

Perceived ambiguity about cancer prevention recommendations: associations with cancer-related perceptions and behaviours in a US population survey

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Abstract

Background Health information reaching the public today is often characterized by what decision theorists have termed ‘ambiguity’ – i.e. uncertainty regarding the information’s reliability, credibility or adequacy. This is a critical problem, as growing research suggests that ambiguity has important effects – promoting pessimistic judgments about risks and potential outcomes of risk-reducing behaviours, and lowering adoption of these behaviours. However, little is known about the public’s perceptions of ambiguity in the health information domain, the effects of these perceptions, and the factors that influence these effects.

Objective To examine associations between perceived ambiguity regarding cancer prevention recommendations and prevention-related perceptions and behaviours, and to explore how these associations differ by cancer type.

Study design and participants Cross-sectional analysis of data on 4070 adults participating in the 2005 US Health Information National Trends Survey.

Main variables and outcome measures We examined associations between perceived ambiguity about colon, skin and lung cancer prevention recommendations and two main outcome variables: (i) risk-related cognitions (perceived cancer risk and preventability, cancer-related worry) and (ii) risk-modifying behaviours (colon cancer screening, sunscreen use and smoking abstinence).

Results Perceived ambiguity was inversely associated with perceptions of the preventability of all three cancers, and with cancer-specific risk-modifying behaviours including sigmoidoscopy–colonoscopy testing, sunscreen use and smoking abstinence. Relationships with cancer risk perceptions and worry varied across different cancer types.

Conclusions Perceived ambiguity about cancer prevention recommendations has significant and predictable associations with cancer prevention-related cognitions and behaviours, and some associations differ by cancer type. These findings have implications for future research and communication efforts.

Introduction

Health information reaching the public today through various channels is increasing in both magnitude and complexity. Popular media coverage of both breakthroughs and controversies in health care has exploded in recent years,^{1–3} while promotional activities of pharmaceutical companies and health advocacy groups have grown in number, diversity and influence.^{4,5} At the same time, the medical profession has devoted increasing attention to disseminating complex health information to the lay public. A growing emphasis on informing and involving patients in health-care decisions—goals articulated through the ideals of informed and shared decision making^{6–11}—has fuelled concerted efforts to educate the public about the benefits, risks and uncertainties surrounding various medical interventions.¹²

What are the effects of these trends? Ideally, greater exposure to health information should enable people to be more educated, competent consumers of health care, and better equipped to make reasoned choices. This potential outcome is a central justification for health communication efforts as well as patient education and counselling interventions such as health decision aids.^{11,13–17} To what extent this outcome is actually attained, however, is not known. Although the provision of health information through formal educational interventions has been shown to improve patient knowledge,¹³ it may have mixed psychological effects.

For example, research in other decision-making domains suggest that exposure to complex information may overwhelm, frighten or confuse people, rather than empowering them. Multiple options have been shown to impose a heavy cognitive burden that may hinder optimal decision making.^{18–21} Furthermore, the presence of what decision theorists have termed ‘ambiguity’ – i.e. uncertainty regarding the reliability, credibility or adequacy of information about risks and the potential outcomes of decisions²² – has been shown to have distinct psychological and behavioural effects. Specifically, ambiguity causes people to judge risks and choice out-

comes pessimistically, and to avoid decision making.^{22–26}

This response to ambiguity, known as ‘ambiguity aversion’, pertains to information concerning various types of risks; however, it has particular relevance for understanding the outcomes of exposure to complex health information. The health interventions that often receive the greatest attention in informed decision-making efforts are those that are the most ambiguous – for which existing evidence on the balance of benefits and harms is unclear and more than one reasonable course of action exists – e.g. hormone replacement therapy and prostate-specific antigen screening.^{7,9,10,27,28} At the same time, it is ambiguity that defines the complex nature of the information presented to patients. Informed decision making entails the provision of comprehensive information regarding not only the projected risks and benefits of a health service, but the uncertainties surrounding these projections and the range of clinical options available.^{6,7,9,12} An instrumental goal of informed decision making, in other words, is to increase patients’ awareness of ambiguity.

For this reason, it is important to understand the effects of ambiguity in health decisions. Relatively little research has been devoted to this problem, although past work suggests that ambiguity aversion pertains to at least some health decision-making domains. In a previous study, we focused on the domain of cancer prevention and explored how perceptions of ambiguity regarding cancer prevention recommendations relate to other risk-related cognitions known to influence health-related decisions and behaviours.²⁹ In that study, we analysed cross-sectional data from a large nationally representative survey of the US public, the National Cancer Institute’s 2003 Health Information National Trends Survey (HINTS 2003).

We found that perceptions of ambiguity about cancer prevention recommendations were related to other important psychological variables in ways consistent with the phenomenon of ambiguity aversion (Fig. 1)²⁹. Higher perceptions of ambiguity were associated with lower

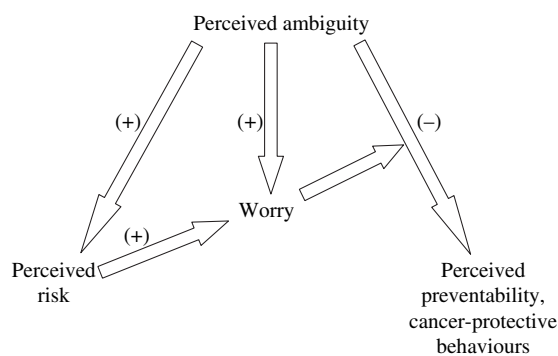


Figure 1 Predicted relationships between perceived ambiguity, perceived cancer preventability, perceived cancer risk, cancer worry and cancer-protective behaviours.

perceptions of the preventability of cancer, higher perceived cancer risk, and higher cancer-related worry. Also consistent with predictions, cancer-related worry moderated the degree of ambiguity aversion—higher worry being associated with a more negative relationship between perceptions of ambiguity and cancer preventability. Finally, the association between perceived ambiguity and worry appeared to be partially mediated by perceived risk – i.e. perceived ambiguity influenced worry not only directly, but indirectly through its influence upon perceived risk. Although the cross-sectional nature of this study restricted inferences about causality, the results supported theory-based predictions and the findings of related research, and raised the possibility that exposure to ambiguous health information may indeed have negative psychological consequences.

To what extent these findings can be replicated in other samples and health information domains, and with respect to actual health risk-modifying behaviours – i.e. behaviours aimed at either primary or secondary prevention – remains to be seen. Limited evidence from studies utilizing hypothetical scenarios has suggested that ambiguity of information concerning environmental health risks and the outcomes of primary prevention measures such as immunizations lead people to heightened perceptions of these health risks and lowered interest in these measures.^{30–33} Similarly, in the domain of secondary prevention, intervention studies have

demonstrated that educating people about uncertainties surrounding particular controversial cancer screening measures decreases their interest in screening, further implying that people are ambiguity averse.^{34–37}

In the current study, we attempted to build upon this work and to replicate and expand upon our earlier findings regarding the potential outcomes of perceived ambiguity about cancer prevention recommendations. Applying methods similar to those used in our previous study,²⁹ we analysed data on the new sample population surveyed by the most recent HINTS (2005). Furthermore, because the 2005 HINTS – unlike the earlier survey – measured cognitions pertaining to the prevention of specific malignancies (colon, skin and lung cancer) rather than to cancer in general, we were able to expand our analysis to how ambiguity perceptions relate to specific cancer risk-modifying behaviours (e.g. colon cancer screening, sunscreen use and smoking abstinence), as well as cognitions, and to determine how cancer type influences these relationships.

Methods

Data source and study population

The HINTS is a biennial telephone-based nationwide survey conducted by the National Cancer Institute and aimed at tracking trends in the public's cancer-related knowledge, attitudes and behaviours. The HINTS surveys a nationally representative sample of US adults aged 18 and older, utilizing a complex stratified sampling design with oversampling of African-American and Hispanic households.³⁸ For the HINTS 2005, interviews were completed with a total of 5586 adults aged 18 and older; the overall response rate was 21%. Further details about the study methods, survey design and variables in HINTS are published elsewhere.³⁸ We limited our analysis to the subpopulation of individuals aged 40 and older ($N = 4070$), with the rationale that it is this group for which cancer prevention and screening recommendations are most salient and potentially controversial, and

with the objective of comparing findings to those of our earlier study which employed this age cutoff in a different population sample.²⁹

Data collection

The HINTS assesses several cancer-related cognitions known to be important determinants of cancer-protective behaviour: perceived preventability of cancer, perceived cancer risk, cancer-related worry and perceived ambiguity about cancer prevention recommendations. These cognitions represented the primary outcome and predictor variables for the current analyses. Unlike the 2003 survey, however, HINTS 2005 measured these variables not in terms of cancer in general, but in terms of three specific cancer types: colon, skin and lung cancer. Individual respondents were randomly assigned, using a computer-generated number for each sampled household, to answer cancer cognition items about only one of these three malignancies. The final study sample included a total of 1447, 1231 and 1392 respondents, respectively, for the colon, skin and lung cancer items. Unequal totals for these groups were due to missing data and non-response. HINTS 2005 also included questions about several cancer-specific prevention and screening behaviours, which were asked of all survey respondents in our sample population, although the survey design was such that questions on colon cancer screening behaviours were asked only of respondents aged 45 and older.

Cancer risk-related cognitions

The primary outcome variables for our analyses were measured by three survey items coded on Likert scales, with each item made specific to one of the three cancer types (colon, skin or lung). *Perceived preventability of cancer* was assessed by the question, 'There is not much you can do to lower your chances of getting (colon/skin/lung) cancer'. Response options were 'agree' and 'disagree'. *Perceived cancer risk* was assessed by the question, 'How likely do you think it is that you will develop (colon/skin/lung) cancer in the future?' Response options were 'very low', 'somewhat low', 'moderate',

'somewhat high' and 'very high'. *Cancer-related worry* was assessed by the question, 'How often do you worry about getting (colon/skin/lung) cancer?' Response options were 'rarely or never', 'sometimes', 'often' and 'all the time'.

Cancer risk-modifying behaviours

Several risk-modifying behaviours specific to the three cancers were measured and treated as additional outcome variables in our analyses. *Colon cancer risk-modifying behaviours* consisted of the secondary preventive interventions of past colon cancer testing by colonoscopy or flexible sigmoidoscopy and by faecal occult blood testing (FOBT), which were ascertained by separate questions asking respondents whether or not they had ever had these tests. *Skin cancer risk-modifying behaviours* consisted of the primary preventive intervention of sunscreen use, which was measured by a single item, 'When you go outside for more than 1 h on a warm, sunny day, how often do you wear sunscreen?' Response options were: 'always', 'often', 'sometimes', 'rarely' and 'never'. *Lung cancer risk-modifying behaviours* consisted of lifetime history of cigarette smoking at least 100 cigarettes, which was measured by a single item with 'yes' and 'no' response options, and current cigarette smoking in respondents with a past smoking history, which was measured by a single item, 'Do you now smoke cigarettes...?' Response options were 'every day', 'some days', 'not at all', 'do not know' and 'refused.'

Perceived ambiguity

The primary independent variable for all analyses was *perceived ambiguity about cancer prevention recommendations*. This construct was assessed by the question, 'There are so many different recommendations about preventing (colon/skin/lung) cancer, it is hard to know which one to follow'. Response options were 'agree' and 'disagree'.

Sociodemographic variables

Various sociodemographic factors were treated as covariates in all analyses. *Age* was coded using four response categories (40–49, 50–59,

60–69 and 70 and older). *Race* was coded using three response categories (White, Black and Other) while *education level* used four response categories (less than high school, high school graduate, some college and college graduate). *Gender* was also treated as a covariate. These factors have been shown to be associated with both health cognitions – e.g. perceived risk and preventability beliefs – as well as health-protective behaviours such as cancer screening; the potential for confounding effects justified controlling for these variables in our analysis.^{35,39–44} Income was previously shown to be highly correlated with education level, and was not included in subsequent analyses to avoid potential problems with multicollinearity.

Data analysis

To adjust for the complex sampling design of the HINTS,³⁸ the statistical program SUDAAN (version 9.0.2, Research Triangle Institute, Research Triangle Park, NC, USA) was used in all analyses,⁴⁵ utilizing sample weights provided with the HINTS public use data file. These weights were post-stratified to the US census distributions by age, sex and race/ethnicity for the year 2005 to provide estimates representative of the general US population. Variances of parameter estimators were calculated using a jackknife method.

We excluded individuals with ‘not ascertained’, ‘no opinion’, ‘do not know’ or ‘refused’ responses to any of the main survey items examined. The proportion of excluded data in the study sample exceeded 5% for the following individual variables: perceived colon cancer risk (10.4%), perceived colon cancer preventability (5.7%), and perceived ambiguity about colon cancer recommendations (7.1%).

Univariate and multivariate analyses were performed. Binary and ordinal logistic regression analyses were used to examine the relationships between perceived ambiguity and each of the primary outcome variables, adjusting for sociodemographic variables. We also explored predicted interactions and mediating relationships

between perceived ambiguity and the primary outcome variables.

Predictions

Based on our previously derived theoretical model and the findings from our earlier study,²⁹ we predicted that perceived ambiguity about cancer prevention recommendations would demonstrate several associations with other cognitive and behavioural variables (Fig. 1), in directions consistent with the theoretical concept of ‘ambiguity aversion’.

1. Lower perceived preventability of cancer.
2. Higher perceived cancer risk.
3. Higher cancer-related worry.
4. Lower adherence to cancer-specific risk-modifying behaviours (colon cancer testing, sunblock use and cigarette smoking abstinence).

Based on past research, we also predicted an interaction between baseline perceived ambiguity and cancer-related worry (perceived ambiguity \times cancer-related worry), such that higher levels of worry would be associated with a stronger inverse relationship between perceived ambiguity and perceived cancer preventability, compared with the associations present at lower levels of worry. In addition, we predicted that perceived ambiguity would influence worry as well as cancer risk-modifying behaviours not only directly but indirectly, through its effects upon risk and preventability perceptions, respectively, which would act as mediating variables. We had no *a priori* reasons to expect cancer-specific differences in any of these predicted relationships.

Results

Distributions and US population-weighted percentages for the sociodemographic and cognitive variables examined in this study are shown in Tables 1 and 2. Most respondents were less than age 60 and white, and reported high school or greater education. The proportion of respondents who agreed with the perceived ambiguity item, ‘There are so many different

Table 1 Distribution and weighted percentages of sociodemographic characteristics of Health Information National Trends Survey (HINTS) respondents aged 40 and older (2005 HINTS)*

Sociodemographic variables	N*	Percentage [†]
Age		
40–49	1029	34.6
50–59	1057	27.2
60–69	872	19.9
70+	1112	18.3
Education level		
Less than high school	500	14.1
High school graduate	1094	35.3
Some college	1113	25.4
College graduate	1226	25.2
Race		
White	3351	83.2
Black	337	10.0
Others	156	6.8
Gender		
Female	2708	47.1
Male	1380	52.9

*Total sample $N = 4070$; decreased and unequal 'n' for individual variables because of excluded and missing data.

[†]Percentages weighted to the US population using 2005 census data.

recommendations about preventing cancer, it is hard to know which ones to follow', ranged from 44% for lung cancer recommendations to 54% for colon cancer recommendations. Nevertheless, with respect to each of the three cancer types, most respondents still reported high preventability beliefs and low levels of perceived risk and cancer-related worry. With respect to cancer-protective behaviours, at least 40% of the entire study population reported past sigmoidoscopy–colonoscopy and FOBT, as well as at least some sunscreen use and past smoking history of > 100 cigarettes. Of the 52% of respondents with a prior smoking history, 37% reported that they currently smoked.

Relationships between perceived ambiguity and perceived preventability of cancer

Across all three cancer types, a strong inverse relationship was found between perceived ambiguity and perceived preventability of cancer, controlling for sociodemographic variables (Table 3). As predicted and consistent with the

phenomenon of ambiguity aversion, perceived ambiguity was associated with lower preventability beliefs. Sociodemographic covariates demonstrating significant associations with perceived cancer preventability included age (for colon and lung cancer) and education level (for skin and lung cancer), with older age and lower education levels predicting lower perceived preventability.

Contrary to predictions, perceived ambiguity did not interact with cancer-related worry (perceived ambiguity \times cancer-related worry) in its relationship with perceived cancer preventability, for any of the three cancer types.

Relationships between perceived ambiguity and perceived cancer risk

For lung cancer only, a positive relationship [odds ratio (OR) 1.85, 95% CI: 1.27–2.69 and $P = 0.001$] was found between perceived ambiguity and perceived cancer risk, controlling for sociodemographic variables (Table 4). Consistent with predictions, high perceived ambiguity was associated with higher levels of perceived lung cancer risk. However, this relationship was not observed with perceived colon and skin cancer risk. Sociodemographic covariates demonstrating significant associations with perceived lung cancer risk included age, education level, and race, with older age and higher education being associated with lower perceived lung cancer risk, and non-white, non-black race being associated with higher perceived lung cancer risk.

Relationships between perceived ambiguity and cancer-related worry

For lung cancer only, a positive relationship (OR 1.48, 95% CI: 1.00–2.19 and $P = 0.046$) was found between perceived ambiguity and lung cancer-related worry, controlling for sociodemographic variables (Table 5). As predicted, higher levels of perceived ambiguity were associated with higher levels of lung cancer-related worry. This relationship was not observed with colon and skin cancer-related worry, although the association with colon cancer approached

Table 2 Distribution and weighted percentages of cognitive and behavioural variables by cancer type, for Health Information National Trends Survey (HINTS) respondents aged 40 and older with no history of cancer (HINTS 2005)*

Colon cancer	N [†]	Percentage [‡]	Skin cancer	N [§]	Percentage [‡]	Lung cancer	N [¶]	Percentage [‡]
Cognitive variables								
Perceived ambiguity								
Low	610	46.0	Low	623	55.3	Low	761	55.7
High	701	54.0	High	493	44.7	High	560	44.3
Perceived preventability								
Low	296	23.3	Low	180	15.3	Low	247	18.6
High	1036	76.7	High	950	84.7	High	1084	81.4
Perceived cancer risk								
Very low	497	40.8	Very low	325	27.5	Very low	672	47.8
Somewhat low	380	27.5	Somewhat low	275	24.7	Somewhat low	264	20.3
Moderate	322	26.3	Moderate	351	33.6	Moderate	253	21.1
Somewhat high	57	4.6	Somewhat high	109	10.3	Somewhat high	82	6.8
Very high	11	0.8	Very high	44	3.8	Very high	33	4.0
Cancer-related worry								
Rarely/never	1099	77.1	Rarely/never	762	64.6	Rarely/never	1092	78.1
Sometimes	270	19.0	Sometimes	300	28.4	Sometimes	198	15.2
Often	29	2.1	Often	49	4.2	Often	44	3.3
All the time	12	1.9	All the time	35	2.8	All the time	33	3.4
Behavioural variables								
Past colonoscopy			Sunscreen use			Lifetime cigarette smoking		
Yes	1890	49.2	Always	717	15.7	Yes	2017	51.7
No	1564	50.8	Often	610	14.0	No	1997	48.3
Past faecal occult blood testing			Sometimes	769	19.8	Current smoking		
Yes	1608	40.0	Rarely	643	17.3	Every day	521	30.1
No	1863	60.0	Never	1126	33.2	Some days	124	6.5
						Not at all	1371	63.4

*Total sample N = 4070; decreased and unequal 'n' for individual variables because of missing data.

[†]n = 1447 for cognitive variables, n = 3487 for behavioural variables.

[‡]Percentages weighted to the US population using 2005 census data.

[§]n = 1231 for cognitive variables, n = 4041 for behavioural variables.

[¶]n = 1392 for cognitive variables, n = 4025 for behavioural variables.

Table 3 Multivariate logistic regression models of the relationship between perceived ambiguity and perceived cancer preventability, by cancer type (2005 Health Information National Trends Survey)*

Variables	Colon cancer preventability (n = 1199)			Skin cancer preventability (n = 1031)			Lung cancer preventability (n = 1243)		
	OR	95% CI	P-value [†]	OR	95% CI	P-value [†]	OR	95% CI	P-value [†]
Age									
40–49	1.00		0.040	1.00		0.264	1.00		0.019
50–59	0.52	0.24–1.11		0.97	0.45–2.09		0.94	0.45–1.97	
60–69	0.76	0.38–1.52		0.95	0.48–1.85		0.54	0.30–0.97	
70+	0.43	0.23–0.81		0.55	0.28–1.08		0.74	0.39–1.41	
Education level									
Less than high school	1.00		0.059	1.00		0.008	1.00		0.007
High school graduate	1.19	0.68–2.10		1.70	0.87–3.34		1.97	1.13–3.45	
Some college	2.54	1.18–5.47		2.83	1.29–6.22		2.29	1.20–4.36	
College graduate	1.99	0.88–4.47		6.25	1.83–21.32		2.89	1.51–5.54	
Race									
White	1.00		0.303	1.00		0.324	1.00		0.234
Black	0.60	0.23–1.53		0.72	0.34–1.55		0.78	0.36–1.70	
Others	0.49	0.16–1.55		0.56	0.24–1.28		0.43	0.18–1.02	
Gender									
Female	1.00		0.376	1.00		0.273	1.00		0.720
Male	0.81	0.50–1.31		1.33	0.79–2.24		0.92	0.58–1.46	
Perceived ambiguity									
Low	1.00		< 0.001	1.00		< 0.001	1.00		< 0.001
High	0.27	0.15–0.46		0.20	0.10–0.41		0.23	0.14–0.37	

*Total sample N = 1414; separate models fitted for each cancer type; decreased and unequal 'n' for individual models (indicated in parentheses) because of excluded and missing data.

[†]For Wald chi-squared test of association.

statistical significance (OR 1.41, 95% CI: 0.95–2.11 and $P = 0.081$). Sociodemographic covariates demonstrating significant associations with lung cancer-related worry included age ($P < 0.001$) and education level ($P = 0.018$), with older age and higher education being associated with lower lung cancer-related worry.

Mediational effects

To follow up on the significant main effects found for lung cancer cognitions, we conducted mediational analyses to test the prediction that perceived ambiguity would appear to influence worry not only directly but indirectly, through its effects upon risk perceptions. Using Baron and Kenny's procedure,⁴⁶ we first confirmed significant associations between perceived ambiguity and worry ($P = 0.046$), perceived ambiguity and perceived risk ($P = 0.001$), and perceived risk and worry ($P < 0.001$), in separate logistic regression models. Next, we regressed worry on

perceived ambiguity while controlling for perceived risk; this reduced the previously significant association between perceived ambiguity and worry to non-significance ($P = 0.370$), consistent with a mediational effect of perceived risk, and the OR for the association decreased from 1.48 (95% CI: 1.00–2.19) to 1.17 (95% CI: 0.82–1.68). Supporting the hypothesized causal direction of this effect, we also found no evidence that worry mediated the relationship between perceived ambiguity and perceived risk. The association between perceived ambiguity and perceived risk remained significant ($P < 0.001$) even when controlling for worry.

Relationships between perceived ambiguity and cancer-specific risk-modifying behaviours

Colon cancer screening

Perceived ambiguity about colon cancer prevention recommendations was inversely

Table 4 Multivariate ordinal logistic regression models of the relationship between perceived ambiguity and perceived cancer risk, by cancer type (2005 Health Information National Trends Survey)*

Variables	Colon cancer perceived risk (<i>n</i> = 1141)			Skin cancer perceived risk (<i>n</i> = 1010)			Lung cancer preventability risk (<i>n</i> = 1214)		
	OR	95% CI	<i>P</i> -value [†]	OR	95% CI	<i>P</i> -value [†]	OR	95% CI	<i>P</i> -value [†]
Age									
40–49	1.00		0.022	1.00		< 0.001	1.00		< 0.001
50–59	1.00	0.67–1.48		0.78	0.54–1.11		1.01	0.70–1.47	
60–69	0.98	0.66–1.43		0.70	0.44–1.13		0.92	0.58–1.48	
70+	0.54	0.36–0.82		0.26	0.16–0.43		0.48	0.32–0.72	
Education level									
Less than high school	1.00		0.646	1.00		0.067	1.00		0.052
High school graduate	1.36	0.83–2.24		1.92	1.12–3.28		1.16	0.70–1.92	
Some college	1.34	0.75–2.41		1.78	1.05–3.01		0.79	0.47–1.33	
College graduate	1.25	0.70–2.25		1.94	1.08–3.50		0.63	0.36–1.09	
Race									
White	1.00		0.033	1.00		< 0.001	1.00		0.039
Black	0.47	0.21–1.08		0.23	0.12–0.45		0.86	0.48–1.53	
Others	0.42	0.17–1.00		0.29	0.16–0.54		2.58	1.18–5.64	
Gender									
Female	1.00		0.116	1.00		0.868	1.00		0.751
Male	1.34	0.92–1.94		0.97	0.68–1.39		1.06	0.74–1.50	
Perceived ambiguity									
Low	1.00		0.209	1.00		0.921	1.00		0.001
High	1.24	0.88–1.77		0.98	0.67–1.43		1.85	1.27–2.69	

*Total sample *N* = 1414; separate models fitted for each cancer type; decreased and unequal 'n' for individual models (indicated in parentheses) because of excluded and missing data.

[†]For Wald chi-squared test of association.

associated with self-reported past flexible sigmoidoscopy or colonoscopy (OR 0.59, 95% CI: 0.38–0.92 and *P* = 0.018) (Table 6). Consistent with the phenomenon of ambiguity aversion, perceived ambiguity was associated with less past sigmoidoscopy–colonoscopy. A similar trend was seen with past FOBT, although this association did not reach statistical significance (OR 0.80, 95% CI: 0.57–1.13 and *P* = 0.066). Further mediational analyses⁴⁶ showed only a borderline significant mediating effect of perceived colon cancer preventability in the relationship between perceived ambiguity and sigmoidoscopy–colonoscopy screening. Inclusion of the potential mediating variable in the regression model reduced the significant association between perceived ambiguity and sigmoidoscopy–colonoscopy to non-significance, although the change in *P*-value was relatively small (from 0.018 to 0.054).

Sunscreen use

Perceived ambiguity about skin cancer prevention recommendations was inversely associated with sunscreen use (OR 0.68, 95% CI: 0.47–1.00 and *P* = 0.044) (Table 6). Consistent with the phenomenon of ambiguity aversion, perceived ambiguity was associated with lower levels of sunscreen use. Mediational analysis⁴⁶ showed no significant mediating effect of perceived skin cancer preventability in the relationship between perceived ambiguity and sunscreen use.

Cigarette smoking

Perceived ambiguity about lung cancer prevention recommendations was not significantly associated with lifetime history of smoking at least 100 cigarettes (OR 1.22, 95% CI: 0.92–1.61 and *P* = 0.164), although it was positively associated (OR 1.85, 95% CI: 1.11–3.07 and *P* = 0.015) with current cigarette smoking in

Table 5 Multivariate ordinal logistic regression models of the relationship between perceived ambiguity and cancer-related worry, by cancer type (2005 Health Information National Trends Survey)*

Variables	Colon cancer worry (<i>n</i> = 1242)			Skin cancer worry (<i>n</i> = 1041)			Lung cancer worry (<i>n</i> = 1262)		
	OR	95% CI	<i>P</i> -value [†]	OR	95% CI	<i>P</i> -value [†]	OR	95% CI	<i>P</i> -value [†]
Age									
40–49	1.00		0.755	1.00		<0.001	1.00		<0.001
50–59	0.80	0.48–1.34		0.69	0.42–1.13		0.77	0.51–1.16	
60–69	0.84	0.49–1.44		0.72	0.43–1.21		0.82	0.47–1.44	
70+	0.82	0.54–1.26		0.29	0.18–0.47		0.32	0.18–0.56	
Education level									
Less than high school	1.00		0.237	1.00		0.057	1.00		0.018
High school graduate	0.68	0.35–1.31		2.07	1.00–4.33		0.81	0.42–1.55	
Some college	0.52	0.27–1.02		1.90	0.93–3.88		0.46	0.21–1.00	
College graduate	0.51	0.25–1.05		2.72	1.28–5.77		0.47	0.24–0.89	
Race									
White	1.00		0.086	1.00		0.108	1.00		0.122
Black	2.27	0.88–5.83		0.35	0.12–0.96		1.10	0.62–1.96	
Others	1.68	0.78–3.61		0.84	0.41–1.75		1.86	1.01–3.44	
Gender									
Female	1.00		0.091	1.00		0.062	1.00		0.774
Male	1.40	0.94–2.08		0.74	0.53–1.02		0.93	0.58–1.51	
Perceived ambiguity									
Low	1.00		0.081	1.00		0.837	1.00		0.046
High	1.41	0.95–2.11		1.04	0.70–1.55		1.48	1.00–2.19	

*Total sample *N* = 1414; separate models fitted for each cancer type; decreased and unequal '*n*' for individual models (indicated in parentheses) because of excluded and missing data.

[†]For Wald chi-squared test of association.

respondents with a past smoking history (*n* = 655) (Table 6). No mediators in this relationship were identified.

Discussion

In this nationally representative cross-sectional survey, we found significant relationships between perceived ambiguity about cancer prevention recommendations and other important cognitions pertaining to specific cancers. Consistent with the phenomenon of 'ambiguity aversion', perceived ambiguity had a strong negative relationship with perceptions of the preventability of all three types of cancer – colon, skin and lung examined in the study. These results support both theory-based predictions and the findings of our earlier study which was conducted in a different sample population²⁹ and which focused solely on the relationship between perceived ambiguity and cognitions pertaining to cancer in general.

Furthermore, in addition to these predicted relationships with cancer-related cognitions, perceived ambiguity about the prevention of specific cancers was inversely related to several corresponding risk-modifying behaviours, including sigmoidoscopy–colonoscopy testing, sunscreen use and smoking abstinence (among respondents with a past smoking history). This finding of an association between perceived ambiguity about cancer prevention recommendations and actual preventive behaviours expands upon our previous work and adds to growing evidence that ambiguity perceptions in this domain may have behavioural as well as cognitive manifestations,^{47–49} potentially influencing both primary (sunscreen use and smoking abstinence) and secondary (sigmoidoscopy–colonoscopy testing) prevention behaviours.

The current study, however, did not support all of our predictions regarding the potential effects of perceived ambiguity. Across all cancer types, perceived ambiguity did not demonstrate

Table 6 Multivariate logistic regression models of the relationship between perceived ambiguity and cancer-specific risk-related behaviours, by cancer type (2005 Health Information National Trends Survey)*

Variables	Colon cancer (n = 1085)			Faecal occult blood testing (n = 1090)			Skin cancer (n = 998)			Lung cancer (n = 1263)			Current smoking in ever smokers† (n = 655)		
	OR	95% CI	P-value†	OR	95% CI	P-value†	OR	95% CI	P-value†	OR	95% CI	P-value†	OR	95% CI	P-value†
Age															
40-49	1.00		<0.001	1.00		<0.001	1.00		0.944		0.013	1.00		1.00	<0.001
50-59	5.26	3.07-9.02		1.68	0.83-3.37		1.03	0.71-1.50		1.41	0.87-2.28		0.41	0.24-0.69	
60-69	12.69	6.57-24.53		4.56	2.12-9.81		0.89	0.55-1.42		2.04	1.28-3.27		0.42	0.22-0.81	
70+	14.16	7.36-27.23		6.15	3.03-12.48		0.94	0.58-1.52		1.27	0.80-2.02		0.14	0.06-0.30	
Education level															
Less than high school	1.00		0.002	1.00		0.015	1.00		<0.001		0.093	1.00		1.00	<0.001
High school graduate	1.80	1.01-3.22		1.45	0.81-2.59		3.37	1.79-6.35		0.71	0.38-1.34		0.97	0.46-2.06	
Some college	1.93	1.07-3.49		1.76	1.05-2.94		3.63	1.81-7.29		0.62	0.32-1.21		0.42	0.18-0.98	
College graduate	3.31	1.76-6.23		2.03	1.29-3.20		6.49	3.47-12.15		0.55	0.31-0.95		0.27	0.12-0.62	
Race															
White	1.00		0.040	1.00		0.141	1.00		<.001		0.937	1.00		1.00	0.408
Black	0.45	0.24-0.87		0.93	0.40-2.13		0.20	0.10-0.40		0.96	0.51-1.80		0.82	0.39-1.72	
Others	1.00	0.44-2.25		0.42	0.16-1.06		0.61	0.25-1.50		1.10	0.48-2.54		1.60	0.68-3.78	
Gender															
Female	1.00		0.387	1.00		0.613	1.00		<0.001		<0.001	1.00		1.00	0.254
Male	0.85	0.59-1.23		1.09	0.78-1.52		0.38	0.27-0.53		2.08	1.40-3.10		0.76	0.46-1.23	
Perceived ambiguity															
Low	1.00		0.018	1.00		0.066	1.00		0.044		0.164	1.00		1.00	0.015
High	0.59	0.38-0.92		0.80	0.57-1.13		0.68	0.47-1.00		1.22	0.92-1.61		1.85	1.11-3.07	

*Total sample N = 1414; separate models fitted for each cancer type and behaviour; decreased and unequal 'n' for individual models (indicated in parentheses) because of excluded and missing data.

†For Wald chi-squared test of association.

‡Analysis using ordinal regression.

consistent associations with cancer risk perceptions or worry. Although perceived ambiguity was positively related to both perceived risk and worry pertaining to lung cancer, these relationships were not seen for colon and skin cancer. This finding was contrary to study predictions and the results of our earlier analysis of non-cancer-specific cognitions, suggesting that cancer type moderates the potential cognitive effects of ambiguity perceptions. Because smokers are the individuals most at risk for lung cancer, this finding may reflect tighter coherence among cognitions about cancers for which there is one primary risk factor. This hypothesis needs to be tested.

These cancer-specific differences highlight the need to understand the potential influence of ambiguity perceptions within the larger context of key cognitions that constitute people's mental representations of illness. Important cognitions that might be affected by ambiguity – e.g. perceptions regarding the risk and controllability of a disease, and the risks of both undertaking or foregoing a disease-protective intervention – are components of specific mental models that individuals develop over time as they process health information from different sources.^{50,51} People's responses to ambiguity may be altered by these mental models in various ways. The extent to which ambiguity about preventing a particular cancer heightens risk perceptions or cancer-related worry may be moderated by pre-existing beliefs about the cancer's causes, consequences or natural history. Furthermore, the coherence – as well as the content – of these mental models may influence people's responses to ambiguity. Pertinent illness representations including perceptions of both the preventability and risk of cancer may be well formed and strongly held, because of several factors – e.g. the influence of mass media and disease advocacy groups,^{5,52} cultural values regarding the good of cancer prevention and screening.^{53–55} This may make people more or less resistant to ambiguous information about cancer prevention.

At the same time, the observed relationships between perceived ambiguity and various cancer

risk-modifying behaviours suggest that the potential causal pathways from ambiguity perceptions to behaviours are complex. Cancer risk perceptions and worry may play little role in these pathways, at least for the colon and skin cancer protective behaviours examined. For sigmoidoscopy–colonoscopy screening, perceived ambiguity may influence behaviour through its effect on cancer preventability beliefs, while for other behaviours such as sun-screen use and smoking abstinence, preventability beliefs may not be important mediating factors. Factors related to the protective behaviour itself may also moderate the influence of ambiguity perceptions; this may explain why, for example, perceived ambiguity was associated with sigmoidoscopy–colonoscopy testing, but not with FOBT. Other variables may also act as moderators in these pathways, although contrary to predictions, no significant interactions were found between cancer-specific worry and perceived ambiguity in relation to any of the other outcome variables. These findings remain tentative, however, given that the study may have had insufficient power to detect all potentially significant interactions.

Much more work is needed to elucidate the mechanisms underlying ambiguity aversion. Causal directions need to be firmly established, and this represents the main limitation of the current study. Although our hypothesized causal model and the study's specific findings are consistent with a large body of past research on the outcomes of ambiguity perceptions, longitudinal and experimental studies are necessary to confirm our findings and validate the model.

Furthermore, a large number of associations were examined, and although most of our findings were consistent with theoretical predictions and past empirical work, some observed associations could have resulted from chance alone. We also excluded subjects with 'do not know' responses to several items including those used to measure perceived ambiguity. This could have biased our findings, if such responses indicated high ambiguity perceptions – a possibility supported by additional analyses in which similar associations with outcome variables, such as

perceived colon cancer preventability, were found for the 'do not know' (OR 0.19, 95% CI: 0.09–0.42) and 'high' (OR 0.27, 95% CI: 0.15–0.46) response categories of the perceived ambiguity variable. This suggests that any bias introduced by excluding 'do not know' respondents was likely conservative (biased towards the null), and an acceptable trade-off to avoid analytic problems posed by small cell sizes or imputed responses.

Other study limitations point to additional research needs. HINTS 2005 did not ascertain the specific targets of perceived ambiguity; thus we do not know, for example, whether respondents' ambiguity perceptions related to random exposure to health messages from mass media, or to deliberate communication efforts by health professionals. Nor do we know whether respondents' exposure to ambiguous information was passive or the result of active information seeking. These unmeasured variables, however, might be critical determinants of people's responses to ambiguity. Another methodological concern is that perceived ambiguity and the constructs of perceived cancer preventability, risk and worry were each measured by single items with unknown reliability and validity. This may limit the strength of our conclusions, although cognitions such as risk perceptions have been shown to be highly reliable over time,⁵⁶ and single-item measures of constructs such as cancer risk and cancer worry have been found in other studies to predict behavioural endpoints such as cancer screening.^{57–59}

The behavioural variables analysed in our study may also have had limited validity as indicators of the effects of ambiguity perceptions. HINTS 2005 did not ascertain whether sigmoidoscopy–colonoscopy testing, for example, was performed for the purpose of cancer screening as opposed to diagnostic evaluation. In the strictest sense, furthermore, screening interventions such as sigmoidoscopy, colonoscopy and FOBT do not *prevent* cancer; therefore, ambiguity about colon cancer prevention recommendations should not influence *screening*-related cognitions and behaviours. Likewise, because both sunscreen use and smoking abstinence serve purposes other than cancer preven-

tion, perceived ambiguity about skin and lung cancer prevention might have limited effect on these behaviours. The lack of ascertainment of behaviours more explicitly aimed at the primary prevention of all three cancers likely reduced our ability to determine the full impact of ambiguity perceptions related to cancer prevention recommendations. The fact that perceived ambiguity nevertheless demonstrated significant associations with all these variables suggests that ambiguity perceptions are powerful determinants of behaviour, sometimes being overgeneralized to circumstances in which they do not strictly apply.

Finally, aspects of the study population may limit the generalizability of our findings. The relatively low-response rate for the HINTS 2005 reflects an unfortunate trend in survey research,^{60,61} and may have biased our findings. The exclusion from analyses of participants with 'do not know' and 'refused' responses may have also introduced bias, as non-response and indecision might reflect high perceived ambiguity. Furthermore, because the study sample was predominantly white and well educated, we are less able to generalize our findings to members of other population groups.

In spite of these limitations, the current study provides convergent evidence that ambiguity surrounding cancer prevention recommendations may have predictable effects on important cognitions, emotions and behaviours. It may diminish beliefs in the preventability of cancer, lower adherence to cancer-protective interventions and in some cases heighten perceptions of vulnerability to cancer. The communication of ambiguity to the public thus poses potential ethical trade-offs for clinicians, communication experts, and policy makers who are interested in promoting informed and shared decision making. In the cancer prevention domain at least, these approaches to making health care more patient-centred⁶² could end-up diminishing patient well-being. A critical task, then, is to determine when heightened ambiguity perceptions are truly appropriate and warranted, and how ambiguity should be communicated in these circumstances.

Yet, the current study also suggests that the potential outcomes of communicating ambiguity are not straightforward; ambiguity aversion may manifest in different ways and degrees depending on the type of cancer involved, and other factors. Not all ambiguous situations are aversive, and not everyone confronting ambiguity will react in the same way. But this means that we need to understand much more about the factors that mitigate people's responses to ambiguity, to anticipate these responses and to design effective, supportive, and ethical interventions for communicating ambiguity in cancer control and in health care generally. We view the current study as a preliminary step towards that goal.

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