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Article

Food Safety Information Processing and Teaching Behavior of Dietitians: A Mental Model Approach

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Abstract: Health professionals play an important role in educating the public about food safety risks. However, the ways this important group of educators remains up-to-date on these topics are not well defined. In this study, a national sample of dietitians employed in direct teaching of patients (n = 327) were recruited to complete a web-delivered survey designed to develop a model of factors that promote information processing and teaching in practice about food safety related to fresh vegetables. The resulting mental model demonstrates that dietitians teach fresh vegetable safety using systematic information processing to intellectually understand new information, but this is also associated with a gap in the dietitian's knowledge of food safety. The juxtaposition of an information processing model with a behavioral model provides valuable new insights about how dietitians seek, acquire and translate/transfer important information to move patients toward a higher goal of food safety. The study also informs food safety educators as they formulate teaching strategies that are more effective than other approaches at promoting behavior change.

Keywords: foodborne illness; dietitians; mental models; information processing behavior

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1. Introduction

In Europe and the United States (US), the public ranks trust in health professionals, followed by food safety authorities and university scientists, as important when evaluating sources of food safety information [1–3]. Trust in health professionals is particularly important among consumers who are at increased risk of opportunistic infections as a result of immune suppression, medical therapy, life stage, or pharmaceutical use [4]. A series of qualitative studies with highly-susceptible patient groups in the US queried where patients wanted to find food safety information that related to them and their condition [5–8]. Participants in these studies wanted credible information from trusted sources, and health care providers were the information source they preferred. Each group named their physician as their preferred primary source and a member of the health care team, such as a nurse, dietitian, or social worker, as their preferred secondary source. The participants only occasionally mentioned other sources, such as web sites that reported medical information (for example, WebMD [9]).

Registered dietitians were named as a credible source of food safety information by two groups highly-susceptible to opportunistic infections: cancer [7] and transplant [8] patients. Relying on the dietitian as an information source is appropriate, as food safety competence is required for registration as a dietitian in the US [10]. Additionally, post-graduate continuing education is required to maintain competence in topics of importance to dietetic practice. Dietitians self-select the topics they wish to pursue in continuing education; it is not required that dietitians maintain post-graduate competence in food safety or any other specific topic.

Although dietitians are charged with the career-long responsibility to monitor and update their knowledge base, personal preferences, biases, and professional experiences have the potential to influence the choices they make with respect to continuing educational content. This study was designed to better understand factors that influence how dietitians process information as they use their knowledge of food safety for their personal benefit, and to teach their patients. The goal was to elucidate information processing clues, or the mental model used by dietitians when they seek out new information about the safety of food. This information could aid educational providers as they develop risk communication strategies and continuing education opportunities for dietitians. This study focused on foodborne illnesses (FBI) and information processing behavior associated with teaching fresh vegetable safety because dietitians prize fresh vegetables as a major source of fiber, vitamins and minerals, and because they are traditionally strong advocates for consuming fresh vegetables [11]. Nevertheless, *Salmonella* outbreaks associated with sprouts, tomatoes and lettuce has cast doubt on the safety of these foods, causing many consumers to avoid the products [12]. Furthermore, therapeutic low-microbial diets that limit the consumption of uncooked foods, especially vegetables and fruits are often prescribed in clinical chemotherapy or transplant medical units to minimize opportunistic infections; however, such diets also limit intake from sources of vital nutrients [13].

1.1. The Risk Information Seeking and Processing (RISP) Communication Theory

Prerequisite to trust and credibility is the depth and quality of the teacher's knowledge of their subject. Thus, how a teacher seeks information and then internally processes that information to gain understanding are important characteristics that informs how the teacher progresses to sharing the

information with others, the actionable behavior of interest in this study. The RISP theory was designed to assess information-related behavior and subsequent personal behavior toward a variety of environmental hazards. Two sub-models compose the overall theory: Heuristic-Systematic Model of Information Processing [14] and the Theory of Planned Behavior [15]. A portion of the RISP theory predicts that previous personal experiences with a health-threatening condition may influence a person's perception of the need to seek education, or in the case of the dietitian, to provide educational information to others they see as being susceptible to hazardous conditions they too may have experienced. A mental model approach is appropriate because the underlying perceptions and beliefs structure can either stimulate or obstruct the intellectual processing of new scientific information. The Risk Information Seeking and Processing communication theory (RISP theory) [16] was used as the theoretical base for developing the mental model of registered dietitians who teach patients about fresh vegetable safety, that is microbial or food safety.

1.2. Mental Models

All of life's behavioral decisions are based on a personal or mental model that uses past experiences, knowledge, affect, and logic to formulate a future behavioral course of action. To the researcher and policy maker, mental models are useful to study because they show how influential factors may interrelate, they reveal salient critical issues, and can show causal links, depending on the methodology used to describe a mental model [17]. Even though a mental model is typically unique to the individual, group or collective mental models are useful to educators and academics because they can reveal shared or commonly-held thought processes and a consensus that is helpful in developing therapeutic or educational strategies. Likewise, a company mental model of individuals with dissimilar values or backgrounds who are charged with the completion of a common goal, could be useful to public policy development because divergent-stakeholder viewpoints can be identified that can simplify implementation and promote acceptance of policy [18].

All mental models contain core elements, such as relatively stable, long-term knowledge about a topic, and they contain peripheral elements that change depending on situations that can affect cognitive processes, which provides for the dynamic dimensions of a mental model [17]. Another aspect of a mental model relates to the attributes of the individual, or a person's need for new knowledge, their capacity to grasp new information, or methods for acquiring new information. Thus, a mental model is dependent on pre-existing knowledge, but is compiled as needed to respond to situations, both anticipated situations and actual situations [19].

The development of a personal, collective, or company mental model requires both a foundational discovery process that should be rooted in social science and risk communication theory [20], and an elucidation process that directly queries the target stakeholder. This way, the causal elements of the mental model are more clearly understood, as well as the dynamic elements that will necessitate periodic review and revision [18]. Frewer *et al.* [20] also concluded that the mental model discovery process should be extended to consider subsequent actionable behavior, as that is essential to the educational and public policy application of the mental model.

1.3. Study Objectives

This study is third in a series to explore if health professionals are influenced by personal beliefs and experience with topics such as foodborne illness, or if they are independently influenced by professional concern for the health status of their patients? We have previously reported knowledge, information sources and training used by dietitians [21,22] that most registered dietitians use to teach patients about the safety of fresh vegetables as potential sources of invasive foodborne pathogens [12]. When food safety was not taught, important barriers to dietitians' provision of information included time constraints, having incorrect information about food safety, and having a lack of confidence in personal knowledge of food safety [21]. Therefore, the first objective of the present study was to identify information processing behavior of registered dietitians, specifically information about fresh vegetable safety, in the discovery of the causal factors used by dietitians in their decision to gain new food safety information and that leads to teaching food safety to patients. The second objective was to create the mental model of information processing and teaching behavior used by the dietitians in this study, based on statistical discovery of salient model elements that are used by dietitians when they teach food safety to patients.

2. Results and Discussion

The priority of dietetics is to provide nutritional information to patients and to educate about high-nutrient food sources; for example, fresh vegetables are highly desirable and nutritious foods [11]. However, vegetables are also frequently cited as the food attribute associated with foodborne illness outbreaks [12]. Where and how dietitians inform themselves about the food safety risks associated with consumption of fresh vegetables is essential to the quality of the education they provide patients.

There were two types of causal models developed in this study, the information processing models and the actionable behavior models. These are the theoretical components of the RISP communication theory but were approached separately in this study because of the different construction of the outcome variables. Together and supported by statistical analyses (means separation, discriminant analysis, and hierarchical linear regression), these causal models informed the dietitian's mental model of food safety information processing; and, most important to their health and the health of their patients, the actionable behavior of teaching food safety to others.

2.1. The RISP Communication Theory

Individual characteristics, previous experience with the hazard of interests and political philosophy are the control variables in the RISP theory. Gender, Ethnic group, Income, Political philosophy and Education level did not differ between Teaching-behavior groups. Age differed with a significant number of younger dietitians in the Do not currently teach group ($P < 0.001$) and more dietitians in the oldest Age category in the Currently-teach group ($P < 0.001$). To construct the RISP theory, Education is entered into hierarchical linear regression (HLM) prior to the variables measuring Information sufficiency to account for variation in Current knowledge independent of Education level. In this study, Education failed tests of multicollinearity and was removed from the final models. Dietitians

had little experience with foodborne illness as few had been medically treated for FBI (n = 22, 6.7%). Patients counseled by the dietitians were more likely than dietitians to have had FBI as indicated by responding that they counseled patients who had been medically treated for FBI (overall n = 140, 42.8%), with a difference found between Teaching-behavior groups (n = 56, 40%, Do not currently teach; n = 84, 60%, Currently-teach; $P < 0.001$). Political philosophy was not a significant variable between Teaching groups, nor was it a significant contributing factor in either the HLM analysis for Systematic information processing (Table 1) or for Heuristic information processing (Table 2). Less diversity among the findings for the control variables was consistent with the characteristics of the population of dietitians in the US [23]. The educational and post-graduate training requirements for credentialing inadvertently selects for greater homogeneity among dietitians' characteristics.

Table 1. Hierarchical linear model of the Risk Information Seeking and Processing (RISP) model variables for Systematic information processing (standardized β-coefficients for final model).

Variables	Systematic information processing		
	Do not Currently Teach (n = 144)	Currently Teach (n = 155)	Overall (n = 299)
Individual characteristics			
Caucasian ethnic group	0.223	0.314	0.265 *
Other ethnic group	0.220	0.279	0.224 *
Income $64K or less	0.159	−0.004	0.020
Income $65K to $ 99K	0.169	−0.071	0.008
Income $100K or more	0.055	−0.033	−0.066
Age 18–29 years	-------	−0.142	−0.077
Age 30–44 years	0.096	−0.145	-------
Age 45 years and older	0.158	-------	0.072
Liberal political philosophy	−0.008	−0.027	−0.013
Neutral political philosophy	−0.053	−0.010	−0.027
Conservative political philosophy	−0.058	0.153	0.035
FBI-self, medical	0.111	0.021	0.039
FBI-self, no medical	−0.097	0.101	0.039
FBI-others, medical	0.129	−0.062	0.009
FBI-others, no medical	0.057	−0.135	−0.052
FBI-patients, medical	−0.035	−0.071	−0.060
FBI-patients, no medical	0.080	0.003	0.028
Perceived hazard characteristics			
Risk judgment	0.001	0.119	0.091
Institutional trust	0.055	−0.037	0.017
Personal control-self	0.155	0.125	0.141 *
Personal control-patients	0.094	−0.123	−0.009
Informational subjective norms			
People	0.022	−0.016	0.030
Patients	0.145	0.049	0.063
Affect, worry			
Self	0.121	−0.175	−0.083
Patient	−0.032	0.149	0.013

Table 1. *Cont.*

Variables	Systematic information processing		
	Do not Currently Teach (*n* = 144)	**Currently Teach (*n* = 155)**	**Overall (*n* = 299)**
Channel beliefs			
Media bias beliefs	−0.106	−0.189 *	−0.131 *
Validity cues beliefs	0.077	0.189 *	0.131 *
Information source credibility	0.248 **	0.079	0.169 **
Information gathering capacity			
Capacity	0.038	−0.043	0.002
Current knowledge			
General food safety knowledge	−0.005	−0.001	−0.027
Pathogen awareness	0.060	−0.008	0.036
Pathogen understanding	−0.124	0.206	0.056
Information insufficiency			
Knowledge threshold	−0.093	0.158	0.070
Final model statistics	$P = 0.019$ $R^2 = 0.126$	$P = 0.023$ $R^2 = 0.114$	$P < 0.000$ $R^2 = 0.139$

* $P \leq 0.05$; ** $P \leq 0.01$; *** $P \leq 0.001$ Standardized β-coefficients.

Table 2. Hierarchical linear model of RISP variables for Heuristic information processing (standardized β-coefficients for final model).

Variables	Heuristic information processing		
	Do not Currently Teach (*n* = 144)	**Currently Teach (*n* = 156)**	**Overall (*n* = 300)**
Individual Characteristics			
Caucasian ethnic group	0.167	−0.083	−0.005
Other ethnic group	0.038	−0.085	−0.022
Income $64K or less	0.105	−0.064	0.005
Income $65K to $ 99K	0.082	0.054	0.065
Income $100K or more	0.054	−0.142	−0.037
Age 18–29 years	-------	0.104	0.044
Age 30–44 years	−0.018	0.127	-------
Age 45 years and older	−0.153	-------	−0.105
Liberal political philosophy	0.140	0.166	0.118
Neutral political philosophy	0.018	0.174	0.084
Conservative political philosophy	0.070	0.210	0.102
FBI-self, medical	−0.040	−0.067	−0.055
FBI-self, no medical	0.089	−0.086	0.004
FBI-others, medical	−0.124	0.037	−0.035
FBI-others, no medical	−0.054	−0.055	−0.073
FBI-patients, medical	0.000	−0.060	−0.037
FBI-patients, no medical	0.084	0.204 **	0.152 **

Table 2. *Cont.*

Variables	Heuristic information processing		
	Do not Currently Teach (*n* = 144)	**Currently Teach (*n* = 156)**	**Overall (*n* = 300)**
Perceived hazard characteristics			
Risk judgment	0.087	0.067	0.056
Institutional trust	−0.062	0.145	0.032
Personal control-self	−0.043	0.162	0.102
Personal control-patients	0.012	−0.156	−0.081
Informational subjective norms			
People	−0.066	-0.248 *	−0.156 *
Patients	−0.014	0.088	0.049
Affect, worry			
Self	−0.239	0.038	−0.034
Patient	0.055	0.019	0.000
Channel beliefs			
Media bias beliefs	0.062	0.193 *	0.143 **
Validity cues beliefs	−0.033	0.047	0.011
Information source credibility	−0.288 **	−0.365 ***	−0.330 ***
Information gathering capacity			
Capacity	0.178 *	0.082	0.133 *
Current knowledge			
General food safety knowledge	−0.117	−0.053	−0.122 *
Pathogen awareness	−0.079	−0.132	−0.082
Pathogen understanding	0.039	0.096	0.039
Information insufficiency			
Knowledge threshold	−0.035	−0.080	−0.088
Final model statistics	$P < 0.000$ $R^2 = 0.232$	$P < 0.000$ $R^2 = 0.311$	$P < 0.000$ $R^2 = 0.286$

* $P \leq 0.05$; ** $P \leq 0.01$; *** $P \leq 0.001$ Standardized β-coefficients.

The type of information processing that a person engages in when seeking new information is a function of influencing factors, such as their perception of trust in institutions, their judgment about the seriousness and their personal susceptibility to FBI, or their sense of control over the hazard, either personally or for the sake of their patients. Since sanitary handling of foods in retail markets and institutional food preparation are public health-regulated in the US [24], trust in persons and institutions that are responsible for ensuring the safety of food, and the ability to protect the personal and public health can be highly predictive of a person's subsequent attempt to acquire information about the risk hazard and how that external influence affects their actionable behavior regarding the hazard. Slovic *et al.* [25] found that perception of a risk hazard is a function of how well the risk is understood and how much feelings of dread are invoked by thoughts of the health risk. A person's reaction to risk hazards depends on their feeling of personal control and the likelihood that they will become ill from eating a contaminated food, which could lead to a reactionary emotional response. The motivation to begin the information acquisition process that could alleviate negative feelings has been shown to be the degree of worry felt by the individual [26].

For dietitians in this study, however, none of the measures of Perceived hazard characteristics were influencing factors contributing to the RISP theory statistical analysis. Means for the four variables measuring the construct were not different between Teaching-behavior groups. In addition, none of the variables were notable in either HLM or discriminant analysis, with two exceptions. Personal control–self was significant ($P = 0.054$) in the Systematic information processing-overall HLM model (Table 1), and Personal Control–Patients was a minor classifying variable in discriminant analysis (standardized canonical coefficient, −0.263).

The influence of Affect was measured as the degree of Worry respondents felt over possible health risks associated with eating fresh vegetables for either their self or for their patients. There was no difference between Teaching-behavior groups for Affect, Worry–self. The variable was a minor contributor in discriminant analysis (standardized canonical coefficient, −0.257). Those who currently taught fresh vegetable safety to their patients were more concerned for their patients' health risks than were dietitians who did not teach (Affect, Worry–patients, $P = 0.044$). Affect, Worry–patient was also a major classifying variable in discriminant analysis (standardized canonical coefficient, 0.441). Neither of the two Affect measures were significant contributors to the overall variation accounted for in the HLM models (Tables 1 and 2).

In the RISP theory, a person's Current knowledge of a risk hazard and antecedent factors that influence knowledge are, in turn, antecedent to that person's search and understanding of risk-related information. If a person perceives they have sufficient knowledge (as a function of their education and the normative influence of referent others), they may or may not seek and process additional information. Because dietitians are so similarly educated, that effect was removed from the statistical analysis due to multicollinearity. Perception of the influence of people (Informational subjective norms–people) who were important to the respondent, or referent others, was not different between groups. For Informational subjective norms-patients, respondents in the Currently-teach group were highly influenced by the health and food safety learning needs of their patients, compared to the Do not currently teach group ($P < 0.001$). The strength of these variables was reflected in discriminant analysis as each were major variables on which the Teaching-behavior groups were classified (standardized canonical coefficients, Informational subjective norms–patients, 0.641; Informational subjective norms–people, −0.353). The variable, Informational subjective norm–people was significant in the HLM models for Heuristic information processing (Table 2).

For dietitians who are counseling patients at high-risk for FBI, both broad and deep understanding of food safety principles is critical. We have previously reported that teaching food safety in this sample of dietitians was a function of their greater general knowledge of food safety [21]. Food safety knowledge and information sources were also explored with the finding that knowledge credibility is compromised by the depth of factual understanding and the type of information sources selected [22]. Previously reported measures of General food safety knowledge were also used in this study of information processing and actionable behavior. Additionally, food safety knowledge as measured by Pathogen awareness and Pathogen understanding are reported.

General food safety knowledge was not significant ($P > 0.05$) between Teaching groups, but scores were higher for the Currently-teach group. Mean differences for both Pathogen awareness and Pathogen understanding were highly significant ($P < 0.001$), with the Currently-teach group having higher scores or greater awareness and understanding of four common FBI-causing pathogens (*Listeria*

monocytogenes, *Salmonella* spp., *E. coli* O157:H7, or *Campylobacter jejuni*). This was a positive finding because of the unique learning needs of high-risk patients and the need for their health providers to have in-depth and mechanistic knowledge when devising medical nutritional therapies. In contrast, all of the measures of Current knowledge were associated with lower Systematic information processing (Table 1) and Heuristic information processing scores (Table 2).

Griffin *et al.* [27] argued that knowledge alone is not a strong predictor of information processing, but that perception of the need for new or additional knowledge to meet a personal or professional goal is the primary driver toward active information gathering and processing. A variable, Knowledge threshold, was added to the RISP theory as a variance-adjusted score independent of a person's current knowledge. It is a representation of an individual's perception of their need for additional information, a construct called Information sufficiency. The construct represents the gap between what a person already knows about the risk hazard and the additional information they perceive they need for them to progress toward actionable behavior. We found that dietitians who Currently-teach food safety of fresh vegetables to their patients also had higher scores for Knowledge threshold ($P < 0.001$) than those who did not teach food safety. Knowledge threshold was also a major classifying variable in discriminant analysis (standardized canonical coefficient, 0.433). Knowledge threshold was not significant in any of the HLM models tested (Tables 1 and 2).

The construct, Information sufficiency, becomes the main predictor of the type of information processing utilized. A large gap reflects greater use of Systematic information processing and smaller difference is indicative of greater use of Heuristic information processing. More recently, the name, Information sufficiency, has evolved in the RISP theory literature into a construct called Information insufficiency [27]. The change from the original iteration of the theory [16] occurred as a truer interpretation of the data analysis outcome. The relationship between Information insufficiency and method of information processing is attenuated by antecedent constructs that measure a person's perception of their ability to locate and understand risk information and beliefs about information sources [27].

A successful search for information may be related to a person's belief in their capacity to locate the information and to understand the complexity of the information (e.g., the variable, Information gathering capacity) [15]. Furthermore, beliefs associated with the source of information can influence the credibility that the person gives to the information coming from that source. Neither Media bias beliefs nor Validity cues beliefs differed between Teaching-behavior groups. Information source credibility ($P = 0.021$) and Information gathering capacity ($P = 0.001$) differed between groups, with the Currently-teach group having the higher mean scores. Media bias beliefs was a major classifying variable (standardized canonical coefficient, 0.369), and Information source credibility (standardized canonical coefficient, 0.221) and Validity cues beliefs (standardized canonical coefficient, −0.204) were minor classifying variables in discriminant analysis. Information gathering capacity was not found to contribute to discrimination of the two Teaching-behavior groups. All of these variables contributed significantly to the HLM analyses shown in Tables 1 and 2. The variables entered into the HLM models were major contributors to the total variance accounted for in the six models. The higher the use of Heuristic information processing, the greater the belief that media are bias information sources (Table 2). Information source credibility, which measured the degree of attention paid to various media, was negatively associated to Heuristic information processing for all HLM analyses with this behavioral outcome. The less attention paid to media, the more Heuristic information

processing was used. Similar effects were evident in the three HLM analyses for Systematic information processing, except the direction of the effects were opposite and complimented findings for these variables in the Heuristic information processing models (Table 1).

The information processing variables are the outcome behavioral variables in the Heuristic-Systematic Model of Information Processing portion of the RISP theory [16]. Mean difference between Teaching-behavior groups was significant for Systematic information processing ($P = 0.005$), and the variable was a minor contributor in discriminant analysis (standardized canonical coefficient, 0.200). Heuristic information processing did not differ between groups, nor did the variable contribute to discriminant analysis. For the HLM models with Systematic information processing as the dependent variable, a modest amount of variation was accounted for in the analysis (R^2 below 14% for each of the three models) (Table 1). Models where Heuristic information processing was the dependent variable were stronger, based on R^2 ranging from 23.2% to 31.1% (Table 2). As with Education and depending on the model, various categories of Age were excluded from the analysis because of multicollinearity.

From the three types of statistical analyses completed, we can conclude that in this sample of dietitians, Systematic information processing was the predominant style of information processing used by dietitians who Currently-teach safety of vegetables to their patients as evidenced by their belief that they have the capacity to find information they need and that they will process the information with a critical eye for potential bias toward a particular position regarding the risk hazard.

2.2. The Theory of Planned Behavior

To proceed to the causal model predicting actionable behavior, constructs of the Theory of Planned Behavior were included in the RISP theory. According to Ajzen [15], Indirect attitude is correlated to other Theory of Planned Behavior constructs, and is the most predictive variable of behavioral intent, and in turn actionable behavior. Ajzen [15] describes measures of attitude as the product of a belief and the companion evaluation of that belief; the product of the two measures is a surrogate of attitude or Indirect attitude. Principle component analysis was used to identify factors to serve as predictive variables in the statistical analysis for the Theory of Planned Behavior portion of the causal models (Table 3). As with the information-processing portion of the RISP theory, influence of referent others attenuates progression to behavior. This construct is similar to the Informational subjective norms assessed in the RISP theory portion of the data analysis. Perceived barriers that control behavior differ for each behavior and population and must be accounted for in the study of actionable behavior. Perceived barriers are measures of self-efficacy, as in other behavior decision-making models [15], and they assess whether or not a person believes they have the actual or perceived means to accomplish a desirable behavior. In the RISP theory this is similar in concept to Information gathering capacity.

Table 3. Principle components within Indirect attitude variables [a].

Indirect Attitude Measures	Factor Loading [b]			
	Factor 1	**Factor 2**	**Factor 3**	**Factor 4**
	Local Produce	**Benefits Teaching**	**Organic Produce**	**Nutrition Quality**
Total nutrition content important				0.723
Total fiber content important				0.777
Vitamin content important				0.727
Choose easy to prepare vegetables				0.549
Fresh vegetable cost important				0.540
Less foodborne illness among patients		0.640		
More thankful patients		0.737		
Teaching food safety good for dietitian's reputation		0.732		
More awareness about food safety in community		0.681		
Food safety necessary for highly susceptible patients		0.503		
Local produce has less bacterial contamination	0.583			
Local produce tastes better	0.904			
Local produce is better quality	0.914			
Local produce helps the local economy	0.876			
Being organically grown is important			0.583	
Organic produce tastes better			0.833	
Organic produce is more nutritious			0.855	
Organic produce has less bacterial contamination			0.780	
Organic produce has less pesticide contamination			0.548	
Cronbach alpha	0.89	0.79	0.79	0.76
Variance explain by factor (%)	11.62	11.31	10.14	9.11

[a] Measures of indirect attitude computed as the product of paired survey items assessing behavioral beliefs and evaluation of that belief. Measures with factor loading >0.5 retained; [b] Rotation method = Varimax with Kaiser normalization (KMO = 0.79).

The binary structure of the Teaching behavior outcome variable in the Theory of Planned Behavior portion of the RISP theory necessitated a switch to a non-parametric statistical procedure, but was judged necessary to answer the question about the predictive strength of information processing style on actionable behavior as part of the mental model developed in this study. The significance of this question is that design of educational strategies in food safety will depend on a thorough understanding of the dietitian as a life-long learner. How do they approach information gathering and processing? What attitudes do they have about the teaching of food safety as a risk hazard? What barriers do they perceive to this effort? Furthermore, who influences dietitians suggests whether or not they will be easily persuaded to the desirable goal of teaching patients about fresh vegetable safety, or if they will persist with their prior beliefs, either pro or con, about new information that can give them the broadest and most in-depth knowledge base possible.

The binary logistic models for both Systematic information processing (Figure 1) and Heuristic information processing (Figure 2) included similar significant predictors of teaching behavior. In common, patients were the primary referent other used by the Currently-teach group, and this group felt they had control over whether or not they had the freedom to teach this topic.

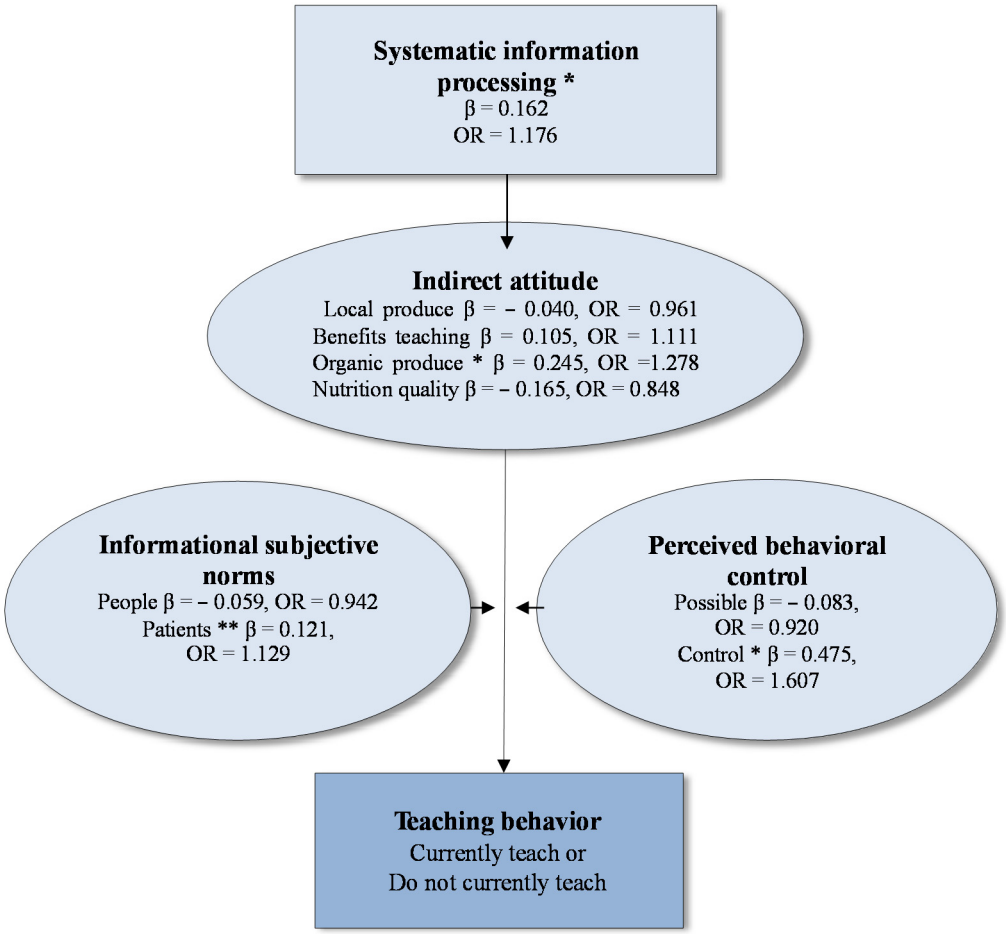

Figure 1. The binary logistic regression model for Systematic information processing and Teaching behavior of dietitians who either Currently teach or Do not currently teach fresh vegetable food safety to their patients. Model, $P < 0.001$, −2 Log Likelihood = 388.1, Cox and Snell $R^2 = 0.13$, Nagelkerke $R^2 = 0.17$, Correct classification = 64.0%. Odds ratio (OR). * $P \leq 0.05$; ** $P \leq 0.01$.

Unfortunately, both models had as a significant predictor of Current Teaching behavior the belief in the inherent safety of organic vegetables. The safety of organic vegetables as superior to non-organic vegetables has not been unequivocally confirmed [28], and could represent a strongly-held belief of those in the Currently-teach group who also have high use of the Systematic information processing style. Systematic information processing was a positive and significant predictor of Teaching-behavior (Figure 1), but Heuristic information processing was not (Figure 2). The finding that a significant portion of the dietitians surveyed believed that organic vegetables are the safer choice for selecting vegetables could be problematic for educators and risk communicators who are trying to persuade dietitians to incorporate food safety best practices into their patient education (Figures 1 and 2).

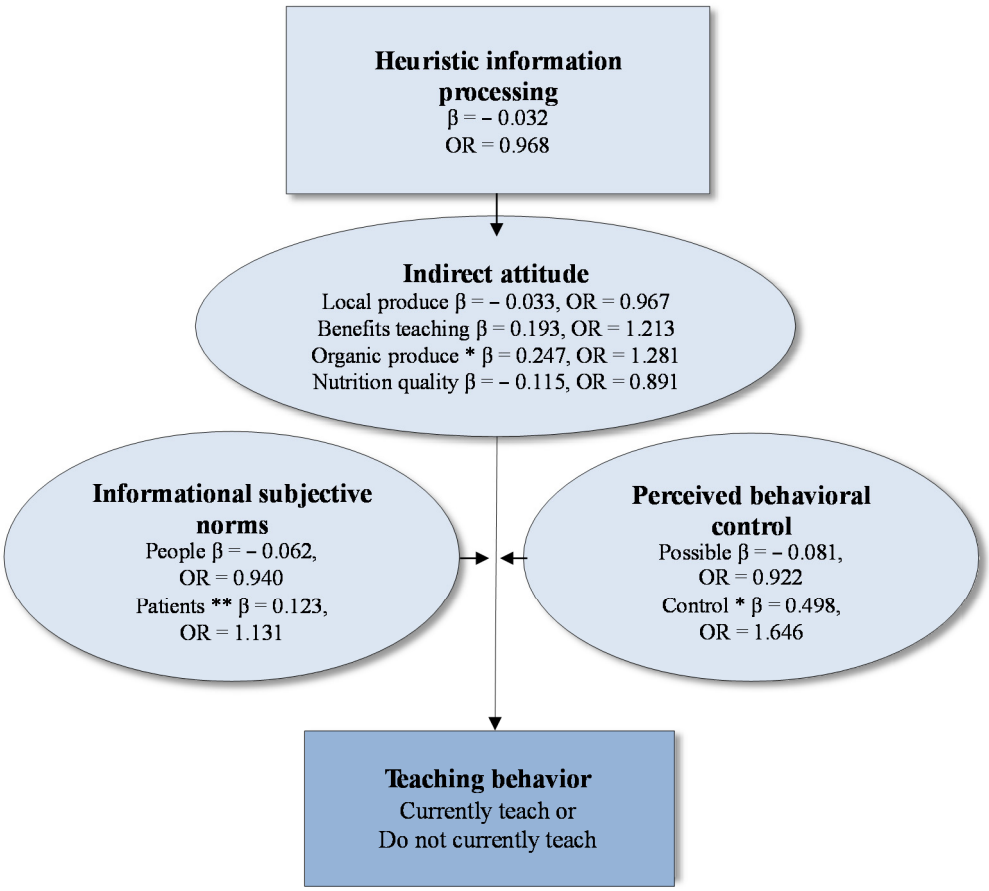

Figure 2. The binary logistic regression model for Heuristic information processing and Teaching behavior of dietitians who either Currently teach or Do not currently teach fresh vegetable food safety to their patients. Model, $P < 0.001$, −2 Log Likelihood = 392.6, Cox and Snell $R^2 = 0.12$, Nagelkerke $R^2 = 0.16$, Correct classification = 63.8%. Odds ratio (OR). * $P \leq 0.05$, ** $P \leq 0.01$.

In the model with Systematic information processing as a dependent variable (Figure 1), Systematic information processing behavior ($P = 0.047$), the Indirect attitude factor, Organic produce ($P = 0.053$), Informational subjective norms–patients ($P = 0.001$), and Perceived behavioral control–control ($P = 0.014$) accounted for a significant portion of the variation in the binary logistic regression model. The model was significant ($P < 0.001$) and accounted for 13% to 17% of the model variation.

For the binary model with Heuristic information processing as a dependent variable (Figure 2), the Indirect attitude factor, Organic produce ($P = 0.052$), Informational subjective norms–patients ($P = 0.001$), and Perceived behavioral control–control ($P = 0.01$) were significant and accounted for 12% to 16% of the model variation depending on the statistical measure ($P < 0.001$).

2.3. The Mental Model

A mental model is useful to understand how pieces of information are used and intellectually processed when individuals are making a decision toward actionable behavior. The mental model can represent an individual or a group of individuals who operate as a collective or who share common characteristics. The dietitians who Currently-teach food safety of fresh vegetables to their high-risk patients are a collective who are representative of dietitians in the US, thus the mental models proposed in Figure 3 have application to populations of dietitians with similar characteristics.

Frewer *et al.* [20] pointed out that the most representative mental model is one in which the target population is studied both quantitatively and qualitatively. Multiple statistical and modeling approaches are useful to support the findings of the mental model process. There is always, however, a high degree of subjective selection of the various elements that a researcher uses to formulate a mental model. The statistical data shown in the causal models supports the subjective selection of variables to inform the mental model.

Figure 3 is the mental model that we have devised based on the statistical analyses and causal models computed for this study. The model supports the teaching of fresh vegetable safety with the use of Systematic information processing style associated with a large information gap in the dietitian's knowledge of food safety, attenuated by patients as the social or referent influence, worry about health risk associated with FBI in the patient population as the affect influence, and a belief that the dietitian has the control to proceed to actionable behavior; but, factual knowledge of food safety is marginal. This mental model is powerful information that will support and perhaps change the way in which dietitians in the US are prepared to educate others about food safety, especially regarding fresh vegetables, and has the potential to influence both didactic educational preparation and life-long continuing education. There in an inherent challenge exposed from this study for providers of advanced food safety education. Factual food safety information is marginal, is deeply believed and not easily influenced, and highly influenced by others beyond formal educational channels. If the educational approach for dietitians is modified to consider these findings, the ultimate outcome from this study could be fewer cases and outbreaks of FBI, fewer deaths due to FBI, and an improved public health.

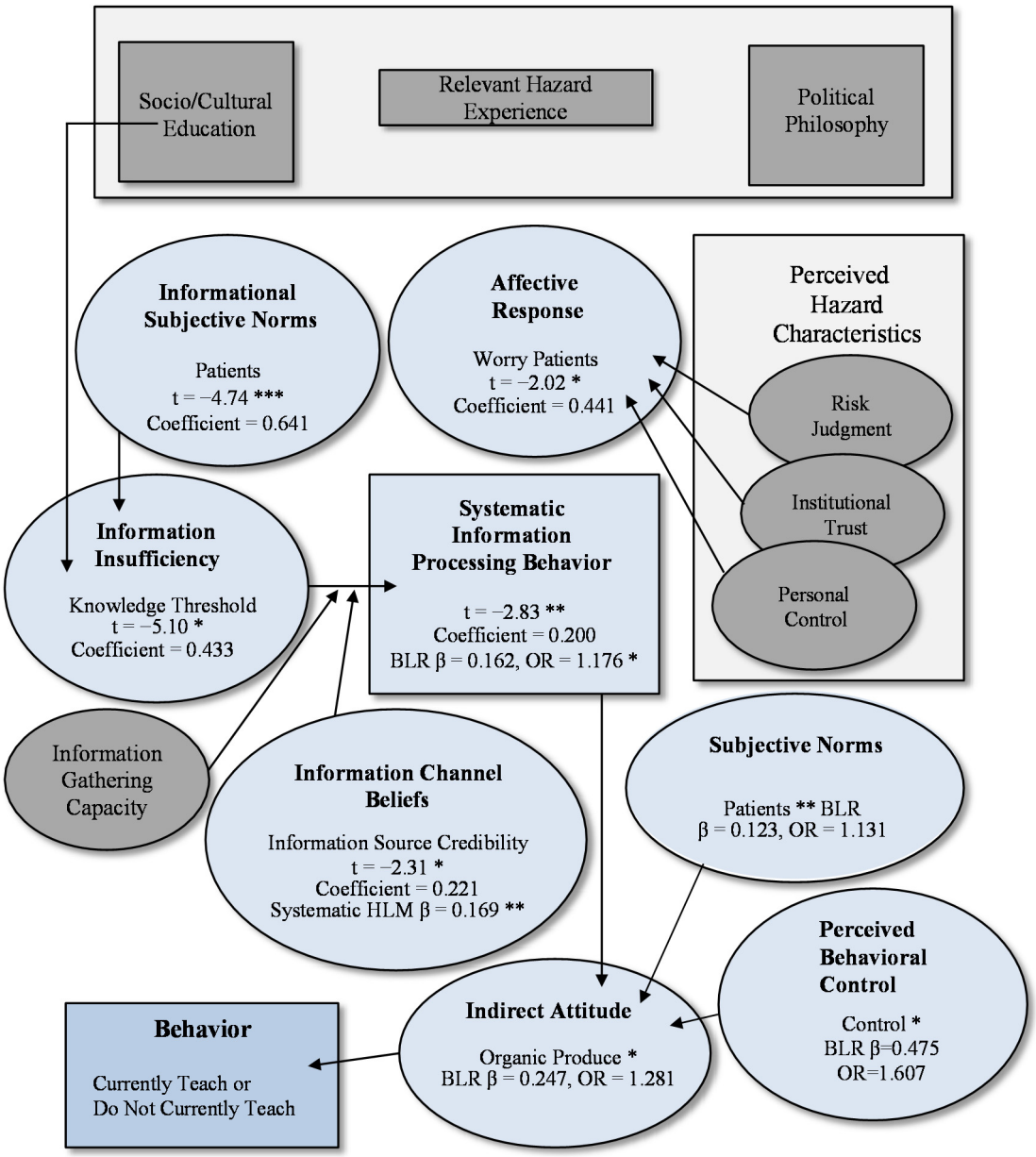

Figure 3. The mental model for teaching behavior of dietitians who either Currently teach or Do not currently teach fresh vegetable food safety to their patients. Grayed objects are the least influential factors in the mental model based on means testing, discriminant analysis, and hierarchical linear modeling. Coefficients are standardized canonical discriminant function coefficients. Beta coefficients (β) = HLM (hierarchical linear models) or BLR (binary logistic regression). Odds ratio (OR). * $P \leq 0.05$; ** $P \leq 0.01$; *** $P < 0.0$.

3. Experimental Section

3.1. Respondent Recruitment

The recruitment process for this study has been previously described [21]. In brief, registered dietitians were recruited via advertisements and emails to listservs sponsored by state affiliates of the Academy of Nutrition and Dietetics. The majority of responses (74.3%) originated from Colorado,

Connecticut, Florida, Georgia, Maine, Nevada, North Dakota, Ohio, and Texas. Individual characteristics of the respondents were measured for Age, Gender, Ethnicity, Income, and Education. Although the sample was a non-probabilistic sample of volunteers who responded to the advertisements, the sample was a near representation of the population of registered dietitians in the United States, based on a comparison of the descriptive statistics with demographic statistics of dietitians in the year the study was conducted [23]. Respondents to the survey agreed to a waiver of written informed consent prior to completing the survey, as per human subjects' protocol approved by The Ohio State University Institutional Review Board for Social and Behavioral Sciences (Protocol #2008B0345, approved 2009). Survey respondents were financially compensated for participation.

3.2. The Survey

The survey was designed for implementation on the Internet and was based on the Risk Information Seeking and Processing (RISP) theory of risk communication [16]. Survey items originated from previous studies [29–32] and were tested with five key informants for content and face validity. The online version of the survey was developed using SelectSurvey.NET (ClassApps, Release 2.0, Overland Park, KS, USA). Registered dietitians (n = 16) were recruited to pilot test the web survey prototype; and, to beta test functionality, provide further face and content validity, and generate data for item analysis (reported elsewhere, [21]). Revisions to the survey were completed prior to study implementation. The survey was opened for participants for approximately two weeks, or until a minimum of 300 responses was received. Sample size was determined using pilot study data. If participants agreed to waive written consent, the following survey page asked questions to determine if they met inclusion criteria: registered dietitian status, age 18 years or older, and employed in a position requiring direct client/patient education. If inclusion criteria were met, the participant proceeded to the survey. Each item required a response to advance to subsequent items; thus, an option was included in all items to check if they voluntarily choose to not answer the item. Items that were not answered were considered missing data. Only surveys from respondents who advanced through all items were included in the data analysis. There were 349 partial or completed surveys submitted to the survey database, and 327 completed surveys were included in the data analysis.

3.3. Control Variables

Control variables included individual characteristics, previous experience with the risk hazard, foodborne illness, and Political philosophy. All control variable items were constructed as binomial yes/no response choices.

Individual characteristics were asked for Gender, Age, Education, Income, and Ethnicity. Five Age categories were collapsed into three categories and then converted to dummy variables for regression analysis. Since inclusion criteria specified credentialed dietitian status (registration in the US), none of the respondents had less than a college education, as required for registration. Two education categories were created as dummy variables, either college graduate or post-graduate education (including both academic and professional degrees). Income control variables were created from seven original categories. Over 90% of participants were Caucasian and the remainder were a mixtures of other ethnicities. Data for all ethnicities other than Caucasian were collapsed into one variable (named,

Other ethnicities). Six items asked dietitians about their previous experience with foodborne illness (FBI). One item referred to the dietitian's personal experience and another item if they had received medical care. Similar items asked if close friends or relatives, or if the dietitian's patients had experienced a FBI and did they seek medical care. Political philosophy was collapsed from five original categories into three dummy variables.

3.4. RISP Communication Theory Variables

Respondents' perception of the risk hazard posed by FBI was measured by three constructs: Risk judgment (Perceived likelihood and Perceived severity), Personal control, and Institutional trust. Perceived likelihood and Perceived severity were constructed in the survey as 11-point semantic differential scale items with 0 (not very likely) and 10 (very likely) as the discriminators for perceived likelihood and 0 (not very serious) and 10 (very serious) as discriminators for perceived severity. Personal control was measured by two items (5-point Likert scale). One item measured the respondents' sense of personal control over avoiding FBI, and another item asked if they perceived that their patients had control over avoiding FBI. Survey items were constructed as 5-point Likert scales from 1 (strongly disagree) to 5 (strongly agree). A summed scale was computed from four items that measured the respondent's trust in institutions charged with responsibility to maintain the safety of the food supply (Institutional trust, $\alpha = 0.68$, minimum score = 4, maximum score = 20).

Two variables were computed as the product of an item that measured the belief that referent others expected the participant to be informed about food safety (Normative belief) and an item that measured the degree to which the participant believed that referent others' opinions were important to them (Motivation to comply) [15]. One variable addressed personal influences (variable name, Informational subjective norm-people) and the second variable addressed the dietitian's patients (variable name, Informational subjective norm-patients) as their referent others and the influence these external forces exerted on the sufficiency of the participants' food safety knowledge. (Minimum score response = 5, maximum score = 25 for both subjective norm variables).

The Affect construct was constructed from two items asking respondents about how much worry they felt about the possible health risk posed by eating fresh vegetables. One item measured worry according to the health risks to the respondent (variable name, Worry-self) and the other item measured worry according to the health risk of the dietitian's patients (variable name, Worry-patient). Items were constructed as 11-point semantic differential scales from 0 (no worry) to 10 (worry a lot).

Six items measured participant's beliefs about various media they used to gain information about food safety (five-point Likert scale). Principal component analysis was used to identify two factors that addressed beliefs about media bias (Media bias beliefs, $\alpha = 0.62$) and validity of food safety information (Validity cues beliefs, $\alpha = 0.58$). The strength of the principle component analysis was acceptable (KMO = 0.67) and 56.0% of the variance in the six items was accounted for in the two factors. Four items queried the amount of attention or credibility paid to various information sources (television, newspaper, personal discussion, and radio) (0, No attention; 10, A lot of attention). Items were summed to form a computed variable, Information source credibility ($\alpha = 0.89$).

Two items were summed to form the variable, Information gathering capacity. One item addressed how easily the participant could get needed information about the safety of fresh vegetables (five-point

Likert scale), and the other addressed the degree to which the participant agreed that useful information about the safety of fresh vegetables was hard to get (five-point Likert scale, reverse coded). Items were summed to form the variable, Information gathering capacity ($\alpha = 0.72$).

The development of the construct, Current (food safety) knowledge, has been previously reported [22] and consisted of three variables. Four items on the survey addressed self-reported awareness (4-point Likert scale) of *Salmonella* spp., *E. coli* O157:H7, *Campylobacter jejuni*, and *Listeria monocytogenes*. Data were summed to form the variable, Pathogen awareness ($\alpha = 0.79$). Four additional items measured understanding of the same pathogens (5-point Likert scale), and were summed to form the variable, Pathogen understanding ($\alpha = 0.83$). General food safety knowledge items were scored as either correct or incorrect. Of the 17 original items included on the survey, eight were retained for data analysis after item analysis with this data set ($\alpha = 0.51$). Scores for Pathogen awareness, Pathogen understanding, and General food safety knowledge were converted to percentiles for data analysis.

The variable, Knowledge threshold, was computed from two items that measured the degree to which dietitians agreed that they had a sufficient amount of food safety knowledge about fresh vegetables for either their own use, or for their ability to adequately teach their patients. Items were five-point Likert scales and were summed to form the variable ($\alpha = 0.91$). Data were converted to percentiles for data analysis.

Eight items measured the participants' information processing characteristics, either heuristic or systematic processing. Four items were summed to measure Systematic information processing (five-point Likert scale, $\alpha = 0.53$). Four items measured Heuristic information processing on the survey, but two were eliminated from data analysis to improve internal consistency of the summed scale (five-point Likert scale, $\alpha = 0.52$).

3.5. Theory of Planned Behavior Variables

Indirect attitude items were computed as the product of scores from survey items assessing behavioral beliefs and a paired item assessing the perceived evaluation of that belief [15,21]. Item products were considered to be indirect measures of attitude. Thirty attitude products had internal consistency ($\alpha = 0.72$) and were thus used in principle component analysis to identify factors. Nineteen attitude products were reduced to four factors, each with improved internal consistency (Table 3). Factor scores were computed and used in logistic regression as independent variables. The strength of the principle component analysis was strong (KMO = 0.79) and 42.2% of the variance in the 30 original Indirect attitude measures was accounted for in the four factors.

Two items measured barriers to Teaching behavior as indicators of Perceived behavioral control. One item measured the possibility of including information about the food safety of fresh vegetables in their educational sessions (variable name, PBC-possible, five-point sematic differential, definitely impossible to definitely possible). The other item measured the perception of control that the dietitian has over teaching patients about fresh vegetable safety (PBC-control, five-point Likert scale).

An item with three response options queried the participants' food safety Teaching behavior. Response options were: I currently teach my patients about fresh vegetable safety ($N = 159$); Even though I don't currently teach my patients about fresh vegetable safety I plan to in the future ($N = 143$); or, I don't and never plan to teach my patients about fresh vegetable safety ($N = 25$). The Do

not currently-teach behavior response option was computed from the summed responses of those who are not teaching food safety to their patients. The new variable name was Teaching behavior, with yes, Currently-teach (n = 159, 48.6%) or no, Do not currently teach (n = 168, 51.4%) as response levels.

3.6. Data Analyses

The study was designed as a cross-sectional, descriptive study. The Statistical Package for the Social Sciences software (SPSS Version 19.0, Chicago IL) was used for all data analyses. Descriptive statistics were calculated for all control variables, and differences by Teaching-behavior group determined with Chi-Square analysis. For summed-scale variables, internal consistency was assessed with Cronbach α and accepted if α was near or exceeded 0.60 [33]. Discriminant analysis was used to identify RISP theory variables that were the most influential in characterizing Teaching-behavior groups. Continuous scaled variables were selected for analysis, which were: Risk judgment, Personal control–self, Personal control–patient, Institutional trust, Informational subjective norm–people, Informational subjective norm–patients, Worry–self, Worry–patient, Media bias beliefs, Validity cues beliefs, Information source credibility, Information gathering capacity, Pathogen awareness, Pathogen understanding, General food safety knowledge, Knowledge threshold, Heuristic information processing, and Systematic information processing. Standardized canonical discriminant function coefficients ±0.30 or above were considered as major classifying variables, and coefficients between ±0.30 and ±0.19 were considered as minor classifying variables. Student's t-test was used to identify mean differences with the same RISP variables that were used in discriminant analysis as the dependent variables and Teaching behavior as the categorical variable. Hierarchical linear modeling (HLM) was used to test the predictive strength of the above RISP theory variables for six models (Heuristic or Systematic information processing; and, Overall; Currently teach, and Do not currently teach). For regression analysis, control variables were recoded to dummy variables. For all tests of significance, differences were declared if probability was at or less than the 5% significance level. Binary logistic regression analysis was used to determine the strength of the regression model for two levels of the dependent variable, Teaching behavior. Independent variables used in binary logistic regression analysis were Systematic information processing, Heuristic information processing, Indirect attitude (Local produce factor, Benefits teaching factor, Organic produce factor, and Nutrition quality factor), Informational subjective norms-people, Informational subjective norms-patients, Perceived behavioral control–possible, and Perceived behavioral control-control).

For objective 2 (the mental model), statistical results from all analyses were inspected and triangulated to qualitatively determine the most salient factors that explained the mental model of dietitians' information processing and teaching behavior.

4. Conclusions

Eight different causal models were generated to understand the relationships between RISP theory variables and Information processing behavior (Tables 1 and 2) and the ultimate outcome of interest in this study, Teaching Behavior (Figures 1 and 2). These models were developed using the theoretical framework of the Heuristic-Systematic Model of Information Processing [14] and the Theory of Planned Behavior [15], as previously proposed by Griffin *et al.* [16]. The juxtaposition of two

behavioral models provides valuable new insight about how dietitians seek, acquire and translate/transfer important information about knowledge to move patients toward a higher goal of food safety.

Of interest is this study's finding that dietitians who have significantly higher knowledge and awareness of foodborne illness pathogens use Systematic information processing when learning new information about food safety. Their higher Knowledge threshold scores may suggest that they were aware of their knowledge gap on information that could be critically needed by their patients, prompting them to seek and learn new, and more in-depth information. Supporting this insight is the significantly higher concern for patients associated with the teaching group (Affect), and that patients are normative (Subjective Norms) for those dietitians who teach food safety. Additionally, dietitians who teach food safety were significantly more likely to view information sources critically (Information Source Credibility).

In contrast, General food safety knowledge did not differ between groups but was overall low in comparison to other groups surveyed when the survey items were first developed [31]. Incorrect knowledge may have contributed to the finding that dietitians who believed that organic vegetables are the safer choice for patients was also predictive of who will teach fresh vegetable safety. This suggests that food safety educators should seek ways to place in-depth food safety information in locations that are readily assessable to health professionals who have the critical skills needed to evaluate the information. Suggested locations for placing food safety information are peer-reviewed journal articles, trade-journals for specific professions, and webinars that provide continuing education credit. We have previously reported that this sample of dietitians frequently uses the internet to locate food safety information [22]. This is an opportunity for educators to combine quality food safety instruction with a popular means to access new information. To attract dietitians to the in-depth information locations, educators are advised to use motivational factors, specifically the health of their patients that were shown in this study to be predictors of teaching behavior.

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Author Contributions

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Author, Medeiros designed the survey, completed all data analyses, designed the mental model graphics, provided key discussion on the results, and co-writing the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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