



Published in final edited form as:

J Health Commun. 2016 ; 21(SUP2): 6–15. doi:10.1080/10810730.2016.1193917.

How are information seeking, scanning, and processing related to beliefs about the roles of genetics and behavior in cancer causation?

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Abstract

Background—Understanding that cancer is caused by both genetic and behavioral risk factors is an important component of genomic literacy. However, a considerable percentage of people in the U.S. do not endorse such *multifactorial beliefs*.

Methods—Using nationally representative cross-sectional data from the U.S. Health Information National Trends Survey (N=2,529), we examined how information seeking, information scanning, and key information processing characteristics were associated with endorsing a multifactorial model of cancer causation.

Results—Multifactorial beliefs about cancer were more common among respondents who engaged in cancer information scanning ($p=.001$), were motivated to process health information ($p=.005$), and who reported a family history of cancer ($p=.0002$). Respondents who reported having previous negative information seeking experiences had lower odds of endorsing multifactorial beliefs ($p=.01$). Multifactorial beliefs were not associated with cancer information seeking, trusting cancer information obtained from the Internet, trusting cancer information from a physician, self-efficacy for obtaining cancer information, numeracy, or being aware of direct-to-consumer genetic testing ($ps>.05$).

Conclusion—Gaining additional understanding of how people access, process, and use health information will be critical for the continued development and dissemination of effective health communication interventions and for the further translation of genomics research to public health and clinical practice.

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Compliance with Ethical Standards

Human and Animal Rights: This article does not contain any studies with human participants or animals performed by any of the authors.

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

Keywords

Multifactorial beliefs; genetics; information seeking; information scanning; causal beliefs; cancer

Introduction

Many common health conditions, including cancer, diabetes, heart disease, stroke, obesity, and hypertension are multifactorial in nature—that is, they are caused by a combination of genetic, behavioral, and environmental factors (Collins, Green, Guttmacher, & Guyer, 2003). Understanding the multifactorial nature of disease etiology is a critical component of genomic health literacy, which has been defined as “the capacity to obtain, process, understand, and use genomic information for health-related decision making” (Hurle et al., 2013). Yet, many laypeople do not endorse the multifactorial model of disease causation (Ashida et al., 2011; Claassen et al., 2011; O’Neill, McBride, Alford, & Kaphingst, 2010; Parrott, Silk, & Condit, 2003; Sanderson et al., 2013; Sanderson, Waller, Humphries, & Wardle, 2011; Wang, Miller, Egleston, Hay, & Weinberg, 2010; Wold, Byers, Crane, & Ahnen, 2005). Examination of population-level data indicates that 21–36% of people in the U.S. do not hold multifactorial causal beliefs for many common health conditions (Waters, Muff, & Hamilton, 2014). The absence of multifactorial beliefs is particularly notable for cancer, with 35.7% of the population failing to recognize the interplay between genes and behavior. There is also preliminary evidence that multifactorial beliefs may be less common among men, people with less formal education, non-Hispanic whites, residents of urban geographic areas, and people with limited numeracy (Waters et al., 2014).

Endorsing a multifactorial model of cancer causation is important not only because multifactorial beliefs are an accurate reflection of how the disease develops, but also because causal beliefs are associated with engagement in health behaviors (Leventhal, Brissette, & Leventhal, 2003). For example, individuals who endorse genetic causal beliefs may believe that a disease will develop regardless of their lifestyle behaviors, and consequently choose to take a medication instead of changing their behavior (Cameron, Marteau, Brown, Klein, & Sherman, 2012; Marteau & Weinman, 2006). In contrast, individuals who endorse behavioral causal beliefs may believe that their behavior can modify their risk of developing a health condition, and consequently, change their behavior (Nguyen, Oh, Moser, & Patrick, 2015). Simultaneously endorsing both genetic and behavioral causes of cancer (i.e., multifactorial cancer beliefs) is associated with higher engagement in cervical, breast, colorectal, and prostate cancer screening (Waters et al., 2014).

In sum, the available evidence indicates that there are substantial unmet information needs about the multifactorial nature of cancer causation. These unmet needs are associated with lower engagement in key cancer detection behaviors and may be related to socio-demographic characteristics that are associated with cancer disparities. Causal beliefs are generally formed based on specific information people obtain about a health condition (Leventhal et al., 2003). Therefore, improving understanding of the process by which people obtain cancer information, as well as the relationship between this process and endorsement of multifactorial beliefs, could inform the development and dissemination of health

messages aimed at improving knowledge about the multifactorial nature of cancer causation. Such efforts would further the translation of genomics research into practice by helping the public understand ongoing developments in scientific knowledge about the complex interplay between genes and behavior and increase their adherence to cancer screening guidelines.

Obtaining Cancer Information

Information seeking and information scanning are two general strategies through which people can obtain information about cancer and other health conditions. Information *seeking* refers to actively and deliberately searching for and gathering information from the media, interpersonal conversation, the Internet, medical providers, or other information sources that are outside of the normal flow of conversation (Niederdeppe et al., 2007; Powe, 2015; Wong, 2012). This is different from information *scanning*, which refers to passively encountering information or being exposed to information unintentionally (Lee, Zhao, & Pena, 2016; Shim, Kelly, & Hornik, 2006).

Theories of health behavior (Conner & Norman, 1995), persuasion (Chaiken, Giner-Sorolla, & Chen, 1996; Petty & Cacioppo, 1996), and communication (Griffin, Dunwoody, & Neuwirth, 1999; McGuire, 1984; R. E. Smith & Swinyard, 1982) posit that information affects behavior by changing attitudes and beliefs. Although there is ample empirical evidence that information seeking and scanning are indeed important precursors of engagement in health behaviors, such as fruit and vegetable consumption (Beaudoin & Hong, 2011; Lewis et al., 2012; Ramirez et al., 2013) and colon and breast cancer screening behaviors (Shim et al., 2006; Shneyderman et al., 2015), much less research has examined the direct effect of cancer information seeking and scanning on health knowledge, attitudes, and beliefs. One study reported that higher engagement in information scanning (but not information seeking) was associated with stronger beliefs about the preventability of colon cancer and heart disease (Hovick & Bigsby, 2015). Another study reported that obtaining information about the human papilloma virus (HPV) was associated with more favorable beliefs about vaccinating a daughter against HPV (McRee, Reiter, & Brewer, 2012).

Data regarding the relationships among information seeking, scanning, and genetics-related knowledge, attitudes, and beliefs are particularly sparse. Information seeking was related to increased genetic knowledge among family members and patients with inherited bone marrow failure syndromes in one study (Hamilton et al., 2015), and increased awareness of direct-to-consumer (DTC) genetic testing in another (Agurs-Collins et al., 2015). Research about the association between information scanning and genetics-related knowledge is lacking, and similarly, no research has examined how information seeking or scanning may be related to the endorsement of multifactorial beliefs about cancer. This gap in the literature has implications for the development and dissemination of cancer education and communication efforts. For example, understanding the extent to which information seeking versus scanning contributes to the formation of multifactorial beliefs could help determine whether messages that require active engagement versus passive exposure, respectively, may be more effective.

Processing Cancer Information

The development of multifactorial beliefs may also be influenced by the way in which individuals process cancer information. Information processing is an important determinant of whether a given piece of information actually changes attitudes, beliefs, and behavior (Chaiken et al., 1996; Griffin et al., 1999; Petty & Cacioppo, 1996). Factors such as beliefs about the source of the information, perceived and actual ability to learn more about the issue, prior experience with the specific issue in question, and motivation to process information can all influence the extent to which a given piece of information changes knowledge, attitudes and beliefs.

Relatively few studies have examined these factors in the cancer domain, but there is some empirical support for many of these proposed relationships. For example, one study reported that having high levels of trust in health information from government agencies was associated with higher awareness of tobacco cessation telephone hotlines (Kaufman, Augustson, Davis, & Finney Rutten, 2010). Other research demonstrated that individuals with limited actual ability to understand and use numerical information (i.e., low numeracy) responded to colon cancer educational materials with less favorable attitudes towards colon cancer screening compared to individuals who had higher numeracy (S. G. Smith et al., 2014). Another study reported that daily smokers who were more confident in their ability to quit smoking (i.e., high self-efficacy) had more favorable attitudes towards quitting in response to an anti-smoking public service announcement than those who had lower self-efficacy (Falcone et al., 2013). In contrast, individuals who reported having negative experiences while seeking cancer information reported more pessimistic beliefs about cancer prevention than individuals who had more positive experiences (Arora et al., 2008). People who reported not wanting to know their risk of cancer (i.e., low motivation) also had more pessimistic beliefs about cancer prevention activities (Emanuel et al., 2015). Although some research demonstrated that prior experience with DTC genetic testing was associated with higher odds of endorsing multifactorial beliefs about cancer causation (Waters et al., 2014), very little is known about what other information processing factors are associated with the development of multifactorial beliefs. Understanding these relationships could further inform the development of future cancer communication efforts.

Objective and Hypotheses—This study explores the possible role of cancer information seeking, scanning, and processing in the development of multifactorial beliefs about cancer. It is guided by a conceptual framework that describes how information seeking, information scanning, information processing, and socio-demographic factors might contribute to the development of multifactorial causal beliefs about cancer and, consequently, influence engagement in healthy behaviors (Figure 1). Adapted from prior research (Waters et al., 2014), this framework draws upon theoretical and empirical work from psychology, communication, public health, and genomic medicine (Chaiken et al., 1996; Collins et al., 2003; Costanzo, Lutgendorf, & Roeder, 2011; Griffin et al., 1999; Hesse, Arora, & Khoury, 2012; Leventhal et al., 2003; Marteau & Weinman, 2006; McBride et al., 2008; Petty & Cacioppo, 1996; US Department of Health and Human Services, 2012). The following hypotheses were tested:

H1. Cancer information seeking and scanning will be associated with increased odds of endorsing multifactorial beliefs about cancer.

H2. The following information processing factors will be associated with *increased* odds of endorsing multifactorial beliefs: Higher trust in sources of cancer information, higher perceived ability to obtain cancer information (i.e., self-efficacy), higher actual ability to obtain cancer information (i.e., numeracy), higher motivation to process cancer information, and having prior experiences with genetics (i.e., aware of DTC genetic testing) and/or cancer (i.e., family history).

H3. Reporting more negative information seeking experiences will be associated with *decreased* odds of endorsing multifactorial beliefs.

Methods

Data Source

Data were obtained from the Health Information National Trends Survey (HINTS 4, Cycle 2), which was administered through mailed self-report questionnaires from October 2012 through January 2013. HINTS is a population-based, nationally representative survey of the adult (ages 18 or older) civilian non-institutionalized population of the U.S. Detailed information about its methodology and response rate is available at hints.cancer.gov/docs/HINTS_4_Cycle2_Methods_Report.pdf.

Measures

Acquiring health information—*Cancer information seeking* was assessed with two items: “Have you ever looked for information about health or medical topics from any source?” and “Have you ever looked for information about cancer from any source?” [Yes; No]. Individuals who responded “No” to the health information seeking question were recoded as having not sought cancer information. *Cancer information scanning* was assessed indirectly with seven items that shared a question stem (Shim et al., 2006): “How much attention do you pay to information about cancer from each of the following sources: [In online newspapers; In print newspapers; In special health or medical magazines or newsletters; On the internet; On the radio; On local television news programs; On national or cable television news programs]?” The response options for each source ranged from [1] Not at all to [4] A lot. These seven items were averaged to create a scale in which higher scores were associated with more information scanning, $\alpha = 0.87$.

Influences on information processing—*Trust in the information source* was assessed with two items: “In general, how much you would trust information about cancer from each of the following: [A doctor; Family or friends; Newspapers or magazines; Radio; Internet; Television; Government health agencies; Charitable organizations; Religious organizations and leaders]?” Response options ranged from [1] Not at all to [4] A lot. Because most people obtain their health information from the Internet (67.6%) or a healthcare provider (15.7%) (Volkman et al., 2014), we only examined trust in these two domains. *Information seeking self-efficacy* was assessed with the item: “Overall, how confident are you that you

could get advice or information about cancer if you needed it?” Response options ranged from [1] not confident at all to [5] completely confident. *Numeracy* was assessed using the item, “As far as you know, who has a greater chance of getting cancer—a person with a 1 in 1,000 chance of getting cancer, or a person with a 1 in 100 chance?” Individuals who skipped the item were considered incorrect. *Motivation to process cancer information* was assessed with the item, “I’d rather not know my chance of getting cancer.” Response options ranged from [1] strongly agree to [4] strongly disagree.

Several items assessed prior experience—The *family history of cancer* item asked, “Have any of your family members ever had cancer? [Yes; No; Not sure].” *Awareness of DTC genetic testing* was assessed with the item, “Genetic tests that analyze your DNA, diet and lifestyle for potential health risks are currently being marketed by companies directly to consumers. Have you heard or read about these genetic tests? [Yes; No].” *Negative cancer information seeking experience* was assessed only for individuals who had ever sought cancer information. Four items shared the following question stem: “Based on the results of your most recent search for information about cancer, how much do you agree or disagree with each of the following statements: [It took a lot of effort to get the information you needed; You felt frustrated during your search for the information; You were concerned about the quality of the information; The information you found was hard to understand]?” Response options ranged from [1] strongly disagree to [4] strongly agree. These items were averaged to create a scale in which higher scores indicated more difficulty in obtaining and understanding cancer information, Cronbach’s $\alpha = 0.85$ (Hesse, Arora, Burke Beckjord, & Finney Rutten, 2008).

Multifactorial beliefs—To examine the simultaneous endorsement of genetic and behavioral causal beliefs about cancer, we combined two causal beliefs items into a single dichotomous variable (Waters et al., 2014). The original items read, “How much do you think [health behaviors like diet, exercise, and smoking / genetics, that is characteristics passed from one generation to the next] determine whether or not a person will develop each of the following conditions: Diabetes; Obesity; Heart disease; High blood Pressure; Cancer?” The response options ranged from [1] Not at all to [4] A lot. Because this study focused specifically on cancer, only responses to the cancer items were examined. Respondents were defined as endorsing multifactorial beliefs about cancer if they responded “A lot” or “Somewhat” to *both* the genetic and behavior items. Respondents who provided any other combination of responses were coded as not endorsing multifactorial beliefs.

Covariates—Based on prior research examining predictors of multifactorial beliefs (Waters et al., 2014) and other research documenting differences in information seeking and/or scanning by socio-demographic characteristics (Finney Rutten et al., 2015; Kelly et al., 2010) and family history (Lee et al., 2016; Rutten, Squiers, & Hesse, 2006), several respondent characteristics were included as covariates. These included age, gender, education, race/ethnicity, and rural/urban geographic residence.

Analytic Strategy

In compliance with data analytic guidelines for HINTS (National Cancer Institute, 2013), data were analyzed using SAS 9.4 SURVEYFREQ and SURVEYLOGISTIC procedures using jackknife variance estimation. These procedures reduce the likelihood of a Type I error by accounting for the survey's complex design and sampling scheme (Korn & Graubard, 1999). They also weight the data to yield estimates representative of the U.S. adult population.

There were 3,630 survey respondents, but our primary analytic sample is comprised of a subset of 2,529 individuals who provided complete data for all items of interest except those items assessing information seeking experiences. Information seeking experiences items were asked only of individuals who reported having ever purposefully sought cancer information. Because we were also interested in understanding the role of information scanning in the development of multifactorial beliefs, and information scanning can occur among people who do not seek information, we elected to examine information seeking experiences separately from the other information processing variables. Cancer survivors ($n = 468$) were also excluded due to the low number of respondents (which raised concerns about small cell sizes for some of the variables such as numeracy), as well as their unique information needs and experiences (Arora et al., 2008; Hesse et al., 2008). To permit accurate estimation of variance estimates for the subpopulation of respondents who provided complete data, the DOMAIN statement was used in conjunction with the SURVEY procedures (Korn & Graubard, 1999).

Respondents' demographic characteristics, information seeking and scanning behavior, and information processing factors were examined using weighted descriptive statistics. Bivariate logistic regressions were used to examine the unadjusted associations between multifactorial beliefs (outcome) and information seeking, scanning, and processing (predictors). One multivariable logistic regression tested the combined influence of all information seeking, scanning, and processing variables (except negative information seeking experience) to determine which, if any, were most important for the endorsement of multifactorial cancer causal beliefs. A second multivariable logistic regression included negative information seeking experience as a predictor. Because negative information seeking experience was only relevant for information seekers, information seeking was not included in the second model. All multivariable analyses adjusted for age, gender, race, education, and geographic residence.

Results

Detailed information about respondents' demographic and information seeking, scanning, and processing characteristics are described in Table 1. Weighted analyses indicated that the respondents were approximately equal in gender, primarily non-Hispanic white, primarily resided in an urban location, and were on average 43.5 years of age. A majority of respondents had at least some education beyond a high school diploma. The majority (65.6%) of the sample endorsed multifactorial beliefs about cancer causation. Information seeking and scanning behaviors were relatively limited; far less than half of respondents (37.3%) reported having ever sought cancer information, and the mean cancer information

scanning rating was only slightly above “a little.” In general, trust in cancer information was moderate to high. Respondents reported “some” trust in cancer information obtained from the Internet and “a lot” of trust in cancer information from a doctor. Perceived (self-efficacy) and actual (numeracy) ability to obtain information were high. Motivation to process cancer information was moderate to high, with respondents “somewhat disagreeing” with not wanting to know their cancer risk. The sample also had relatively high prior experience with cancer, either through family history (66.5%) or awareness of DTC genetic testing (51.1%). Furthermore, respondents reported relatively low levels of negative information seeking experiences, generally “somewhat disagreeing” with statements about negative experiences.

Bivariate examination of the relationship between demographic variables and information seeking indicated that women engaged in more information seeking and scanning than men, but lower information seeking was associated with having less than a college degree and being a member of a racial or ethnic minority group (Table 2). In contrast, information scanning was associated race/ethnicity but not educational attainment.

As shown in Table 3, bivariate analyses indicated that multifactorial beliefs were statistically significantly more common among people who had higher information scanning behaviors, higher motivation to process cancer information, and who had a family history of cancer ($p < .05$). In contrast, multifactorial beliefs were significantly less common among people who had more negative information seeking experiences ($p < .05$). Endorsing multifactorial beliefs was not related to cancer information seeking, trust in cancer information obtained from the Internet, trust in cancer information obtained from a doctor, self-efficacy for obtaining cancer information, numeracy, or having prior awareness of DTC genetic testing services ($p < .05$).

The adjusted multivariable models showed nearly identical results. In both models, higher motivation to process cancer information and having a family history of cancer were associated with higher endorsement of multifactorial beliefs (Table 3). The examination of information seeking, scanning, and negative experiences was more complex due to the skip patterns embedded within the survey. Model A examined cancer information seeking and scanning but not negative information seeking experiences, because the information seeking experiences scale was not administered to people who reported not seeking health information. In Model A, cancer information scanning was associated with endorsing multifactorial beliefs, but cancer information seeking was not (Table 3, Multivariable analysis-A).

Model B examined the role of negative information seeking experiences and information scanning, but only among people who reported seeking information in the previous year. Again, this was because the information seeking experiences scale was administered only to information seekers. In Model B, cancer information scanning was no longer statistically significant. However, as in the bivariate analysis, having prior negative information seeking experiences was associated with less endorsement of multifactorial beliefs (Table 3, Multivariable analysis-B).

Discussion

Multifactorial beliefs are a key component of genomic literacy and have cross-sectional associations with higher engagement in cancer screening behaviors (Waters et al., 2014). However, a sizeable proportion of the U.S. population does not endorse a multifactorial model of cancer causation. In addition to its potential implications for cancer screening behaviors, lack of concordance between lay and expert conceptualizations of risk, as indicated by not endorsing multifactorial beliefs, may promote mistrust of health communicators and skepticism of scientific findings (Gurmankin Levy, Weinstein, Kidney, Scheld, & Guarnaccia, 2008). This, in turn, could further complicate the translation of basic genomics research to clinical and public health practice.

This study sought to improve understanding of what information seeking, scanning, and processing factors may contribute to the development of multifactorial beliefs, with the goal of informing the development and dissemination of health communication interventions and furthering the translation of genomics research into clinical and public health practice. We found that happenstance encounters with cancer information (i.e., information scanning) may have a more important relationship with multifactorial beliefs than purposive cancer information seeking. This is consistent with research examining the combined association between information seeking and scanning with health beliefs (Hovick & Bigsby, 2015). To speculate, it could be that people who are searching for specific information, as is the case with purposive information seeking, are less open to other types of information that either do not seem directly relevant to their goals or that conflict with their pre-existing beliefs (Petty & Cacioppo, 1996). This relative lack of openness may result in the information seeker who is searching for specific types of cancer information (e.g., treatment) to either not read or not encode seemingly extraneous information about the multifactorial nature of cancer into their causal models. This question should be examined using experimental and prospective research designs to confirm the directionality and causal relationships among variables.

We also found support for some—but not all—of the examined information processing variables. Although theories of health communication and persuasion posit that information processing factors such as trust in the message source and individual ability are critical for shaping attitudes and beliefs (Chaiken et al., 1996; Griffin et al., 1999; Petty & Cacioppo, 1996), our findings suggest that other factors may have greater importance in this health context. We observed that multifactorial beliefs were more common among people with higher motivation to process information, who reported having a family history of cancer, and who had more positive prior information seeking experiences. These findings are consistent with other research (Arora et al., 2008; Emanuel et al., 2015), and suggest areas for future theoretical and empirical work. For instance, there is a need to better understand motivation to process health-related information, including identifying specific situations or strategies that can effectively enhance people's motivation and/or increase their receptivity to communication regarding genetic and behavioral contributors to cancer. Clarifying the role of motivation in health information seeking and scanning may therefore facilitate the development of future genomics-related health communication efforts.

The absence of a relationship between multifactorial beliefs and numeracy was unexpected, because numeracy has been shown to be an important predictor of understanding health information generally (Nelson, Reyna, Fagerlin, Lipkus, & Peters, 2008) and genetic information in particular (Ostergren et al., 2015). It is possible that our results are due to a restricted range in numeracy; less than 10% qualified as having low numeracy in our analytic sample. This restricted range was likely the result of a single-item measure, which was implemented due to space constraints in the survey. Unfortunately, there was no health literacy item in the survey. Future research should examine the interrelationships among health literacy, numeracy, and multifactorial beliefs using validated measures.

A critical unanswered question regarding the formation of multifactorial beliefs about cancer relates to the temporal and causal relationships among information seeking, scanning, and processing. When comparing the two multivariable analysis models, it is notable that adding negative information seeking experiences to the model reduced the significance of information scanning to non-significance. Yet, the study data limit our ability to infer that negative information seeking experiences is a mediator of the relationship between cancer information scanning and multifactorial beliefs. First, because mediation is a causal process and our data were cross-sectional, it is not appropriate to test mediational hypotheses in this situation. Second, the model that includes negative information seeking experiences is comprised solely of information seekers, whereas the other model includes both seekers and non-seekers. Future research should attempt to unpack these relationships using an experimental design to manipulate the quality of an information seeking experience. This could be done by comparing information scanning levels after participants read health information written at a purposefully higher versus lower reading level, or by placing relevant information in the middle versus at the beginning of paragraphs.

Strengths, Limitations, and Additional Future Directions

A notable strength of this study is the use of a large, population-based survey to examine novel associations between information seeking, scanning, and processing and the presence of multifactorial beliefs about the etiology of cancer. Evidence consistent with some aspects of the conceptual framework and study hypotheses was obtained. Despite the cross-sectional nature of our data, these findings generate several hypotheses that can be examined in future studies. For example, a prospective study that experimentally varies the complexity of information (therefore producing more negative information seeking experiences) could yield important insights into the conditions under which people do and do not learn about the multifactorial basis of cancer. This type of study could help confirm the role of the information environment in shaping the development of multifactorial beliefs and the subsequent adoption of health-promoting behaviors. Prospective work should also confirm the directionality of the link between multifactorial beliefs and engagement in health behaviors.

As is true of HINTS and many other large, population-based surveys, single-item, self-reported measures were used to assess the study variables. As a result, there are limitations in the scope and depth of data available for examining these research questions. For example, items did not assess the frequency of cancer information seeking behaviors. Thus,

while we did not observe a significant association between ever seeking information about cancer and multifactorial beliefs, it remains possible that these beliefs are more common among those who more frequently seek out cancer information. Furthermore, the measure of multifactorial beliefs was limited in scope, assessing only a dichotomous endorsement of the shared role of genetics and behavior in cancer causation. There is a need for measures of multifactorial beliefs that are more statistically powerful (e.g., scale measures, or single-item measures that assess this construct as a continuous variable) and comprehensive (e.g., incorporate a broader range of risk factors such as environmental exposures).

The constantly-evolving information environment also presents challenges to the assessment of information scanning behaviors. For instance, HINTS assessed information scanning from sources including “online newspapers” and “the Internet”; yet, the extent to which respondents conceptualize these as distinct sources of information is unclear. Respondents’ experiences with additional online sources that have gained increasing traction in recent years, including social media websites like Facebook, Twitter, and Instagram, as well as blogs of celebrities or laypeople, were not specifically evaluated. However, these information sources may have unique, strong, and lasting effects on the public’s understanding of health and disease (Dunn, Leask, Zhou, Mandl, & Coiera, 2015; Neubaum & Kramer, 2015).

Finally, it is unknown whether the observed relationships will hold true for non-cancer-related health conditions. Multifactorial beliefs for health conditions including heart disease, hypertension, diabetes, and obesity are fairly common (Waters et al., 2014). Future investigations should examine how exposure to health messages may influence people’s understanding of these and other important health conditions.

Conclusion

There is an abundance of cancer-related information available for public consumption, including messages that reflect growing scientific understanding about the role of genes and heredity in relation to traditional behavioral risk factors such as tobacco use, diet, and exercise. Making sense of this complex interplay of risk factors is challenging, and a key aspect of genomic literacy—understanding that cancer is caused by both genetic and behavioral factors—is limited. People who experience difficulties understanding and obtaining health information are particularly vulnerable to misunderstanding this concept, which may prompt them to reject messaging related to multifactorial beliefs. Improving the public’s awareness of the multifactorial nature of cancer causation is important, particularly because these beliefs are associated with the adoption of protective health behaviors. Gaining additional understanding of how people access, process, and use genetic and behavioral risk information will be critical for the continued development and dissemination of effective health communication interventions and for the further translation of genomics research to public health and clinical practice.

Acknowledgments

Funding: This work was supported by MRSRG-11-214-01-CPPB (Erika A. Waters) and NCI 2 P30 CA08748-48 (Jada G. Hamilton). The funding agreement ensured the authors’ independence in designing the study, interpreting

the data, writing, and publishing the report. There are no real or potential conflicts of interest with the funding organization.

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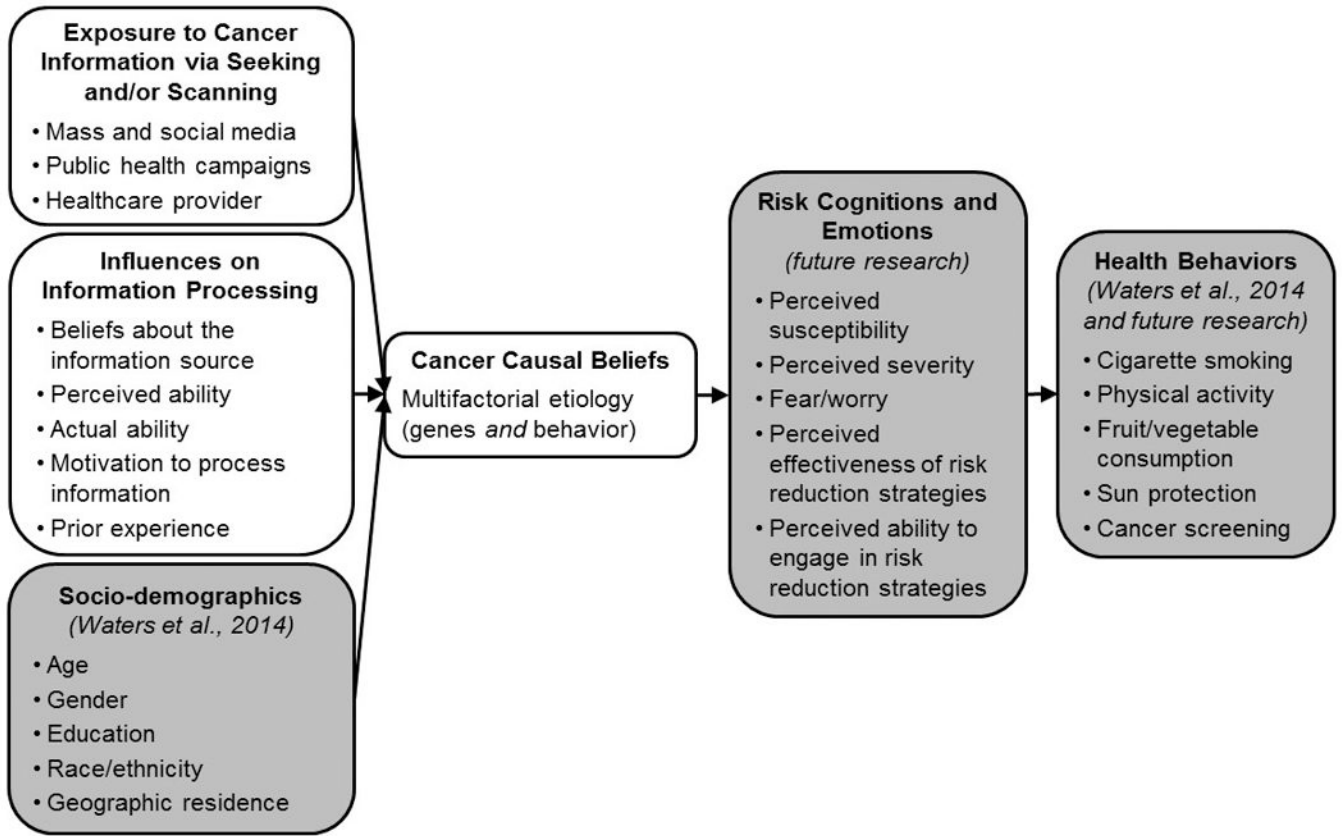


Figure 1. Conceptual framework describing the precursors and consequences of multifactorial beliefs about cancer causation, adapted from (Waters et al., 2014).

Table 1

Respondent characteristics (N = 2,529)

Characteristic	n (unweighted)	% (weighted)
<u>Socio-demographics</u>		
Sex		
Men	995	50.7
Women	1534	49.3
Education		
Less than 12 years	167	10.0
12 years or high school degree	507	19.6
Vo-Tech or some college	757	38.4
College graduate or more	1098	32.0
Race		
Non-Hispanic white	1575	68.0
Non-white	954	32.0
Geographic location		
Urban	2170	84.8
Rural	359	15.2
Age (Mean, SE)	43.5	0.27
<u>Beliefs</u>		
Multifactorial beliefs		
Yes	1720	65.6
No	809	34.4
<u>Information Seeking and Processing</u>		
Seek Cancer Information		
Yes	1022	37.3
No	1507	62.7
Actual Ability-Numeracy		
Correct	2254	91.3
Not Correct	275	8.7
Prior Experience-Family History		
Yes	1726	66.5
No	803	33.5
Prior Experience-Aware DTC Genetic Testing		
Yes	1300	51.1
No	1229	48.9
Scan Cancer Information (Mean, SE)	2.2	0.03
Trust-Internet (Mean, SE)	2.9	0.03
Trust-Doctor (Mean, SE)	3.7	0.02
Perceived Ability-Self-Efficacy (Mean, SE)	3.8	0.04
Motivation to Process Information (Mean, SE)	2.8	0.03
Prior Experience-Negative Information	2.2	0.04

Characteristic	n (unweighted)	% (weighted)
Seeking (Mean, SE)		

Note. DTC = Direct-to-Consumer. Negative Information Seeking Experiences n = 986. All continuous variables except age have four response options.

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Bivariate relationships between sociodemographic characteristics and information seeking and scanning

Table 2

Predictor	Information seeking (N = 2,529)			Information scanning (N = 2,529)		
	OR	95% CI	p	b	95% CI	p
Age	1.0	1.0 - 1.0	.12	0.0	0.0 - 0.0	.80
Female	1.8	1.4 - 2.2	.0001	0.2	0.1 - 0.2	.0005
Education						
Less than 12 years	0.2	0.1 - 0.4	.0001	0.1	-0.1 - 0.3	.34
12 years or high school degree	0.4	0.3 - 0.6	.18	-0.1	-0.2 - 0.1	.30
Vo-Tech or some college	0.6	0.5 - 0.8	.01	0.0	-0.1 - 0.1	.91
College graduate or more	Ref			Ref		
Non-White Race	0.7	0.5 - 1.0	.03	0.3	0.2 - 0.4	.0001
Rural Geographic Residence	1.1	0.8 - 1.6	.58	-0.1	-0.2 - 0.0	.08

Table 3

Predictors of endorsing multifactorial beliefs about cancer

Predictor	Bivariate analysis (N = 2,529)			Multivariable analysis-A (N = 2,529)			Multivariable analysis-B (N = 986)		
	OR	95% CI	p	OR	95% CI	p	OR	95% CI	p
<u>Information Seeking and Scanning</u>									
Seek Cancer Information	1.1	0.8 - 1.5	0.52	0.8	0.6 - 1.2	0.28	-	-	-
Scan Cancer Information	1.4	1.1 - 1.7	0.004	1.4	1.1 - 1.7	0.001	1.3	0.9 - 1.8	0.23
<u>Information Processing</u>									
Trust-Internet	1.3	1.0 - 1.6	0.08	1.2	0.9 - 1.6	0.25	1.2	0.8 - 1.9	0.29
Trust-Doctor	1.1	0.9 - 1.4	0.30	1.0	0.8 - 1.2	0.73	0.9	0.6 - 1.4	0.68
Perceived Ability-Self-Efficacy	1.1	0.9 - 1.2	0.39	1.0	0.9 - 1.2	0.98	0.9	0.7 - 1.2	0.51
Actual Ability-Numeracy	1.2	0.8 - 1.7	0.32	1.2	0.8 - 1.8	0.32	1.6	0.7 - 3.6	0.29
Motivation to Process Information	1.2	1.1 - 1.4	0.01	1.3	1.1 - 1.5	0.005	1.3	1.1 - 1.6	0.01
Prior Experience-Family History	1.8	1.4 - 2.5	<0.001	1.9	1.4 - 2.7	0.001	2.0	1.1 - 3.6	0.03
Prior Experience-Aware DTC Genetic Testing	1.2	0.8 - 1.6	0.40	1.2	0.8 - 1.6	0.36	1.0	0.6 - 1.7	0.92
Prior Experience-Negative Information Seeking	0.7	0.5 - 1.0	0.03	-	-	-	0.7	0.5 - 0.9	0.01
<u>Socio-Demographic Covariates</u>									
Age	1.0	1.0 - 1.0	.13	1.01	1.00 - 1.02	.02	1.0	1.0 - 1.0	.13
Female	1.3	0.9 - 1.8	.10	1.2	0.9 - 1.7	.23	1.4	0.8 - 2.3	.27
<u>Education</u>									
Less than 12 years	0.6	0.4 - 1.3	.61	0.7	.04 - 1.3	.44	0.5	0.1 - 1.9	.50
12 years or high school degree	0.8	0.5 - 1.3	.55	0.8	0.5 - 1.3	.79	0.5	0.3 - 1.1	.44
Vo-Tech or some college	0.9	0.6 - 1.2	.92	0.8	0.6 - 1.2	1.0	0.8	0.5 - 1.3	.58
College graduate or more	ref			ref			ref		
Non-White Race	1.1	0.8 - 1.5	.47	1.2	0.9 - 1.8	.20	1.5	0.9 - 2.7	.14
Rural Geographic Residence	1.5	0.9 - 2.3	.11	1.6	1.0 - 2.8	.06	1.4	0.7 - 2.9	.37

Note. Multivariable models controlled for age, sex, education, race, and geographic residence. Prior experience-negative information seeking was asked only of individuals who reported ever seeking cancer information. Thus, it could not be included in analyses examining the relationship between cancer information seeking and multifactorial beliefs (i.e., Multivariable analysis-A). Similarly, the relationship between prior negative information seeking experiences and multifactorial beliefs could not be examined with cancer information seeking in the model (i.e., Multivariable analysis-B).