Lay beliefs about risk: relation to risk behaviors and to probabilistic risk perceptions

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Abstract Lay illness risk beliefs are commonly held philosophies about how risk works. These include beliefs that one's personal illness risk is unknowable and beliefs that thinking about one's risk can actually increase that risk. Beliefs about risk may impact risk behaviors and thereby subsequent health status. However, limited research examines the relation between lay risk beliefs and health behavior. This paper explores this possible relation. A nationally representative sample of adults (N = 1005) recruited from an internet panel were surveyed about lay risk beliefs and risk perceptions regarding diabetes and colorectal cancer, psychosocial factors (i.e., health literacy, need for cognition, locus of control), demographics, and current health behaviors (i.e., cigarette smoking, red meat intake, physical activity). In separate sets of regressions controlling for either demographics, psychosocial factors, or risk perceptions, lay risk beliefs remained significantly related to health behaviors. It may be important to consider how to address lay risk beliefs in intervention content and targeting in order to increase adaptive health behaviors and thereby prevent chronic disease.

Introduction

Risk perceptions regarding illness likelihood influence engagement in many health behaviors (Sheeran et al., 2014). The proposition that risk perception affects health behaviors is a central aspect of health behavior theories (Sutton, 1987; Weinstein & Klein, 1995; Brewer et al., 2007), including the health belief model (Rosenstock, 1974), protection motivation theory (Rogers, 1975), and the self-regulation model (Leventhal et al., 1980). However, the observed relations between risk perceptions and health behaviors are often smaller than expected (Atkinson et al., 2015; Brewer et al., 2007; Sheeran et al., 2014).

Over and above one's risk perceptions, the *belief*s one holds about risk itself may influence health behaviors. Such beliefs likely encompass less rational, more intuitive elements of the process of risk consideration, including philosophies or intuitions about how risk works (Hay et al., 2005). Such beliefs about risk are very common in the general population (Hay et al., 2014). Work examining beliefs about the nature of risk has demonstrated evidence for five types of lay risk beliefs (Hay et al., 2014, 2016a, 2016b). In the current study, we examine two of these: cognitive causation, which entails the superstitious belief that thinking about a disease will increase the likelihood that you will develop that disease, and unpredictability,

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which entails the belief that there is no way of knowing who will get a disease. Lay risk beliefs are distinct from risk perceptions, which are traditionally conceptualized as deliberative (e.g., asking participants to estimate "How likely are you to get breast cancer in the next 10 years/your lifetime?"; Peters et al., 2006; Weinstein & Klein, 1995).

Lay risk beliefs and health behavior

Examining lay risk beliefs may help explain patterns of engagement in health behaviors. If a person does not know what his or her risk is, that person may not be able to act in accordance with their risk. For example, with unpredictability beliefs, if a person believes that whether or not one gets a disease is unpredictable and therefore that their health behavior actions will increase or decrease their risk for disease, they may see no reason to engage in health promoting behaviors or to cease maladaptive health behaviors. With respect to cognitive causation beliefs, endorsing that thinking about a disease may cause that disease may actually lead to avoidance of health promotion behaviors.

The research examining the nature, prevalence, and outcomes of lay beliefs about risk is situated within a broader move towards consideration of an important role for the rapid, automatic formulation of cancer risk judgments, bypassing the cognitive effort associated with rational analysis (Cameron & Leventhal, 2003; Finucane et al., 2000; Loewenstein et al., 2001; Peters et al., 2006; Slovic et al., 2005). For instance, fuzzy-trace theory (Reyna et al., 2015) well articulates the importance of the bottom line distillation or meaning of risk information, or "gist" representations, in influencing behavioral decision making. These "gist" representations are shaped by emotion (Zikmund-Fisher et al., 2010) as well as knowledge, culture, and context among other factors. There have been multiple efforts to operationalize and examine both the cognitive as well as affective elements of intuitive elements of risk, such as experiential risk perceptions (e.g., Ferrer et al., 2016), and fatalistic beliefs about cancer (e.g., National Cancer Institute, 2019). Superstitious thinking about risk has been examined in the social psychological literature (Wegner and Wheatley 1999, Subbotsky and Quinteros 2002, Pronin et al., 2006, Risen and Gilovich 2008) but has not been extensively examined in the health risk context.

Little research has examined how and why lay risk beliefs may influence engagement in health behaviors. A notable exception is a study demonstrating that lay risk beliefs predict uptake of colorectal cancer screening in a longitudinal study with a chart-review-confirmed outcome (Hay et al., 2016b). However, lay risk beliefs have yet to be explored in relation to other health behaviors.

Correlates of lay risk beliefs

There are important demographic and psychosocial factors relevant to lay risk beliefs. These factors may possibly moderate the risk belief-health behavior relation. For example, some demographic factors such as low educational attainment have been positively associated with the endorsement of lay risk beliefs (Hay et al., 2014, 2016b). Additionally, several psychosocial characteristics have been associated with lay risk beliefs as well (Hay et al., 2014; Ferrer & Klein, 2015). *Perceived personal control* over health may influence the relation of lay risk beliefs and behaviors (Heimlich & Ardoin, 2008); prior work confirms that a common superstitious behavior, knocking on wood, is higher among those with a greater desire for control (Keinan, 2002). *Need for cognition* involves preferences for processing information, either deliberatively and effortfully through the central route of processing, or through the peripheral route of processing which is faster and uses more gist-based heuristic cues (Cacioppo et al., 1996). Lay risk beliefs may be related to avoiding thinking deeply about risk, and using peripheral processing cues rather than effortful central processing—therefore less need for cognition. Thus, need for cognition may confound the relation between lay risk beliefs and health behaviors.

Health literacy involves the degree to which an individual has the capacity to obtain, communicate, process, and understand basic health information in order to make appropriate health decisions (CDC, 2017d). The relation of health literacy and health behavior engagement has been repeatedly demonstrated (Berkman et al., 2011; Noar et al., 2007). Health literacy is also a potential confounder of the relation between lay risk beliefs and health behaviors because health literacy can be related to misinformation or lack of information about health, which overlaps with lay risk beliefs and is related to how people may engage in health behaviors.

Risk perceptions are also positively associated with lay risk beliefs (Hay et al., 2014, 2016a, 2016b), although they are also a separate construct (Hay et al., 2014). Whether lay risk beliefs relate to health behaviors above and beyond risk perceptions is unknown. Determining this will demonstrate a unique relationship between this relatively new construct and health behaviors.

Study goal and hypothesis

We examined lay beliefs about unpredictability and cognitive causation about each of two diseases—diabetes and colorectal cancer. We selected these two diseases because both are prevalent, cause high morbidity and mortality in the US (CDC, 2018, 2019), and are both associated with known, common behavioral risk factors (Knowler et al.,

2002; Bassett et al., 2010). Our outcomes were three health behaviors that increased the risk of each disease—increased smoking (Sasco et al., 2004; Willi et al., 2007), increased red meat intake (Chan et al., 2011; Micha et al., 2012), and decreased physical activity (Monninkhof et al., 2007; Umpierre et al., 2011). These maladaptive health behavior patterns are also less common among people who report low socioeconomic status and racial and ethnic minorities (Pampel et al., 2010; Jackson et al., 2010). We hypothesized that lay risk beliefs would be related to increased maladaptive health behavior patterns (e.g., increased smoking, decreased physical activity), even when accounting for demographics, psychosocial factors, and risk perceptions in separate regression analyses.

Method

Participants

Participants were 1005 community adults recruited from an established Internet survey panel maintained by GfK (formerly Knowledge Networks). Eligibility criteria included being 18 years of age or older, able to communicate in English, and not having a personal history of *both* colon cancer and diabetes mellitus. Participants who had a personal history of one disease only received survey items related to the other disease.

Procedure

GfK recruited individuals into its Internet survey panel using an address-based random sampling recruitment strategy to obtain a nationally-representative, population-based sample of the non-institutionalized U.S. population. GfK provides KnowledgePanel panelists with a personal computer and/or Internet connection for free if they do not already have a computer or Internet access. GfK randomly selected potential participants for this study from KnowledgePanel and sent them an email invitation to complete the questionnaire. If the panelist did not complete the survey within 3 days, they were sent a reminder email; if they did not complete it within another 3–4 days, they received an automated reminder phone call. The survey took approximately 20 min to complete via a web-based interface.

Eligibility criteria were as follows: at least 18 years old, ability to communicate in English, and no personal history of both colon cancer and diabetes mellitus. Panelists with a history of only one of the two disorders were eligible. Of 1818 panelists screened, 1007 (55.4%) agreed to participate and provided valid data. Refusers did not differ sig-

nificantly on any demographic data collected. Of these, two reported history of both diabetes and colon cancer and were withdrawn from the study. Of the 1005 remaining eligible respondents, 112 reported having diabetes and therefore only received questions about colon cancer, and 6 reported having colon cancer and only received questions about diabetes. The remaining 887 respondents did not report being diagnosed with either illness, and received questions about both colon cancer and diabetes.

Measures

The survey included items assessing lay risk beliefs, demographics, psychosocial variables, risk perception and health behaviors. This study was part of a larger project assessing risk perceptions and don't know responding about risk. Below we describe only the measures used for the analyses reported in this paper.

Lay risk beliefs

Cognitive causation Cognitive causation was assessed using a measure developed by Hay et al. (2014). Participants received seven items assessing the belief that risk appraisal can actually increase risk likelihood (e.g., "If I think too hard about the possibility of getting cancer, I could get it"). Participants responded using a four-point Likert scale with response options ranging from 1 = strongly disagree to 4 = strongly agree. The mean of the 7 items, scaled up to a range of 0–100 (Baser et al., 2017) served as the measure of cognitive causation ($\alpha = 0.97$).

Unpredictability Unpredictability was assessed using a 3-item measure developed by Hay et al. (2014). Participants responded to a series of items assessing the belief that one's risk for disease is unknowable (e.g., "Anybody can get diabetes, no matter what they do"). Response options were the same as those for cognitive causation. The mean of the 3 items, also scaled up to a 0–100 scale, served as the measure of unpredictability ($\alpha = 0.87$).

Demographic characteristics

Participants reported their education (recoded to dichotomous: high school or less, more than high school), income (recoded to categorical: < $25k, $25k to < $50k, $50k to < $75k, $75k to < $100k, $100k to < $125k, $125k and up), employment status (recoded to dichotomous: working or not), race/ethnicity (categorical: White, Non Hispanic; Black, Non Hispanic; Other, Non Hispanic; Hispanic; 2 + races, Non Hispanic), gender (dichotomous:

male, female), birth date (used to calculate age; continuous), marital status (recoded to categorical: married/partnered, single-never married, divorced/separated, widowed), and weight/height (used to calculate BMI; continuous).

Psychosocial variables

Locus of control We assessed individual differences in perceived control over health outcomes with the internal health locus of control subscale of the six item Multidimensional Health Locus of Control scale ($\alpha = 0.77$; Wallston & Wallston, 1978). An example item includes "I am in control of my health." Response options ranged from (1) strongly agree–(4) strongly disagree. Responses to each item were summed to calculate an overall locus of control score.

Need for cognition We assessed need for cognition with the Need for Cognition Scale, short form (7 items, $\alpha = .80$) (Caccioppo & Petty, 1982; Sheerard & Czaja, 1999). An example item includes "Thinking is not my idea of fun." Responses were on a four-point Likert scale from (1) strongly agree–(4) strongly disagree and were summed to calculate scores.

Health literacy We administered the Newest Vital Sign (NVS) measure. The NVS involves reading a nutrition label for ice cream and then answering six comprehension-based questions about the nutrition label (Weiss et al., 2005). It has adequate reliability ($\alpha = 0.66$) in this study. Items were scored correct or incorrect and the number of correct items (0–6) served as the measure of health literacy.

Risk perceptions We assessed both absolute and comparative perceived risk for each disease using items developed for the National Cancer Institute's Health Information National Trends Survey (HINTS; Nelson et al., 2004), modified to include a don't know response option. For absolute risk, options were on a four point Likert scale: "not at all likely," "somewhat likely," "fairly likely," and "very likely," plus a fifth "don't know" option. For comparative risk, options were on a three point Likert scale: "less likely," "about as likely," and "more likely," plus a "don't know" option. Given our goal to examine standard risk perception measures, for the purposes of this study we marked the "don't know" option responses as missing (19% of responses for diabetes, 31% for colorectal cancer).

Health behaviors

Smoking We assessed smoking by asking participants a standard question about self-identified smoking status,

inquiring about whether or not they had smoked at least 100 cigarettes in their entire life ("Have you smoked at least 100 cigarettes in your entire life?;" no = never smoker, yes = former or current smoker).

Red meat consumption We asked about red meat consumption in servings per day or per week using risk assessment tools to calculate colon cancer and diabetes risk ("How many servings per day of red meat do you consume?;" Wells et al., 2014). We asked participants to identify how many servings per day or per week they consumed, describing a usual serving (i.e., "about a deck of cards or 3 oz"). We recoded this variable to ounces per day.

Exercise We asked separate questions about self-reported moderate and vigorous physical activity ("How many minutes per day of physical activity do you do?"; with definitions included for moderate and vigorous activity). Moderate and vigorous activity were summed together to form a single minutes-of-exercise-per-day measure; Bang et al., 2009).

Analysis plan

Statistical analyses were performed using SPSS. First, preliminary analyses included examination of data normality and descriptive statistics. Second, bivariate analyses used correlations to examine relationships between lay risk beliefs and demographic variables, psychosocial variables, and risk perceptions. Third, we ran a series of regression models examining the association between lay risk beliefs and health behaviors, with six models per series (one for each of three health behaviors with the two diseases modeled separately). We applied survey weights to all regression models to ensure that the models reflected a nationally representative sample.

We began the third category of analyses by running unadjusted linear regressions with lay risk beliefs as the predictors and health behaviors as the outcomes. Then, we conducted three separate series of hierarchical regression models (i.e., one series for each of the three sets of potential confounders: demographic factors, psychosocial factors, and risk perceptions). Specifically, the first step of each model included one set of potential confounders (i.e., either demographics, psychosocial variables, or risk perceptions) and the second step included the two lay risk beliefs (i.e., cognitive causation and unpredictability). Models were run separately for each health behavior outcome. As such, in the first series of hierarchical models, we entered demographic factors at step one and

lay risk beliefs at step two. In the second series of hierarchical models, we entered psychosocial factors at step one and lay risk beliefs at step two. In the third series of hierarchical models, we entered risk perceptions (absolute and comparative) at step one and lay risk beliefs at step two. Logistic regressions were run for the dichotomous smoking variable.

Power

Without weighting, the sample size of N = 893 for models of diabetes lay risk belief models would provide at least 80% power to detect even a small but significant correlation of at least $r = \pm 0.10$. The sample size for the diabetes models was no larger than 893 and for colorectal cancer was 998, due to prevalent cases.

Results

Sample descriptives

Of the 1005 participants, 741 were white (73.7%) and 521 were female (51.8%). Their average age was 50.02 years old (SD = 17.18) (unweighted; see Table 1). Among the CRC survey respondents, there were 627 (63.2%) never smokers and 365 (36.8%) former or current smokers. Participants reported exercising (moderate plus vigorous exercise) an average of 22.8 min a day (SD = 13.2 [0–92]). Participants reported consuming 3.1 oz of meat each day (SD = 2.6 [0–16]; see Table 2). The two lay risk beliefs measures were correlated with each other moderately and positively (diabetes $r = 0.41$, $p < .05$; colorectal cancer $r = 0.34$, $p < .05$).

Relationships between lay risk beliefs and potential confounders

Lay risk beliefs and each of the demographics were correlated, albeit in different ways depending on the demographic variable (see Table 3). Lay risk beliefs were also related to psychosocial variables in the directions expected, with the exception of locus of control and unpredictability of colon cancer (see Table 3). For the most part, lay risk beliefs were positively but modestly related to risk perceptions, indicating minimal overlap in the constructs ($r = 0.06$–0.13; $p < .05$); there was no significant relation between unpredictability beliefs about colorectal cancer and perceived risk, which was not statistically significant (absolute $r = .064$, $p > .05$; comparative $r = .04$, $p > .05$; see Table 3).

Lay risk beliefs and health behaviors

In unadjusted regressions, then hierarchical regressions controlling for demographics, psychosocial variables, and risk perceptions, we found that lay risk beliefs were consistently related to health behaviors (i.e., in most steps of the hierarchical models; see Table 4). Participants with stronger cognitive causation beliefs for both diabetes and colorectal cancer (CRC) reported more red meat intake (Diabetes: $B = 0.06$, $p < .05$; CRC: $B = 0.01$, $p < .05$) and more physical activity (Diabetes: $B = 0.40$, $p < .05$; CRC: $B = 0.45$, $p < .01$). Those with stronger unpredictability beliefs for either diabetes or colorectal cancer reported a slightly greater likelihood of being a current rather than former or never smoker (both: OR = 1.01, $p < .05$) (see Table 4).

A few potential confounders were independently related to health behaviors when all constructs were included in the models. Of the demographic variables, income was significantly negatively related to red meat intake in the diabetes cognitive causation model ($B = -2.27$; $p < .05$). Of psychosocial variables, health literacy was the only significant covariate such that higher health literacy was significantly related to lower cognitive causation and more physical activity ($B = -7.91$; $p < .05$). For risk perceptions, higher comparative risk perceptions about colorectal cancer were related to more red meat intake ($B = 1.32$; $p < .05$); no other risk perceptions were related to health behaviors.

Notably, lay risk beliefs added statistically significant variance (adjusted R squared change) in most models above and beyond demographics, psychosocial variables, and risk perceptions (see Table 4). With the exception of red meat intake with psychosocial confounders included, the addition of lay risk beliefs added statistically significant variance to every model.

Post-hoc analysis: cognitive causation and physical activity

In order to examine the unexpected positive relation between stronger cognitive causation beliefs and greater physical activity, we conducted additional exploratory analyses. We explored several demographic characteristics as potential moderators (i.e., age, gender, education, income, race/ethnicity, and BMI). Analyses including interaction terms in multiple regressions show that key demographic variables moderate the cognitive causation to physical activity relation. Lower health literacy ($B = -3.12$; $p < .05$), nonwhite race/ethnicity ($B = 1.57$; $p < .05$) and lower income ($B = -2.52$; $p < .05$) strengthen the positive relation between cognitive causation and physical activity ($B = 3.12$; $p < .05$).

Table 1 Sample demographics and descriptives (N = 1005)

Demographic	N	%	Demographic	N	%
Sex			Educational attainment		
Female	521	52	Less than high school	77	8
Male	484	48	High school	295	29
Age			Some college	283	28
18–24	86	9	College grad or higher	350	35
25–34	153	15	Current employment status		
35–44	135	13	Employed	518	51
45–54	175	17	Self-employed	59	6
55–64	218	22	Retired	221	22
65 years or more	238	24	Unemployed	207	21
Race/ethnicity			Marital status		
White, not Hispanic	741	74	Married/partnered	611	61
Black, not Hispanic	98	10	Single-never married	228	23
Other	69	7	Divorced/separated	122	12
			Widowed	44	4
Hispanic	97	10	BMI (WHO, 2017)		
			Underweight	14	1
Annual income			Normal weight	317	32
< $25k	143	14	Overweight	334	33
$25k to < $50k	199	20	Obese	311	31
$50k to < $75k	185	18	Missing	29	3
$75k to < $100k	143	14			
$100k to < $125k	152	15			
$125k and up	183	18			

Table 2 Study means and standard deviations of key variables

	M	SD
Health behaviors		
Smoking	627 (63.2%) never smokers	N/A
	365 (36.8%) former/current smokers	
Red meat intake	3.1 oz per day	2.6
Physical activity	22.8 min per day	13.2
Lay risk beliefs		
Cognitive causation—diabetes	12.3	20.7
Cognitive causation—colorectal cancer	13.4	21.3
Unpredictability—diabetes	62.2	24.9
Unpredictability—colorectal cancer	73.0	22.2
Risk perceptions		
Absolute—diabetes	2.7	1.6
Absolute—colorectal cancer	3.2	1.8
Comparative—diabetes	2.1	1.2
Comparative—colorectal cancer	2.3	1.2
Psychosocial variables		
Locus of control	17.3	2.8
Need for cognition	19.9	3.6
Health literacy	5.0	1.4

N/A not applicable. Lay risk beliefs range is 0–100. Absolute risk perceptions range is 1–5. Comparative risk perceptions range is 1–4

Table 3 Study variables: bivariate correlations and ANOVA

	Cognitive causation		Unpredictability	
	Diabetes	Colorectal cancer	Diabetes	Colorectal cancer
A. Demographics				
Age	− 0.22**	− 0.16**	− 0.01	− 0.03
Gender	− 0.07	− 0.05	0.02	0.05
Education	− 0.11**	− 0.10**	− 0.12**	− 0.06
Income	− 0.16**	− 0.19**	− 0.17**	− 0.14**
Race/ethnicity[#]	1.75	3.36**	0.50	2.20
BMI	0.01	− 0.06[t]	2.58*	0.62
B. Psychosocial variables				
Locus of control	0.03	0.04	0.04	0.04
Need for cognition	− 0.24**	− 0.22**	− 0.14**	− 0.05
Health literacy	− 0.29**	− 0.30**	− 0.12**	0.02
C. Risk perceptions				
Absolute risk perceptions				
Diabetes	0.13**	–	0.15*	–
Colorectal cancer	–	0.07*	–	0.06
Comparative risk perceptions				
Diabetes	0.08*	–	0.07*	–
Colorectal cancer	–	0.06*	–	0.04

*Indicates $p < .05$, and **indicates $p < .01$

[#]Indicates that race/ethnicity is a categorical variable, and, as such, we ran an ANOVA and eta squared. As such, numbers reported are the F statistic. The group that reported the highest cognitive causation for colorectal cancer were those who indicate they are Hispanic. Education is dichotomized as more than high school versus high school or less

Discussion

Overall, lay risk beliefs are associated with health behaviors, even when taking into account either demographic factors, psychosocial factors, or risk perceptions. Nonetheless, the associations between lay risk beliefs and health behaviors are small. Our hypotheses were predominantly supported.

As hypothesized, participants who reported stronger lay risk beliefs reported more red meat intake, increased likelihood of reporting cigarette smoking, and more physical activity. This relationship remained even after taking into account demographic factors. The only significant demographic correlate of health behavior was income for the diabetes cognitive causation to red meat intake model. As such, along with cognitive causation, lower income also is associated with increased red meat intake. Further, psychosocial confounders did not appreciably change the relation between lay risk beliefs and health behaviors. Health literacy was only a significant covariate of the cognitive causation to physical activity relation for the colorectal cancer model.

Finally, lay risk beliefs' relations to health behaviors remained even when including risk perceptions in regression models. Again, these models only included lay risk beliefs as predictors, the health behaviors as outcomes, and risk perceptions as covariates. It is important to reiterate that these relationships were, although significant, characterized by small effect sizes (e.g., a significant beta of 0.06 for red meat intake means an average increase of 0.06 oz per day). Notably, lay risk beliefs had only very modest relationships with risk perceptions. These findings support the notion that lay risk beliefs are an independent construct from risk perceptions. As is common in cross-sectional research (Brewer et al., 2004), risk perceptions were largely unrelated to health behaviors.

There are important implications of the current findings for each of the health behaviors assessed. Those who believe that their colorectal cancer or diabetes risk is more unpredictable are more likely to report current smoking. This means that we might be able to target those with unpredictability beliefs for smoking cessation or smoking prevention interventions. Alternately, decreasing uncertainty in risk beliefs may be an active ingredient in future smoking cessation or prevention interventions. More longitudinal research is needed. Finally, those who believe that thinking too much about their risk increases their risk for diabetes or colorectal cancer report higher levels of physical activity. This finding was surprising, and at odds

Table 4 Lay risk beliefs and health behaviors: linear hierarchical regressions and logistic regression with unstandardized Betas

	Cognitive causation		Unpredictability		R squared change
	Diabetes	Colorectal cancer	Diabetes	Colorectal cancer	
A. Unadjusted regressions					
Smoking (OR)	1.00	1.00	1.01**	1.01*	–, –, –, –
Read meat intake	0.12**	0.09**	0.01	0.01	–, –, –, –
Physical activity	0.53**	0.61**	0.08	− 0.11	–, –, –, –
B. Demographic covariates only					
Smoking (OR)	1.01*	1.00	1.00	1.00	.01*, .01*, .01*, .01*
Read meat intake	0.01**	0.01*	0.01	0.01	.01*, .01, .01*, .01
Physical activity	0.34	0.46**	− 0.05	− 0.11	.01, .02*, .01, .02*
C. Psychosocial covariates only					
Smoking (OR)	1.00	1.00	1.01*	1.01*	.02*, .02*, .02*, .02*
Read meat intake	0.01*	0.01	0.01	0.00	.01, .01, .01, .01
Physical activity	0.50*	0.48*	− 0.03	− 0.13	.01*, .02*, .01*, .02*
D. Risk perception covariates only					
Smoking (OR)	1.00	1.00	1.01*	1.01*	.02*, .02*, .02*, .02*
Read meat intake	0.06*	0.01*	0.01	0.03	.01*, .01*, .01*, .01*
Physical activity	0.40*	0.45**	0.03	− 0.02	.01*, .02*, .01*, .02*

Logistic regressions were run for the dichotomous smoking variable and odds ratios are presented. Linear regressions were run for the red meat intake and physical activity continuous variables and unstandardized betas are presented

Demographic covariate that were a significant correlate were: income for the diabetes cognitive causation to red meat intake model

Psychosocial covariate that was a significant correlate were: health literacy was related to less physical activity (B =− 7.97**) in the cognitive causation about diabetes model

Risk perception covariates that were significantly correlated were: comparative risk perceptions about colorectal cancer were related to more red meat intake

OR odds ratio

*Indicates $p < .05$ and **Indicates $p < .01$

with our hypothesized relations, which detailed that more cognitive causation would be related to decreased exercise.

In order to further examine relation between cognitive causation and physical activity, we conducted exploratory moderation analyses. Older age, lower income, and ethnic minority increase the strength of the positive relation between cognitive causation and physical activity. The reported increased physical activity of people of low socioeconomic status may be due to more walking to work and public transportation, but that hypothesis needs to be tested in future research.

Implications

Better conceptualizations of the relation between lay risk beliefs and health behaviors may allow for more targeted interventions for disease prevention. Maladaptive health behaviors such as poor diet, lack of exercise, excessive red meat consumption, and cigarette smoking are epidemic in the United States, and are among the biggest threats to future health of the US population; poor health behaviors cause myriad health issues, including obesity, heart dis-ease, diabetes, and cancer. In fact, about 90% of chronic diseases and 50% of cancers are preventable through life-style factors (CDC, 2009, 2014). While decades of research have been dedicated to health behavior interventions, and some have been very successful for public health (e.g., the Tips From Former Smokers campaign; CDC, 2017b), maladaptive health behavior patterns still persist (CDC, 2017a, 2017c). Lay risk beliefs often predict variance above and beyond other strong predictors of health behaviors and should be considered in future interventions. The potential public health impacts are promising. It should be noted that the size of the effects is often small; more research is needed to determine the relative contri-bution these variables to outcomes should they be added as targets in interventions.

It is important to note that health behavior rates reported by participants in this study appear similar to known rates in the general population in the United States, which increases confidence in the generalizability of these find-ings. For example, smoking rates were statistically signifi-cantly similar to U.S. population rates (CDC, 2017d), exercise rates were also statistically significantly similar to

national norms (Fryback et al., 2007), and participants' report of consuming 3.1 oz of red meat each day was in line with national norms for red meat intake (2.4 oz/day; Department of Agriculture, 2013; see Table 2).

We conceptualized need for cognition and health literacy as potential confounders since we were most interested in whether lay risk beliefs had a relationship with health behaviors above and beyond all other related variables. As such, this framing is most consistent with the examination of third variables as confounders in nature, and has helped to justify the unique value of lay risk beliefs as important in the risk perception process. However, examination of such variables as moderators, for example, how the relations of lay beliefs and health behaviors might differ among those with low versus high literacy, would be a fruitful area of research that could help dictate intervention efforts.

This work also extends the literature pointing to the important role of considering conceptualizations of risk outside of traditional deliberative risk perceptions. While we utilized the term *lay risk beliefs*, this construct has also been called *superstitious thoughts about risk* (Kramer & Block, 2007; Peltzer & Renner, 2003), and *intuitive risk perceptions* (Hay et al., 2014; Hay et al., 2016a, 2016b; Orom et al., 2015; Renn, 1998; Renner et al., 2012; Schmalzle, 2008) in previous research. As the term superstitious thoughts may be simplistic and the term intuitive risk perceptions may denote a perception rather than a belief, we chose to use the term lay risk beliefs in this paper. This research supports and extends the new and growing literature examining conceptualizations of risk other than deliberative risk perceptions. More empirical research in this area is needed to create a unifying theoretical framework.

Limitations

Study limitations include a cross-sectional design; as such, longitudinal research to establish temporality and causality and then intervention development work is needed. Cross sectional analyses obscure bidirectional effects and can over- or underestimate the size of relationships. With this cross-sectional design, we are looking at is the relation of lay beliefs to ongoing patterns of behavior. A different question would be how lay beliefs would relate to magnitude of behavior change over time, and addressing that question would require a prospective study. There are also limits of self-report measures of health behaviors such that individuals tend to over-report adaptive health behaviors and underestimate maladaptive health behaviors (e.g., Brener et al., 2003; Ezzati et al., 2006). Further, due to constraints in survey length for the larger study from which this investigation was derived, we only assessed two types of lay risk beliefs. This does detract from our ability to

examine lay beliefs more broadly, and it could be that the other identified lay beliefs (i.e., negative affect in risk, preventability, defensive pessimism), may also be promising to include in future research that will be able to flesh out the role of lay beliefs in motivation for health risk behaviors. Future research should include other lay risk beliefs and intuitive risk perceptions to assess whether these patterns hold or whether there are other variables that should be included in future intervention research. Future research should also consider including a "don't know" response option for the lay risk beliefs measures; this was not included for lay risk beliefs in the present study because none of the psychometric research on them included this option. Finally, affect is an additional important element of risk perception, and has been shown to be important in health behaviors, and affect be included in future research in this area (Ferrer et al., 2016; Salovey et al., 2000; Sirois et al., 2015; Waters et al., 2013). Again, importantly, the observed effect sizes in this study were small; therefore, more research is needed.

Conclusion

Lay risk beliefs are associated with some health behaviors, even when taking into account either demographics, psychosocial variables, or traditional probabilistic risk perceptions. The observed effect sizes are small, but potentially meaningful on a population-wide basis. Intervention development targeting lay risk beliefs may be warranted. Targeting certain individuals who may have high lay risk beliefs which are associated with maladaptive health behavior engagement (e.g., greater belief in cognitive causation or in unpredictability of risk) might also be useful. It is important to note that some portions of the population (i.e., those who report low income) may be at risk for higher lay risk beliefs that confer risk for red meat intake and smoking, but are linked with more adaptive health behaviors such as exercise as well; it will be important to intervene in such a way that changes maladaptive health behaviors and preserves adaptive health behaviors. Should lay risk beliefs continue to explain variance in health behavior engagement and health behavior change, it could be transformative for health behavior interventions, identifying another powerful piece to behavior change.

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