (52.5)	294 (19.4)	1,518		
60-69	325 (29.7)	566 (51.7)	204 (18.6)	1,095		
70-80	353 (32.4)	486 (44.7)	249 (22.9)	1,088		
Total	1,105	1,849	747	3,701		
Race					0.001	19.67
White	1,020 (30.4)	1,885 (50.3)	646 (19.3)	3.351		
Black	53 (24.7)	106 (49.3)	56 (26.1)	215		
Other	25 (21.6)	53 (45.7)	38 (32.8)	116		
Total	1,098	1,844	740	3,682		
Education level					0.0003	21.51
Less than high school	52 (22.7)	117 (51.1)	60 (26.2)	229		
Some college	665 (29.4)	1,112 (49.1)	488 (21.6)	2.265		
College graduate	384 (32.1)	617 (51.5)	197 (16.4)	1,198		
Total	1,101	1,846	745	3,692		
Income					<0.0001	48.79
Under US$30,000	358 (27.7)	600 (46.4)	336 (26.0)	1,294		
Over US$30,000	622 (31.6)	1,034 (52.5)	315 (16.0)	1,971		
Total	980	1,634	6,651	3,265		
Prior mammography history					<0.0001	801.44
No	25 (4.7)	160 (30.1)	346 (65.2)	531		
Yes	1,080 (34.1)	1,689 (53.3)	401 (12.7)	3,170		
Total	1,105	1,849	747	3,701		
Study intervention					<0.0001	1,811.43
None	1,105 (57.1)	809 (41.8)	22 (1.1)	1,936		
Reminder postcard	0	314 (53.2)	276 (46.8)	590		
Reminder telephone call	0	726 (61.8)	449 (38.2)	1,175		
Total	1,105	1,849	747	3,701		
Perceived ambiguity					<0.0001	279.34
Lowest	894 (32.0)	1,465 (52.4)	435 (15.6)	2,794		
Low	158 (31.0)	240 (47.2)	111 (21.8)	509		
High	46 (14.7)	120 (38.3)	147 (47.0)	313		
Highest	6 (8.0)	20 (26.7)	49 (65.3)	75		
Total	1,104	1,845	742	3,691		
Baseline mammography intentions					<0.0001	697.08
Very unlikely	39 (11.1)	82 (23.2)	232 (65.7)	353		
Somewhat unlikely	48 (17.5)	112 (40.7)	115 (41.8)	275		
Somewhat likely	137 (24.0)	310 (54.2)	125 (21.9)	572		
Very likely	849 (35.5)	1,295 (54.1)	249 (10.4)	2,393		
Total	1,073	1,799	721	3,593		
Baseline mammography worry					<0.0001	123.21
Low	683 (34.4)	1,043 (52.5)	259 (13.1)	1,641		
High	414 (25.2)	779 (47.5)	448 (27.3)	1,985		
Total	1,097	1,822	707	3,626		
Baseline perceived cancer risk					0.0005	27.58
Much lower	253 (27.7)	431 (47.2)	229 (25.1)	913		
Somewhat lower	334 (29.7)	580 (51.6)	211 (18.8)	1,125		
About the same	320 (31.84)	506 (50.4)	179 (17.8)	1,005		
Somewhat higher	122 (30.7)	216 (54.3)	60 (15.1)	398		
Much higher	30 (31.9)	50 (53.2)	14 (14.9)	94		
Total	1,059	1,783	693	3,535		

*N (row %).
†No mammography uptake within the 12-mo follow-up period.
‡Total sample N = 3,701 (decreased and unequal n for individual variables due to missing data).

Table 3. Univariate associations between perceived ambiguity regarding mammography recommendations and sociodemographic variables (Maximizing Mammography Participation Trial)

	Perceived ambiguity*				Total †	*P*	χ^2
	Highest	High	Low	Lowest			
Age						0.003	19.58
50-59	25 (1.7)	114 (7.5)	250 (16.5)	1,127 (74.3)	1,080		
60-69	26 (2.4)	95 (8.7)	132 (12.1)	842 (76.9)	1,095		
70-80	24 (2.2)	104 (9.6)	127 (11.8)	825 (76.4)	1,516		
Total	75	313	509	2,794	3,691		
Race						0.002	20.56
White	57 (1.7)	274 (8.2)	465 (13.9)	2,547 (76.2)	3,343		
Black	11 (5.1)	24 (11.2)	28 (13.1)	151 (70.6)	214		
Other	5 (4.3)	14 (12.1)	15 (12.9)	82 (70.7)	116		
Total	73	312	508	2,780	3,673		
Education level						<0.0001	31.21
Less than high school	11 (4.8)	28 (12.3)	18 (7.9)	171 (75.0)	228		
Some college	46 (2.0)	202 (8.9)	294 (13.0)	1,718 (76.0)	2,260		
College graduate	18 (1.5)	82 (6.9)	196 (16.4)	900 (75.3)	1,196		
Total	75	312	508	2,789	3,684		
Income						0.004	13.12
Under US$30,000	31 (2.4)	126 (9.8)	153 (11.9)	980 (76.0)	1,290		
Over US$30,000	35 (1.8)	139 (7.1)	289 (14.7)	1,506 (76.5)	1,969		
Total	66	265	442	2,486	3,259		

*N (row %).
† Total sample $N = 3,701$ (decreased and unequal n for individual variables due to missing data).

sociodemographic differences in women's responses to the mammography controversies (39, 51, 57). These differences may reflect underlying variability in still other factors [e.g., cultural values concerning screening and prevention (20, 58, 59), mass media exposure (60-62), and health-related numeracy (63)], which may alter perceptions or responses to ambiguity.

Our study suggests additional complexities regarding the outcomes of ambiguity perceptions. Contrary to predictions, perceived ambiguity about mammography recommendations

Table 4. Multivariate logistic regression models of the relationship between perceived ambiguity, mammography uptake, and mammography intentions (Maximizing Mammography Participation Trial)

Variables	Prediction 1 model: baseline mammography intentions ($n = 3,161$)		Prediction 2 model: follow-up mammography intentions ($n = 2,843$)	
	OR (95% CI)	*P**	OR (95% CI)	*P**
Age		<0.0001		0.11
50-59	1.00		1.00	
60-69	0.69 (0.57-0.84)		0.77 (0.55-1.08)	
70-80	0.56 (0.45-0.69)		0.69 (0.48-0.99)	
Race		0.06		0.13
White	1.00		1.00	
Black	0.96 (0.63-1.48)		0.58 (0.31-1.09)	
Other	0.68 (0.50-0.93)		0.72 (0.42-1.22)	
Education level		0.15		0.30
Less than high school	1.00		1.00	
Some college	1.36 (0.99-1.87)		0.98 (0.58-1.65)	
College graduate	1.27 (0.90-1.79)		0.77 (0.44-1.36)	
Income		0.13		0.003
Under $30,000	1.00		1.00	
Over $30,000	1.15 (0.96-1.37)		1.58 (1.17-2.14)	
Prior mammography history		<0.0001		<0.0001
No	1.00		1.00	
Yes	4.20 (3.39-5.19)		3.38 (2.49-4.60)	
Study intervention		<0.0001		<0.0001
None	1.00		1.00	
Reminder postcard	0.38 (0.30-0.48)		0.12 (0.08-0.19)	
Reminder telephone call	0.42 (0.35-0.50)		0.21 (0.14-0.31)	
Perceived ambiguity		<0.0001		0.01
Lowest	1.00		1.00	
Low	0.79 (0.63-0.99)		0.77 (0.53-1.13)	
High	0.33 (0.26-0.43)		0.54 (0.37-0.79)	
Highest	0.34 (0.20-0.55)		0.86 (0.44-1.68)	
Baseline mammography intentions				<0.0001
Very unlikely			1.00	
Somewhat unlikely			3.04 (2.03-4.57)	
Somewhat likely			6.18 (4.19-9.11)	
Very likely			18.48 (12.68-26.94)	

NOTE: Total sample $N = 3,701$ (decreased and unequal n for individual models due to missing data).
Abbreviations: OR, odds ratio; 95% CI, 95% confidence interval.
*P for Wald χ^2 test of association.

had no apparent effect on perceived breast cancer risk. One reason may be that cancer risk perceptions are resistant to change and determined principally by past perceptions (64), a possibility supported by the extremely high odds ratios for the association between baseline and future risk perceptions. The lack of association between ambiguity and risk perceptions may also be a logical consequence of the fact that mammography, as a screening intervention, does not alter one's risk of developing breast cancer and should not influence a woman's perceived risk. Had the ambiguity at hand instead involved a preventive intervention, then risk perceptions might have been affected in predicted ways.

Also contrary to predictions, there was no interaction between perceived ambiguity and mammography-related worry in their relationship to mammography uptake, a finding possibly attributable to functional differences between worry about breast cancer and worry about mammography. These two types of worry should have opposite effects on mammography screening behavior (cancer-related worry promoting and mammography-related worry inhibiting screening) consistent with the results of our univariate analyses. Furthermore, although research on ambiguity supports the prediction that worry about cancer will moderate one's aversion to ambiguity, worry about a cancer-protective intervention, rather than the disease, may have different effects (48), overpowering, rather than interacting with, ambiguity perceptions in reducing uptake of the intervention.

Further research is needed to elucidate the mechanisms underlying ambiguity aversion and to address methodologic limitations of the current study. This secondary analysis may have lacked power to test all of our predictions. Measurement issues also warrant consideration. The items used to measure the cognitive variables of the study had unknown reliability and validity. Perceived ambiguity was measured only indirectly; the vignette that described the perception of ambiguity also asked respondents to judge their similarity to a woman who ''didn't want a mammogram.'' Responses to this item might therefore have been confounded by women's desires for mammography, which could have led to biased estimates of the prevalence and influence of perceived ambiguity. However, in the multivariate analysis controlling for baseline mammography intentions (Table 6), perceived ambiguity remained a significant negative predictor of mammography uptake. To the extent that intentions are correlated with desires for mammography, this finding suggests that the perceived ambiguity item was not simply measuring women's desires for mammography.

Nevertheless, the current study raises the need for validated measures. Although ambiguity has been experimentally manipulated in past research on health-related judgments and decisions (65-67), ambiguity perceptions have rarely been measured. In our previous study (21), perceived ambiguity about cancer prevention recommendations was operationalized by a single item measuring respondents' agreement with the statement: ''There are so many different recommendations

Table 5. Multivariate logistic regression models of the relationship between perceived ambiguity, mammography-related worry, and perceived breast cancer risk (Maximizing Mammography Participation Trial)

Variables	Prediction 3 model: mammography-related worry (n = 2,868)		Prediction 4 model: perceived breast cancer risk (n = 2,780)	
	OR (95% CI)	P*	OR (95% CI)	P*
Age		0.01		0.001
50-59	1.00		1.00	
60-69	0.88 (0.71-1.09)		1.00 (0.84-1.19)	
70-80	0.70 (0.55-0.89)		0.72 (0.59-0.88)	
Race		0.004		0.01
White	1.00		1.00	
Black	1.68 (1.01-2.82)		0.73 (0.47-1.12)	
Other	1.75 (1.17-2.61)		0.63 (0.45-0.88)	
Education level		0.30		0.85
Less than high school	1.00		1.00	
Some college	0.75 (0.50-1.11)		0.91 (0.65-1.27)	
College graduate	0.81 (0.53-1.23)		0.92 (0.65-1.31)	
Income		0.48		0.61
Under US$30,000	1.00		1.00	
Over US$30,000	0.93 (0.76-1.14)		1.04 (0.89-1.23)	
Prior mammography history		0.58		0.001
No	1.00		1.00	
Yes	0.92		1.50 (1.18-1.92)	
Study intervention		<0.0005		0.10
None	1.00		1.00	
Reminder postcard	1.66 (1.29-2.16)		0.83 (0.67-1.03)	
Reminder telephone call	1.20 (0.97-1.48)		0.86 (0.72-1.02)	
Perceived ambiguity		<0.0001		0.87
Lowest	1.00		1.00	
Low	1.47 (1.14-1.90)		1.08 (0.88-1.33)	
High	2.60 (1.79-3.78)		1.03 (0.77-1.36)	
Highest	1.53 (0.70-3.34)		0.92 (0.50-1.67)	
Baseline mammography worry		<0.0001		
Low	1.00			
High	8.02 (6.72-9.58)			
Baseline perceived risk				<0.0001
Much lower			1.00	
Somewhat lower			3.53 (2.90-4.29)	
About the same			16.08 (12.89-20.06)	
Somewhat/much higher †			124.94 (92.67-168.44)	

NOTE: Total sample N = 3,701 (decreased and unequal n for individual models due to missing data).
Abbreviations: OR, odds ratio; 95% CI, 95% confidence interval.
*P for Wald χ^2 test of association.
† ''Somewhat higher'' and ''Much higher'' categories collapsed to accommodate small cell sizes in the model.

Table 6. Multivariate logistic regression model of the relationship between all predictor variables and mammography uptake* (Maximizing Mammography Participation Trial)

Prediction 5 model: mammography uptake (n = 3,004)		
Variables	OR (95% CI)	P*
Age		
50-59	1.00	0.28
60-69	0.86 (0.72-1.04)	
70-80	0.97 (0.79-1.20)	
Race		
White	1.00	0.72
Black	0.86 (0.55-1.34)	
Other	0.92 (0.65-1.30)	
Education level		
Less than high school	1.00	0.96
Some college	0.97 (0.69-1.39)	
College graduate	0.96 (0.66-1.39)	
Income		
Under $30,000	1.00	0.09
Over $30,000	1.17 (0.98-1.39)	
Prior mammography history		
No	1.00	<0.0001
Yes	3.19 (2.46-4.13)	
Study intervention		
None	1.00	<0.0001
Reminder postcard	0.01 (0.00-0.01)	
Reminder telephone call	0.01 (0.01-0.02)	
Perceived ambiguity		
Lowest	1.00	0.004
Low	1.11 (0.88-1.39)	
High	0.67 (0.50-0.91)	
Highest	0.43 (0.22-0.84)	
Baseline mammography intentions		
Very unlikely	1.00	<0.0001
Somewhat unlikely	2.04 (1.38-3.03)	
Somewhat likely	3.22 (2.28-4.55)	
Very likely	3.30 (2.41-4.50)	
Baseline mammography worry		
Low	1.00	0.23
High	0.91 (0.77-1.06)	
Baseline perceived risk		
Much lower	1.00	0.16
Somewhat lower	1.03 (0.84-1.27)	
About the same	1.02 (0.83-1.26)	
Somewhat/much higher †	0.80 (0.62-1.03)	

NOTE: Total sample N = 3,701 (decreased and unequal n for individual models due to missing data).
Abbreviations: OR, odds ratio; 95% CI, 95% confidence interval.
*P for Wald χ^2 of association.
† ''Somewhat higher'' and ''Much higher'' categories collapsed to accommodate small cell sizes in the model.

about preventing cancer, it's hard to know which ones to follow.'' In a study by Taplin et al. (18), perceived ambiguity about mammography recommendations was measured by a single item asking women whether they ''ever received conflicting information'' about various aspects of mammography. The refinement of measures of perceived ambiguity is a critical task for future research.

Missing data were an additional problem in regression analyses involving multiple variables. Furthermore, participants with ''don't know'' and ''refused'' responses were excluded from analyses. This may have biased our findings because indecision and non-response could reflect high perceived ambiguity. Although imputation of intermediate values for missing data did not significantly change any of the principal findings, nonresponse bias cannot be ruled out. Finally, the study sample was predominantly White and well educated, with relatively high income and health care access. Thus, we cannot generalize our findings to lower income and minority populations who may differ in their perceptions of and responses to ambiguity.

Despite these limitations, the current study provides new and convergent evidence that perceived ambiguity regarding cancer screening recommendations has strong, predictable, and important effects. It may increase negative feelings and attitudes towards these interventions and discourage some people from undertaking them. Such outcomes are problematic, even if morally justifiable as consequences of informed decision making. They will likely become more problematic in the future, furthermore, due to the many powerful forces that continue to heighten the public's awareness of medical controversies.

Our findings have other implications for health communication practice and policy. The current study and another study (36) have shown that subjective perceptions of ambiguity are often ''inaccurate'' in the sense of being overgeneralized to even unambiguous domains. At the same time, people often fail to perceive ambiguity when it does exist (54). More work is needed to elucidate the factors responsible for inaccuracies in ambiguity perceptions and to determine optimal methods of communicating ambiguity.

As scientific controversies and conflicting expert recommendations in cancer control, and in health care generally, continue to grow in number, visibility, and interest for laypersons and health professionals, ambiguity will become an increasingly important problem. We believe that the current study endorses the value of future research aimed at furthering our understanding of how perceptions of ambiguity affect people and how the communication of scientific uncertainty to the public might be improved.

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Perceived Ambiguity about Screening Mammography Recommendations: Association with Future Mammography Uptake and Perceptions

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