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Beliefs about cancer and diet among those considering genetic testing for colon cancer

A.E.L. Palmquist, Ph.D.¹, R. Upton, M.A.², S. Lee, M.A.², A. T. Panter, Ph.D.², D.W. Hadley, M.S., C.G.C.¹, and L.M. Koehly, Ph.D.¹

¹Social and Behavioral Research Branch, National Human Genome Research Institute, National Institutes of Health, Bethesda, MD 208922

²Department of Psychology, University of North Carolina, Chapel Hill, NC 27599-3270

Abstract

Objective—To assess beliefs about the role of diet in cancer prevention among individuals considering genetic testing for Lynch Syndrome.

Design—Family-centered, cascade recruitment; baseline assessment of a longitudinal study

Setting—Clinical research setting

Participants—Participants were 390 persons, ages 18 and older, including 1) persons with a Lynch syndrome associated cancer and suspected of carrying a disease causing mutation and 2) relatives at risk for inheriting a previously identified mutation.

Main Outcome Measures—Assess 1) clustering of beliefs about the role of diet in cancer prevention, and 2) predictors of class membership

Analysis—Confirmatory factor analysis; 2-class factor mixture model with binary indicators; multilevel regression analyses, individuals nested within families

Results—Women endorsed a relationship between diet and cancer prevention more often than men ($P<.01$). A two-class model was used where: Class 1 = less likely to link cancer to diet, Class 2 = more likely. Factors associated with increased odds of membership in: Class 1 = belief that nothing can prevent cancer ($P<.01$), fate attribution ($P<.01$); Class 2 = personal cancer history ($P<.05$), genetic knowledge ($P<.01$).

Conclusions and Implications—Identifying factors associated with a belief in cancer prevention through dietary behaviors can inform targeted interventions.

Keywords

health beliefs; dietary beliefs; cancer prevention; hereditary cancer; Lynch Syndrome

Corresponding Author: Aunchalee E. L. Palmquist, Ph.D., The MacMillan Center, Yale University, P.O. Box 208206, New Haven, CT 06520-8206, Tel. (203)436-5241, Fax. (203) 203-432-6873, aunchalee.palmquist@yale.edu.

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Introduction

It has been estimated that 50% of cancer in the general population is preventable through modifying lifestyle factors, such as diet, physical activity, alcohol consumption, and tobacco use [1]. Existing research suggests that beliefs about the causal relationship between diet and cancer influences compliance with recommended cancer prevention strategies within the general population. This finding has provided an interesting domain for research. For example, Harnack and others [2] demonstrated that as their participants' level of cancer prevention related knowledge increased, their reported fruit and vegetable intake more closely approximated recommendations for appropriate fruit and vegetable consumption. Satia and Galanko [3] found that a strong belief in a cancer-diet relationship was associated with greater compliance to participate in prostate and breast cancer screening. These studies provide evidence that the general population commonly makes an association between diet and cancer, and this belief may serve to motivate behavioral changes.

Such beliefs among individuals at an increased risk of hereditary cancer syndromes have not been widely studied. Understanding the degree to which perceptions about genetic susceptibility to cancer aligns with a general belief in the controllability of disease is an important research question with practical implications, particularly in the area of nutrition education, genetic counseling, and health intervention design [4,5]. Dietary beliefs and behaviors are especially interesting because they often reflect a larger health belief model of which other types of cancer prevention behaviors, such as participation in screening for early detection, may be a part [3,6,7]

To fill this research gap, we conducted an exploratory study of diet-related cancer prevention beliefs among participants suspected to have or at risk of developing an inherited form of cancer known as hereditary nonpolyposis colorectal cancer (HNPCC) or Lynch Syndrome [8]. HNPCC is a dominantly inherited cancer susceptibility syndrome, which significantly increases risks for cancers of the colon, endometrium, stomach, ovaries, small intestine, hepatobiliary system, upper uroepithelial tract, pancreas, and brain [9]. It results from mutations in any 1 of 4 mismatch repair (MMR) genes. Risks for colon cancer are reported to reach 70% by the age of 70. An estimated 3-5% of colorectal cancer cases diagnosed annually within the United States are attributed to HNPCC [10,11].

Drawing upon perspectives from Cultural Consensus Theory (CCT) [12,13] and the Health Belief Model (HBM) [14] we surveyed beliefs about the link between diet and cancer among individuals at high risk for HNPCC-associated cancers who are considering genetic testing. A major premise of CCT is that culture, when defined as a set of shared beliefs, behaviors, and common experiences, may be operationalized by evaluating the extent to which there is agreement among individuals about a particular cultural domain [12,13]. Beliefs about cancer causation and controllability are examples of cognitive domains that are amenable to analysis using CCT. Accordingly, individuals may be grouped together based on their agreement about specific health beliefs, rather than on socio-demographic variables such as race, ethnicity, age, sex, or level of education. The rationale for using CCT in this study stems from the assumption that, for an inherited cancer syndrome like HNPCC, similarities in health beliefs may emerge from comparable experiences dealing with familial cancers, interactions with health care providers about cancer diagnoses and treatment, and information gained through lay information-seeking about disease causation and prevention (e.g., internet, friends, support groups). Factor mixture modeling was employed to identify consensus among study participants regarding a relationship between diet and cancer causation and controllability.

The HBM is a conceptual framework that characterizes the relationships between an individual's perceived susceptibility for and severity of disease, their beliefs about the controllability or preventability of disease, and perceptions about their ability to engage in behaviors that would lead to decreased risk of disease [14]. It is a useful approach to uncover latent variation in beliefs among individuals in socio-demographically homogenous groups. In the present study, ideas drawn from the HBM were used to consider the broader context of health beliefs in which a diet-cancer relationship was endorsed or not among participants at high genetic risk of cancer.

Together, these theoretical orientations provide a basis for addressing the following research aims among persons receiving genetic counseling and considering genetic testing for HNPCC: (1) to identify and group together study participants based on a shared belief, or consensus, in a diet-cancer relationship; and (2) to examine other aspects of participants' health belief models, specifically non-dietary related perceptions about cancer controllability, demographic characteristics, and level of genetic knowledge, which distinguish the groupings identified through aim 1.

Methods

Study Design

Data for the present report were gathered as part of the baseline assessment from a prospective study conducted jointly by the National Institutes of Health (NIH; protocol #95-HG-0165) and the National Naval Medical Center (NNMC; protocol # NNMC. 1995.0045). This longitudinal study was designed to investigate the psychological, behavioral, and social outcomes resulting from the introduction of genetic risk information within families experiencing an inherited disease. The appropriate NIH and NNMC Institutional Review Boards reviewed and approved the protocol. All participants provided their written informed consent prior to participation.

Study Participants and Recruitment

Potential study participants were identified on the basis of clinical and pathological criteria. Clinical criteria included early age of onset (≤ 40 years of age) of an HNPCC associated cancer, multiple primary HNPCC associated cancers, and/or a strong family history of HNPCC cancers suggesting a hereditary basis. Pathological criteria were met by the presence of "Microsatellite Instability" in a colon or other HNPCC associated tumor. Individuals who exhibited the clinical and pathological criteria for HNPCC (index cases) were referred to the study team, received detailed information about the study and consented to participate, if willing. A family medical history (FMH) was collected by either a Genetics Counselor (Certified by the American Board of Genetic Counselors) or an Advanced Practice Nurse, with training in Clinical Genetics; a 4-generation pedigree was constructed from the FMH to clarify biological relationships. Participants then completed a questionnaire, which collected demographic information and the variables of interest. Following questionnaire completion, each participant participated in structured genetic education and client-centered counseling sessions. Following counseling, participants were offered genetic testing without cost [15]. Index cases choosing genetic testing and found to carry a disease causing mutation could refer their first-degree relatives (FDR) (i.e. children, siblings, and parents) at risk to inherit the familial mutation, into the study. These relatives underwent the same process for consenting, questionnaire completion, education, counseling and the option of genetic testing as the index case. Relatives found to carry the familial mutation could then offer their FDR the opportunity to participate in the study. This cascade sampling approach to recruitment was allowed to continue as far into the family as relationships allowed or knowledge of kinship (or contacting information) existed. In 58 of

the index cases, no mutation was identified, which precluded recruitment of their family members. A total of 390 participants, including 109 index cases and 281 family members, participated in the study.

Measurement Instruments

Two items examined participants' beliefs about the relationship between diet and cancer, 1 specific to causation and 1 specific to prevention. Participants were asked whether they believed that *cancer was a disease that was related to what people eat and drink*. Then, they were asked to indicate the perceived benefits of specific dietary behaviors with the following item: *what dietary behaviors would be helpful if a person wanted to reduce their chances of getting certain kinds of cancer?* Participants could select 1 or more of the following 7 binary dietary behaviors (0 = not selected; 1 = selected): *eating more fiber, avoiding foods with additives, eating less salt, taking vitamins, eating less sugar, eating less fat, and eating more fruits and vegetables*. Consensus in beliefs about the relationship between diet and cancer was assessed by considering participants' responses to these 7 binary items, which appeared to be internally consistent based on a Kuder-Richardson formula 20 (KR20) reliability index [16] of 0.84.

Non-dietary dimensions of participants' health belief models, specifically *perceived controllability of cancer* and *level of genetic knowledge* were measured as follows. *Perceived controllability of cancer* was assessed separately with 2 items. Participants indicated the importance of the belief, *I believe that there is nothing that can be done to prevent getting cancer*, in their decision to have genetic testing for HNPCC, where 0 = *not important at all*, 1 = *somewhat important*, 2 = *very important*. Additionally, participants' responded to the statement, *Cancer is God's will*, by indicating their level of agreement, where 1 = *strongly disagree*, 2 = *somewhat disagree*, 3 = *somewhat disagree*, and 4 = *strongly agree*.

Participants' *level of genetic knowledge* specific to HNPCC was measured, prior to genetic counseling or testing, through a series of 9 questions. A genetic knowledge score was calculated as the total number of items to which they responded correctly. The KR20 reliability coefficient for the genetic knowledge score is 0.77.

Demographic Characteristics—Demographic characteristics were ascertained during the baseline assessment, including age, gender, marital status, education level, and socio-economic status. In addition, each participant's personal cancer history was obtained.

Data Analysis

Analyses of baseline survey data were conducted to identify (i) clustering of beliefs about the role of diet in cancer causation and prevention, and (ii) whether this clustering could be explained by personal cancer history, perceived controllability, and level of genetic knowledge. Covariates that might influence these beliefs, such as gender, socio-economic status, and educational level, were considered. Participants with incomplete data were excluded from the analyses.

A series of factor mixture models with structured means [17,18] were used to identify latent classes (i.e., unobserved heterogeneity) among the 7 binary items used to measure beliefs regarding relationships between dietary behavior and cancer prevention. The underlying continuous latent factor (e.g., a belief that cancer could be caused by what people eat and drink) was identified using a factor mixture model, which accounted for the intercorrelations among the 7 binary items and prevented the over extraction of latent classes [18]. All models were fitted with Mplus 5.1 (MPlus version 5.1, Muthen & Muthen, Los Angeles,

CA, 2007) using maximum likelihood estimation with robust standard errors and the “Type=Complex” option to account for the dependencies of individuals nested within families.

Several alternative models were evaluated to assess the best fit for the 7 binary items. A confirmatory factor analysis (CFA) model (i.e., a 1-class factor mixture model), a 2-class factor mixture model, and a 3-class factor mixture model were each tested for measurement invariance [19,20]. The Akaike Information Criterion (AIC) index, the Bayesian Information Criterion (BIC) index, and the adjusted BIC index were lower for the 2-class model with strong factorial invariance, indicating that this model provided the best overall fit. The 3-class model with weak factorial invariance was under-identified and was not examined.

Once the 2-class model was identified as having the best fit, we examined whether there were statistically significant mean differences between the classes, defined as Class-1 and Class-2. The continuous cancer beliefs factor was then regressed onto study covariates, including gender, education level, household income, cancer history, and family cancer history. Finally, characteristics explaining membership within each class (i.e. personal history of cancer, beliefs about cancer causation and controllability, and genetic knowledge) were explored through regression analyses.

Results

Characteristics of the sample are presented in Table 1. Seventy-six percent of participants indicated that cancer may be related to what people eat and drink. With regard to each of the dietary behaviors that would be helpful if a person wanted to reduce their chances of getting certain kinds of cancer, 77% of the participants selected eating more fruits and vegetables, 73% selected eating more fiber, 57% selecting eating less fat, 52% selected avoiding foods with additives, 47% selected taking vitamins, 28% selected eating less sugar and 21% selected eating less salt.

Using a Type I error rate of .05, results from the 2-class model revealed positive, statistically significant factor loadings for each of the 7 binary items linking cancer prevention to specific dietary behaviors. This finding suggests that higher levels of the continuous underlying latent factor, referred to herein as the “cancer and diet (CAD) belief factor”, were associated with higher odds of endorsing each of the 7 binary items. Analyses considered study covariates, including gender, household income, and level of education. There was a statistically significant association between gender and the CAD belief factor. Household income and highest level of education were not significantly associated with the continuous CAD belief factor (results not shown). Women were more likely to endorse beliefs that one's diet can reduce the risk of cancer as compared to men ($B = .51, P < .05$). After fixing the mean of Class-2 for the CAD belief factor, the mean of the continuous CAD belief factor for Class-1 was $-5.45 (P < 0.01)$, suggesting that, on average, individuals in Class-1 were significantly less likely to believe that one's diet or what one eats can reduce the risk of cancer as compared to individuals in Class-2. Factor loadings, thresholds, factor means, factor variances, and latent class means for the model assessing beliefs by gender appear in Figure 1.

The 2-class factor mixture model with strong factorial invariance indicated that individuals were clustered as follows: Class-1 (17.14%; $n = 66$) and Class-2 (82.86%; $n = 319$). Five participants with missing data were excluded from the analysis, yielding an effective sample size of 385. Most participants supported beliefs that one's diet can reduce the risk of cancer (i.e., Class-2).

The final set of analyses aimed to identify variables that distinguished class membership. Variables considered included personal cancer diagnosis, beliefs that *nothing can be done to prevent cancer* and that *cancer is God's will*, and genetics knowledge. Table 2 provides regression coefficients for these variables, all of which were significant characterizations of class membership.

In all regression analyses, the mean of the CAD belief factor for Class-1 was statistically significantly lower than that of Class-2. Participants reporting a personal cancer history were more likely to be placed in Class-2 compared to Class-1 indicating they were more likely to endorse the belief that diet can reduce the risk of cancer (compared with Class-1 individuals). Individuals endorsing the belief that *nothing can be done to prevent cancer* had higher odds of being placed into Class-1 versus Class-2 so were less likely to indicate that diet could reduce the risk of cancer. A belief that *Cancer is God's will* was negatively associated with endorsing a belief in a diet-cancer prevention relationship. Finally, individuals with a higher level of genetic knowledge were more likely to be placed into Class-2 and, thus, were more likely to endorse beliefs that one's diet can reduce the risk of cancer.

Discussion

In this study we used an innovative approach to evaluate beliefs about the relationship between diet and cancer in the context of an inherited cancer syndrome. This report contributes to the literature by exploring diet-related health beliefs among individuals considered to be at elevated risk for HNPCC associated cancers and by considering the importance of genetic knowledge in endorsing a belief in a diet-cancer relationship.

CCT provided a theoretical foundation for grouping study participants based on their shared health beliefs. The exploratory analyses revealed consistent, statistically significant differences between the 2 groups: those who endorsed a link between diet and cancer and those who did not. Study findings supported the correlation between perceived causes and controllability of disease that one would expect to see based on the tenets of the HBM. A majority of participants endorsed a belief that cancer was related to diet (76%) and that cancer risk reduction may be achieved through dietary behaviors (83%). Having a personal history of cancer, high perceived controllability, and a high level of genetics knowledge were all associated with the group that was more likely to endorse a diet-cancer relationship.

Beliefs about the relationship between diet and disease prevention have been shown to be important predictors of dietary behaviors, such as incorporating recommended amounts of fruits and vegetables into one's diet or consuming more dietary fiber. One study found that men's lower nutritional knowledge was significantly associated with their lower intake of fruits and vegetables [21]. A belief in the relationship between dietary fiber and cancer causation was associated with more frequent use of nutritional food labels among university students [22]. Moreover, in a study to identify psychosocial predictors of self-initiated healthful dietary change, women were more likely to make healthful dietary changes than men, as were individuals who believed there was a strong relationship between diet and cancer [23]. Encouraging healthy eating as a complement to engagement in appropriate cancer screening may be particularly effective among those who believe that there is a link between diet and cancer.

A higher level of genetic knowledge was associated with endorsing a diet-cancer relationship among a majority of participants in the present study. Higher genetic knowledge implies a refined understanding of the complexities involved in HNPCC etiology. Some of this knowledge may have been gained through a personal history of cancer or through

having family members diagnosed with cancer. One obvious research question that emerges from this finding, which has practical implications, is whether increasing an individual's level of genetic knowledge would create shift from a belief that nothing can be done to prevent cancer to a belief that cancer is preventable. Similarly, does a higher level of genetic knowledge also lead to higher levels of engagement in preventive behaviors? These questions deserve further study.

There is a considerable gap in knowledge about the interaction between genetic susceptibility to cancer and environmental factors such as diet. For this reason the potential to endorse specific dietary interventions for those at high risk of hereditary cancer is somewhat limited. However, increasing interest in exploring the intersection between the human genome and the environment (i.e., epigenomics) is changing our knowledge about the impact of our diet, medication, and other environmental exposures on an individual's disease risks. The human epigenome is comprised of chemical compounds, some natural (e.g., foods) and others man-made (e.g., pesticides and pharmaceuticals). These compounds have the potential to affect a person's risk of developing disease by attaching to genes and turning them "on" or "off". Dietary factors play a role in the suppression or expression of cancer genes through epigenetic processes, such as DNA methylation and histone modification [24,25]. Alcohol consumption, obesity and overweight, and folate deficiency have been linked with breast and colorectal cancers by leading to chronic inflammation, oncogenesis, promoting cell growth, and exacerbating cancer cell proliferation [1]. Conversely, a reduction in colorectal cancer risk has been associated with taking calcium supplements, even when controlling for a strong family history of cancer [26]. Calcium binds to bile and fatty acids in the gastrointestinal tract which may reduce damage to large-bowel mucosa, stimulate cell differentiation, and induce cell death in the gastrointestinal tract [1]. In addition, varying levels of penetrance of genetic mutations for hereditary cancers makes it reasonable to include dietary approaches within the cadre of risk reduction strategies encouraged for those with a known genetic susceptibility [27,28]. More basic research into the unique cancer prevention behaviors that are effective among those at high risk of familial cancers is needed, so that these findings may be translated into educational and clinical interventions that meet the needs of patients at high risk of inherited cancers.

Several issues limit the interpretation of study results. Our participants represent a fairly homogenous group, in terms of demographic characteristics as well as their cancer risk profile and family histories. This report adds to the literature on dietary beliefs among a population at risk of HNPCC, however, these findings may not be representative of individuals at risk for other forms of hereditary cancer syndromes. Responses to the survey questions regarding beliefs about the relationship between diet and cancer were collected during the baseline assessment, prior to GCTS. Although other issues, such as cancer screening behaviors, were evaluated post-GCTS, the dietary beliefs component was not a part of the follow up surveys. We also did not evaluate the relationship between dietary beliefs and dietary behaviors pre- and post-GCTS. These are two important research questions for future studies to address.

Implications for Research and Practice

Our analyses revealed a significant difference between men and women in the way that they conceptualized dietary behaviors and cancer prevention. Men were less likely to endorse a relationship between dietary behaviors and cancer prevention than women. Gender differences in dietary knowledge and beliefs about diet and cancer have been identified in other studies as well. For instance, in a study of nutritional knowledge among colorectal cancer patients, women were found to have significantly higher nutrition knowledge scores than men [29]. Another study of fruit and vegetable intake and nutritional knowledge in the

general population found that women were more knowledgeable about both recommendations for fruit and vegetable intake and also the relationship between diet and disease prevention [21]. These findings suggest that men may have educational needs that are unique from women. Identifying strategies to enhance men's knowledge of nutritional information and its importance in disease prevention should be a priority for nutrition educators and those developing nutrition education interventions. Further research on learning styles, level of nutritional knowledge among men and its impact on men's engagement in dietary related cancer prevention behaviors is needed.

The current study raises several important opportunities for nutrition education research and practice in the context of hereditary cancers like HNPCC. The increasing importance of genetics in patients' health belief models creates a challenge for nutrition educators. Nutrition educators may be called upon to help individuals and their family members interpret scientific research on the role of diet in the context of hereditary cancers. Nutrition educators may also find that their expertise complements the work of genetic counselors and other clinicians. They may be able to collect family histories of disease from a uniquely dietary perspective, and through that process learn about the dietary beliefs and behaviors of family members that may influence patient approaches to health maintenance and disease prevention.

As discussed earlier, participants seeking genetic testing often carry with them numerous beliefs drawn from lived experience, family history of disease, and prior experiences with health care educators and clinical professionals. The strong potential for social and familial influences on individuals beliefs about the importance of diet in disease prevention and health maintenance points to the value of shifting nutritional education strategies away from the individual to more family-centered approaches. Nutrition educators and researchers have the opportunity to enrich our understanding of how individuals and their family members cope with hereditary disease from a unique vantage point of food, diet, and nutrition. Because families are involved in influencing food-related behaviors and care-giving through food, there is a great potential for nutrition educators to lead the way in developing dietary approaches to cancer education in various clinical and counseling settings in which those at high risk for hereditary disease seek care, counseling services, health education, and support.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1. Factor loadings and regression coefficients for the 2-Class Factor Mixture Model with Cancer and Dietary (CAD) Belief Factor regressed on Gender

The latent CAD belief factor is characterized by the 7 binary dietary behaviors (represented by boxes at the bottom of figure) as indicated. Unidirectional arrows show predictive relationships. Per a 2-class factor mixture model, participants were grouped into 2 classes. Those in Class-1 were less likely to endorse a belief in a diet-cancer relationship and thus the 7 binary dietary behaviors. Women were more likely than men to endorse a diet-cancer relationship. Measurement errors are not shown.

Table 1

Background Information of Study Participants (N=390)

	%	Range	Mean (SD)
Age	-	18-83	42.2 (14.64)
Gender: Female	58	-	
Race			
Caucasian	94.1	-	-
African American	2.3	-	-
Asian	1.3	-	-
Hispanic	1.8	-	-
Other	0.5	-	-
Education			
> 12 years	1.1	-	-
High School/Equivalent	25.7	-	-
Some College	6.9	-	-
College	44.4	-	-
Graduate Degree	21.8	-	-
Household Income			
<20,000	12.5	-	-
20,001 -35,000	12.8	-	-
35,001 - 50,000	18.1	-	-
50,001–75,000	21.8	-	-
> 75,001	34.8	-	-
Cancer Salience in Family			
Number of First Degree Relatives * with Cancer	-	1-8	1.9 (1.3)
Number of Second Degree Relatives * with Cancer	-	1-9	3.0 (1.8)
Number of participating family members	-	0-36	114 (14.5)

* First degree relatives include children, siblings, and parents. Second degree relatives include aunts and uncles.

Table 2

Results of the 2-Class Factor Mixture Models with Latent Class Factor Regression

Item	<i>B</i>	SE	Mean Class-1
Cancer history	.78*	.31	-6.93**
Genetics knowledge	.23**	.06	-6.47**
Nothing can be done to prevent cancer	-.38*	.19	-6.53**
Cancer is God's will	-.33**	.13	-6.95**

* Note: $P < .05$.** $P < .01$. Factor variances are constrained to equality across latent classes and are not repeated for Class-2.