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How are Multifactorial Beliefs about the Role of Genetics and Behavior in Cancer Causation associated with Cancer Risk Cognitions and Emotions in the U.S. Population?

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Abstract

Objective—People who believe that cancer has both genetic and behavioral risk factors have more accurate mental models of cancer causation and may be more likely to engage in cancer screening behaviors than people who do not hold such *multifactorial* causal beliefs. This research explored possible health cognitions and emotions that might produce such differences.

Methods—Using nationally representative cross-sectional data from the U.S. Health Information National Trends Survey (N=2,719), we examined whether endorsing a multifactorial model of cancer causation was associated with perceptions of risk and other cancer-related cognitions and affect. Data were analyzed using linear regression with jackknife variance estimation and procedures to account for the complex survey design and weightings.

Results—Bivariate and multivariable analyses indicated that people who endorsed multifactorial beliefs about cancer had higher absolute risk perceptions, lower pessimism about cancer prevention, and higher worry about harm from environmental toxins that could be ingested or that emanate from consumer products ($p < 0.05$). Bivariate analyses indicated that multifactorial beliefs were also associated with higher feelings of risk, but multivariable analyses suggested that this effect was accounted for by the negative affect associated with reporting a family history of cancer. Multifactorial beliefs were not associated with believing that everything causes cancer or that there are too many cancer recommendations to follow ($p > 0.05$).

Conclusion—Holding multifactorial causal beliefs about cancer are associated with a constellation of risk perceptions, health cognitions, and affect that may motivate cancer prevention and detection behavior.

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Compliance with Ethical Standards

Conflict of Interest: The authors declare that they have no conflicts of interest.

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Keywords

Multifactorial beliefs; genetics; risk perception; cancer cognitions; worry; oncology

Background

Cancer, like many common health conditions, arises from a complex interplay of genetic, behavioral, and environmental factors. Understanding this multifactorial nature of cancer is an important component of genomic health literacy, because this knowledge can help individuals to obtain, process, and utilize the rapidly evolving and increasingly available genomic information to guide their personal health decisions.¹ Yet, there is variability in the extent to which individuals recognize the multifactorial etiology of cancer. For instance, our work has demonstrated that among the American public, 64.3% believe that cancer is caused by both genetics and lifestyle (i.e., multifactorial causal beliefs).²

Beliefs about disease causation are recognized as contributing to engagement in relevant health behaviors,^{3, 4} and there is evidence to suggest that multifactorial causal beliefs are related to the adoption of preventive behaviors. Specifically, endorsement of multifactorial causal beliefs about cancer has been significantly associated with screening behaviors related to breast, cervical, colorectal, and prostate cancer.² However, it is unclear *how* these multifactorial causal beliefs may ultimately shape behaviors – that is, whether multifactorial causal beliefs are associated with other cognitive and affective variables that theory and research have identified as precursors to the adoption of health behaviors.

Cognitive and affective factors that motivate healthy behaviors, such as perceived likelihood of disease,^{5, 6} feelings of risk,^{7–9} and worry about disease,⁶ are likely informed by an individual's understanding of disease causation.¹⁰ For example, among gynecological cancer survivors, endorsement of various singular causes of gynecological cancer (e.g., genetics, environment, lifestyle, diet) was associated with increased worry about cancer recurrence.¹¹ Similarly, among healthy college students, beliefs about heredity, sunburns, and sun exposure as causes of skin cancer were correlated with heightened absolute perceptions of skin cancer risk and worry.¹² However, research also suggests that an understanding of genetic risk factors, in particular, may have negative effects on health cognitions. For instance, in an experimental study, providing information about genetic risk factors for salt-sensitive blood pressure and high cholesterol led to decreased absolute perceptions of risk for these conditions among individuals who were previously unaware of such risk factors.¹³ Additionally, among adult smokers participating in a smoking cessation trial, those who believed that genetics contributed to their smoking perceived less control over their behavior.¹⁴

Although past research demonstrates that diverse, singular causal beliefs are associated with cognitive and affective motivators of behavior, to date no study has explored how multifactorial causal beliefs are related to these factors. Thus, the objective of the present study was to examine the extent to which multifactorial causal beliefs about cancer are associated with cancer risk cognitions and emotions. Specifically, we evaluated a previously-unexplored link in a conceptual framework that we have developed and adapted,^{2, 15} and

which is informed by theoretical and empirical work from psychology, communication, public health, and genomic medicine.^{3, 4, 16–23} As shown in Figure 1, we examined how multifactorial causal beliefs about cancer were associated with perceptions of cancer risk, cancer cognitions, and worry about toxic environmental exposures. We examined worry about toxic environmental exposures because research suggests that people recognize environmental toxins as a potential cause of cancer.^{24, 25} Therefore, although it was not feasible to incorporate beliefs about environmental toxins into our definition of multifactorial beliefs, it was nevertheless important to account for them in the analyses.

Given our past work demonstrating a positive association between multifactorial causal beliefs and cancer screening behaviors,² we hypothesized directional associations between multifactorial beliefs and cognitive and affective factors that would theoretically lead to healthier behavior. Specifically, we hypothesized that the endorsement of multifactorial causal beliefs would be associated with (1) greater perceptions of cancer risk, (2) cognitions reflecting less pessimism about cancer prevention, and (3) greater worry about environmental exposures.

Methods

Participants

Participants were respondents to the National Cancer Institute (NCI) Health Information National Trends Survey (HINTS 4, Cycle 2 fielded from October 2012–January 2013; survey response rate of 40%).²⁶ HINTS is a mailed, nationally representative, cross-sectional survey of the adult (age 18 and older) civilian non-institutionalized population of the United States. Detailed methodological information, including participant selection strategies and the use of sampling weights to correct for nonresponse and noncoverage biases, is located at hints.cancer.gov/docs/HINTS_4_Cycle2_Methods_Report.pdf. HINTS was reviewed and approved by NCI's Special Studies Institutional Review Board, Westat's Institutional Review Board, and the US Government's Office of Management and Budget.

Measures

Multifactorial beliefs—We created a single dichotomous variable indicating the endorsement (vs. non-endorsement) of both genetic and behavioral causal beliefs about cancer by combining two causal beliefs items into one item.^{2, 15} The original items read, “How much do you think [genetics, that is characteristics passed from one generation to the next / health behaviors like diet, exercise, and smoking] determine whether or not a person will develop each of the following conditions: Cancer; Obesity; Diabetes; High blood pressure; Heart disease? [1] Not at all – [4] A lot.” The analyses reported below focus only on the cancer items. Endorsement of multifactorial beliefs about cancer was defined as responding “A lot” or “Somewhat” to *both* the behavior and genetic cancer-specific items.^{2, 15} Any other combination of responses was considered non-endorsement of multifactorial beliefs about cancer.

Risk perceptions—Three cancer risk perception items were administered. *Absolute perceived risk* was assessed with the item: “How likely are you to get cancer in your

lifetime? [1] Very unlikely – [5] Very likely.” The *comparative perceived risk* item asked: “Compared to other people your age, how likely are you to get cancer in your lifetime? [1] Much less likely – [5] Much more likely.” The *affective perceived risk* item (also referred to as *feelings of risk*; ²⁷) was: “I feel like I could easily get cancer in my lifetime. [1] I feel very strongly that this will NOT happen – [5] I feel very strongly that this WILL happen.”

Cancer cognitions—*Cancer cognitions* were assessed with three items. Response options for each item ranged from [1] strongly agree to [4] strongly disagree. For ease of interpretation, each item was reverse coded so that higher scores indicated more agreement and, therefore, a more pessimistic appraisal of cancer prevention. The items were: “It seems like everything causes cancer,” “There’s not much you can do to lower your chances of getting cancer,” and “There are so many different recommendations about preventing cancer, it’s hard to know which ones to follow.”

Worry about environmental exposures—Eight items assessed worry about the potentially harmful effects of environmental exposures. The question stem read: “How much do you worry that each of the following will harm your health?” The response options were: [1] Not at all – [4] A lot. The specific exposures were: Outdoor air pollution; Indoor air pollution; Man-made chemicals in the water; Pesticides and other chemicals on food; Radiation from cell phones; Radiation from medical imaging tests such as x-rays, mammography, radioactive dyes, etc.; Chemicals in household items such as plastic containers, furniture, paint, etc.; and Chemicals in personal care products such as make-up, fragrances, hair products, etc.

Covariates—Based on our prior research examining predictors of multifactorial beliefs, ^{2, 15} several variables were included as covariates. These included age, sex, education, race/ethnicity, rural/urban geographic residence, numeracy, family history of cancer, awareness of direct-to-consumer genetic testing, motivation to process cancer information, and health information scanning.

Analytic Strategy

In accordance with published recommendations,²⁶ data were analyzed using SAS 9.4 SURVEYFREQ and SURVEYREG procedures with jackknife variance estimation. These procedures account for the survey’s complex design and sampling scheme, and therefore reduce the likelihood of a Type I error.²⁸ The results were also weighted using the weights provided in the public use datasets to obtain estimates that are representative of the U.S. adult population.

There were 3,630 survey respondents, but our use of listwise deletion resulted in a primary analytic sample comprised of the subset of 2,719 individuals who provided complete data for all items of interest. The final analytic sample excludes the 468 cancer survivors because they were not asked to complete the risk perception items. To obtain accurate variance estimates for the subpopulation of respondents who provided complete data, the DOMAIN statement was included in all SURVEY procedures.²⁸

Weighted descriptive statistics were used to examine the distribution of respondents' demographic characteristics, risk perceptions, cancer cognitions, and worry about environmental exposures. Exploratory factor analysis was conducted to evaluate whether the worry about environmental exposures items could be averaged into a single index or if they represented more than one construct. Bivariate linear regressions were used to examine the unadjusted relationships between multifactorial beliefs (predictor) and risk perceptions, cancer cognitions, and worry about environmental exposures (outcomes). Multivariable linear regressions examined the relationship between multifactorial beliefs and each of the outcomes separately while adjusting for age, sex, education, race/ethnicity, rural/urban geographic residence, numeracy, family history of cancer, awareness of direct-to-consumer genetic testing, motivation to process cancer information, and health information scanning.

Results

Descriptives

See Table 1 for detailed information about respondents' socio-demographic characteristics and risk perceptions, cancer cognitions, and worry about environmental exposures. According to weighted analyses, the sample was on average 44.3 years old, was approximately equally divided by sex, had a predominantly non-Hispanic white racial background, and resided in urban locations. Most respondents had obtained more education than a high school diploma. A majority of the sample reported a family history of cancer or reported being aware of direct-to-consumer genetic testing. Furthermore, approximately two-thirds of the sample held multifactorial causal beliefs about cancer.

Factor Analysis and Scale Construction

The 8 worry about environmental exposure items were subjected to an exploratory factor analysis using varimax rotation. It yielded two factors with Eigenvalues greater than 1. The factor loadings for each item on its relevant factor were all > 0.75 . There were no cross-loadings > 0.40 or communality values < 0.70 . The first factor, *Ingested Exposures*, indicated harm from potential toxins that the individual actively takes into the body. Items comprising the ingested exposures factor were those related to outdoor air pollution, indoor air pollution, chemicals in water, and chemicals in food. It accounted for 3.2% of the variance in responses. The second factor, *Emanating Exposures*, indicated harm from potential toxins that diffuse or emanate from consumer and medical products. Items comprising the emanating exposures factor were those related to radiation from cell phones, radiation from medical imaging tests, chemicals in household items, and chemicals in personal care products. It accounted for 3.1% of the variance in responses.

To represent each factor in subsequent analyses, two scales were created by averaging the value of the individual items that loaded on each factor. The internal consistency for Ingested Exposures was $\alpha_{\text{Cronbach}} = 0.89$ and for Emanating Exposures it was $\alpha_{\text{Cronbach}} = 0.87$.

Main Analyses

Unadjusted analyses—As depicted in Table 2, respondents who endorsed multifactorial beliefs about cancer had higher absolute perceived risk of cancer ($p = 0.002$), higher feelings of cancer risk ($p = 0.003$), and lower pessimism about the preventability of cancer ($p < 0.0001$) compared to people who did not endorse multifactorial beliefs. Multifactorial beliefs were also associated with higher self-reported worry about potentially toxic environmental exposures that could be ingested ($p = 0.005$) or exposures that emanate from consumer and medical products ($p = 0.02$). Endorsement of multifactorial beliefs was not associated with comparative risk perceptions, the belief that “everything causes cancer,” or that there are “too many recommendations” about cancer prevention strategies (all $ps > 0.05$).

Adjusted analyses—The strength of the relationships between multifactorial beliefs and risk perceptions, cancer cognitions, and worry about environmental exposures were attenuated after adjusting for the covariates (Table 2), but only feelings of risk was no longer statistically significant ($p = 0.06$). Multifactorial beliefs remained statistically significantly related to absolute risk perceptions ($p = 0.02$), beliefs about the preventability of cancer ($p = 0.0004$), and worry about ingested ($p = 0.02$) and emanating ($p = 0.04$) toxic environmental exposures.

Exploratory analyses—To better understand our findings, we conducted additional exploratory analyses to identify which covariate accounted for the most variance between multifactorial beliefs and feelings of risk. To accomplish this, we compared the point estimate and p -value of the fully adjusted model to the point estimate and p -value of a model that excluded only one of the covariates (e.g., age). We repeated this comparison process for each of the covariates individually. Results indicated that removing family history of cancer from the model resulted in the largest increase in the point estimate, from 0.10 to 0.15 (i.e., a 50% increase). The associated p -value for the association between multifactorial beliefs and feelings of risk in the model with all covariates except family history was $p = 0.023$. This association did not reach statistical significance in any of the remaining models in which other covariates were removed.

Discussion

The present study confirms that multifactorial causal beliefs about cancer are associated with cognitive and affective factors that drive healthy behavior. With the use of nationally representative survey data collected from the U.S. population and adjusting for a number of relevant covariates, these results demonstrate that multifactorial causal beliefs are associated with perceptions of cancer risk, cancer cognitions, and worry about toxic environmental exposures.

As predicted in hypothesis 1, multifactorial causal beliefs were significantly associated with various dimensions of perceived cancer risk. In both unadjusted and adjusted analyses, multifactorial causal beliefs were associated with heightened absolute perceptions of risk, consistent with past research involving singular causal beliefs.^{12, 13} Multifactorial causal beliefs were also associated with affective perceived risk, although this relationship became weaker and non-significant when relevant covariates were included in the model.

Exploratory analyses indicated that the decreased magnitude and significance of this association was attributable to the inclusion of family history in the model. This finding suggests that the unadjusted association between endorsing multifactorial beliefs and having higher feelings of risk may be due to negative affect associated with having a family history of cancer. If this were the case, it would be consistent with the affect heuristic's assertion that the affect generated from personal experiences has a key role in determining the extent to which something is perceived as "risky."⁷⁻⁹ Future research should investigate this possibility. Such research could utilize more extensive measures of family history than were available in the present study, which may provide additional insight into these associations.

Contrary to hypothesis 1, no association was observed between multifactorial causal beliefs and comparative perceived risk. Past research has confirmed that while perceived risk is a multidimensional construct,²⁹ these different aspects of perceived risk can have varying associations with attitudes, emotions, and behavioral intentions.^{27, 30, 31} Comparative perceptions of risk are derived from a social comparison process³² wherein people judge their personal risk by estimating and contrasting the risk of others. These perceptions were uniquely unrelated to multifactorial causal beliefs. One possibility for this null effect is that it may be particularly challenging for an individual to apply her or his understanding of the multifactorial etiology of a disease to the estimation of another's vulnerability to that disease, because this would require information that the individual may not have, such as estimating the extent to which others have been exposed to multiple disease-causing risk factors (e.g., lifestyle habits, environmental exposures, heredity).

Yet, ample research suggests that lack of information does not stop people from formulating comparative risk perceptions and using those perceptions to guide behavior.³³ Instead, people engage in a cognitive process in which they formulate comparative risk judgments by evaluating their personal risk-increasing and risk-reducing factors, but then neglect to account for other people's risk-reducing factors.³⁴ This is thought to be a self-serving action that helps maintain a positive view of the self, especially for hazards that are thought to be under personal control. However, because no one is in control of what genes they inherit, and it is extremely difficult to know what genes another person has inherited, it could be that this comparison process is short-circuited and is not informed in a meaningful way by whether or not someone endorses a multifactorial model of disease causation. This hypothesis requires validation, and presents a novel direction for future research regarding how individuals construct their understanding of others' disease risks based on their endorsement of multifactorial causal beliefs.

Multifactorial causal beliefs were inconsistently associated with cancer cognitions (hypothesis 2). These causal beliefs were unrelated to perceptions that there are too many cancer recommendations to follow or that everything causes cancer. However, individuals who recognized the multifactorial etiology of cancer held a less pessimistic view of the potential to prevent cancer. Past work has demonstrated that individuals' causal beliefs influence their perceptions of the effectiveness of specific coping strategies for reducing disease risk.^{4, 35, 36} For example, those who perceive a health condition as due to genetic causes tend to believe that medication will effectively reduce risk, whereas those who perceive the same condition as due to behavioral causes have been shown to perceive that

dietary interventions are effective risk-reducing strategies.³⁵ Consequently, it is possible that perceiving multiple risk factors could lead one to believe that multiple strategies exist for preventing disease development.

Individuals who endorsed multifactorial beliefs about cancer also reported greater worry about potentially toxic ingested and emanating environmental exposures (hypothesis 3). This association is interesting; because the survey items used to assess causal beliefs did not explicitly address environmental risk factors, there remain several possible explanations for this association. For instance, individuals may only experience worry about the specific risk factors that they believe contribute to disease. Alternatively, individuals who endorse a multifactorial model of disease causation may experience more generalized or global worry about any potential risk factor. Another possible explanation is that people who believe that cancer has both behavioral and genetic components may also be more likely to view environmental factors as a potential source of illness. These individuals would therefore be considered to be endorsing multifactorial beliefs on a tripartite level: behavior, genes, and the physical environment. Additional research that evaluates causal beliefs and corresponding affective reactions regarding a variety of risk factors is necessary to clarify these associations.

Limitations

The present study benefits from the use of a large, population-based survey that allowed for nationally representative estimates of associations between multifactorial beliefs about cancer and relevant cognitive and affective outcomes. However, there are several limitations of this work. As noted, the measurement of causal beliefs about cancer only included genetic and behavioral risk factors, which in turn limited the operationalization of multifactorial causal beliefs. It has been shown that individuals can consider and endorse a variety of additional risk factors for cancer such as environmental toxins, stress, and chance,^{11, 18, 25, 37} which were not directly assessed in this study. An additional limitation is the cross-sectional nature of the survey data. Although analyses were guided by a novel theoretically-informed conceptual framework, it is not possible to determine whether multifactorial beliefs actually cause changes in risk perceptions, cognitions about the preventability of cancer, and worry about environmental exposures. These associations may operate in the opposite direction, or be bidirectional in nature. Nonetheless, this work offers testable hypotheses that can be examined in future studies, and which may allow for further refinement of this conceptual framework. For example, researchers may use experimental methods to influence individuals' causal models of disease, such as with the delivery of relevant health communication messages or risk feedback, and measure corresponding changes in cognitions and emotions, as well as behavioral intentions and adoption. Finally, these results only provide insight into associations between multifactorial beliefs about cancer and cognitive and affective outcomes among members of the U.S. population; future research will be required to determine if similar relationships generalize to non-U.S. populations.

Implications for practice and research

The present study has important implications for clinicians and researchers interested in fostering cancer prevention and risk-reducing behaviors. People are capable of holding

multiple beliefs about the etiology of cancer at the same time,³⁸ and these multifactorial beliefs are common.² These results highlight the potential mechanisms by which these causal beliefs may ultimately support healthy behaviors: through certain health cognitions and emotions. Contrary to past work which has suggested that information about genetic risk factors engenders a sense of fatalism regarding the preventability or controllability of disease,^{14, 39} these results demonstrate that individuals who *discount* the role of both genetics and behavior as causes of cancer have more pessimistic appraisals of the preventability of cancer. Furthermore, individuals who do not endorse multifactorial causes of cancer appear to perceive fewer risks and experience less worry about harmful environmental exposures. Thus, if future research determines that multifactorial beliefs do indeed precede the development of risk perceptions, cancer cognitions, and worry, clinicians may be able to adaptively influence the cognitions and emotions that motivate healthy behaviors by helping individuals to develop a deeper understanding of how genetic and behavioral factors work together to contribute to cancer risk. However, conveying such complex information that is frequently changing because of the fast pace of genomics research is a challenge, and work is needed to determine which communication strategies may be most effective. Furthermore, research is needed to evaluate how multifactorial causal beliefs may be associated with additional malleable cognitive and affective factors, such as self-efficacy, perceived disease severity, and perceived effectiveness of health behaviors, that may be necessary for the adoption of protective health behaviors.

Conclusions

Enhancing public understanding of the complex interplay of genetic, lifestyle, and environmental factors in the development of cancer and other common diseases is an important goal for public health practitioners, clinicians, and researchers.^{1, 40} This study confirms that among the U.S. population, such multifactorial causal beliefs are associated with cancer risk cognitions and emotions that promote healthy behaviors. By identifying possible mechanisms of the ways in which multifactorial beliefs may be linked with behavior, this research could inform future genetic risk communication interventions.

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Figure 1.

Conceptual framework describing the precursors to and consequences of multifactorial causal beliefs about cancer, adapted from Waters and colleagues.^{2, 15} Concepts examined in this study are shown in the white boxes.

Table 1

Respondent characteristics (N = 2,719)

Characteristic	n (unweighted)	% (weighted)
<u>Covariates (Socio-demographic and Information Processing Variables)</u>		
Sex		
Men	1073	50.7
Women	1646	49.3
Education		
Less than 12 years	209	11.5
12 years or high school degree	562	20.1
Vo-Tech or some college	811	38.1
College graduate or more	1137	30.3
Race		
Non-Hispanic white	1685	67.0
Non-white	1034	33.0
Geographic location		
Urban	2335	84.6
Rural	384	15.4
Age (Mean, SE)	44.2	0.24
Numeracy		
Correct	2397	89.7
Not Correct	322	10.3
Family history		
Yes	1851	65.9
No	868	34.1
Aware of direct-to-consumer genetic testing		
Yes	1378	50.5
No	1341	49.5
Motivation to process information (Mean, SE)	2.8	0.3
Information scanning (Mean, SE)	2.1	0.3
<u>Multifactorial Beliefs</u>		
Yes	1861	66.0
No	858	34.0
<u>Risk Perceptions</u>		
Absolute risk (Mean, SE)	3.2	0.04
Comparative risk (Mean, SE)	2.8	0.04
Risk feelings (Mean, SE)	2.8	0.03
<u>Cancer Cognitions</u>		
Everything causes cancer (Mean, SE)	2.8	0.03
Not much can prevent cancer (Mean, SE)	2.0	0.03
Too many recommendations (Mean, SE)	2.9	0.03
<u>Worry about Toxic Environmental Exposures</u>		

Characteristic	n (unweighted)	% (weighted)
Ingested Exposures (Mean, SE)	2.6	0.03
Emanating Exposures (Mean, SE)	2.0	0.03

Note. Information scanning, motivation to process information, cancer cognitions, and worry were measured on a scale of 1–4. Risk perceptions were measured on a scale of 1–5. In all cases, higher scores indicated more agreement. Use of listwise deletion yielded an analytic sample of N=2,719 with no missing data on any of the items.

Table 2

Unadjusted and adjusted analyses of associations between multifactorial causal beliefs about cancer and the outcomes of risk perceptions, cancer cognitions, and worry

Predictor	Unadjusted (N = 2,719)			Adjusted (N = 2,719)		
	b	95% CI	p	b	95% CI	p
<u>Risk Perceptions</u>						
Absolute risk	0.22	0.09–0.36	.002	0.17	0.03–0.30	0.02
Comparative risk	0.06	–0.07–0.19	.34	0.03	–0.10–0.16	.64
Risk feelings	0.15	0.05–0.25	.003	0.10	–0.01–0.20	.06
<u>Cancer Cognitions^a</u>						
Everything causes cancer	0.07	–0.04–0.18	.22	0.08	–0.04–0.20	.18
Not much can prevent cancer	–0.23	–0.33–0.12	<.0001	–0.19	–0.30–0.09	.0004
Too many recommendations	–0.03	–0.16–0.10	.68	–0.01	–0.14–0.12	.88
<u>Worry about Toxic Environmental Exposures</u>						
Ingested Exposures	0.22	0.07–0.37	.005	0.18	0.04–0.32	.02
Emanating Exposures	0.19	0.03–0.35	.02	0.14	0.01–0.28	.04

Note: Adjusted analyses included the following covariates: age, sex, education, race, geographic residence, numeracy, family history, awareness of direct-to-consumer genetic testing, motivation to process cancer information, and health information scanning.

^aHigher scores on these items indicate more agreement.