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PEER-REVIEWED ARTICLE

Food Protection Trends, Vol 46, No. 2, p. 45–56
https://doi.org/10.4315/FPT-25-014

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Is Your Meal Safe When Eating Out with Diabetes: Applying a Health Belief Model Approach

ABSTRACT

Although foodborne pathogens can lead to severe complications for individuals with diabetes, this group remains underrepresented in food safety research compared to other vulnerable populations. This study evaluates the food safety knowledge of individuals with diabetes and empirically investigates potential mediators in the relationship between this knowledge and perceptions of food safety when consuming foods outside the home, utilizing the Health Belief Model. A total of 414 individuals with diabetes were recruited through Amazon Mechanical Turk. Data were analyzed using independent *t*-tests, hierarchical regression, and the PROCESS macro (Model 4). Findings indicate that food safety knowledge varies by gender, family history of diabetes, and previous experiences with food poisoning. Additionally, self-efficacy and attitudes toward food safety significantly mediated the relationship between food safety knowledge and perceptions of food safety when dining out. The study provides valuable implications for researchers, government health agencies, and diabetic consumers by emphasizing the importance of targeted educational interventions to enhance food safety perceptions and practices.

INTRODUCTION

Foodborne illnesses pose a significant threat to public health, affecting millions of people worldwide each year *(32)*. According to the World Health Organization *(60)*, one in ten people fall ill annually from consuming unsafe food, resulting in 600 million cases of foodborne illness and 420,000 related deaths. Although everyone is vulnerable to foodborne illness, certain groups are at greater risk, including children, older adults, and pregnant women. Among these, individuals with diabetes are particularly susceptible due to their weakened immune systems and the complexities involved in managing their blood glucose levels *(11, 17)*. According to the International Diabetes Federation (IDF), approximately 537 million adults were living with diabetes in 2021, and this number is projected to rise to 643 million by 2030 *(33)*. For people with diabetes, the consequences of foodborne illness can be especially severe, leading to extended recovery periods or even death,

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making the management of food safety a critical concern for this population *(49)*.

Epidemiological studies have shown that insulin-dependent individuals with diabetes are more susceptible to developing Salmonellosis during a *Salmonella* Enteritidis outbreak than healthy individuals *(51)*. This elevated risk is due to compromised immune function and the impact of high blood sugar on the body's defenses, which increase susceptibility to infections from bacteria such as *Salmonella*, *Campylobacter*, and *Listeria*. These pathogens can cause severe gastrointestinal issues and other complications. Moreover, individuals with diabetes may struggle to recognize the environmental and handling conditions that promote the growth of harmful bacteria and viruses, which can delay their response and increase their risk of infection *(16, 52, 53)*. Diabetes can also impair the cells that produce stomach acid and the nerves that facilitate the movement of food through the digestive system *(19)*. Consequently, food may remain in the digestive tract longer than usual, providing an opportunity for harmful bacteria and viruses to proliferate. USDA *(53)* recognizes this increased vulnerability and recommends that individuals with diabetes take extra precautions to avoid contaminated food. There is an urgent need to enhance awareness and implement preventive measures through targeted public health interventions to protect these vulnerable groups.

Dining out has become a common practice for many individuals, including those with diabetes. According to the National Restaurant Association *(38)*, the frequency of dining out has increased significantly over the past decade. In the United States, Americans spent a total of $955.6 billion on dining out, accounting for 55% of total food expenditures. For individuals with diabetes, dining out can pose serious risks due to potential exposure to foodborne pathogens in commercial foodservice settings, such as restaurants, where control over food preparation and handling is more limited than with home-cooked meals *(13)*. These individuals face higher risks of foodborne illness and are often more concerned about restaurant safety and hygiene. Studies have identified key attributes consumers use to assess a restaurant's safety, including cleanliness, staff appearance, inspection results, and overall impression *(24)*. Functional cues such as the freshness, temperature, and taste of food, along with the absence of foreign objects, are important perceived indicators of food quality and safety *(58)*. The physical environment of a restaurant, including the cleanliness of service areas, utensils, tableware, and restrooms serves as a perceived hygiene cue and is linked to customers' emotional responses *(31)*. By contrast, ambient elements such as lighting primarily shape diners' emotions. Wall and Berry *(58)* further emphasized humanic cues, particularly servers' food handling behaviors and appearance, as perceived safety cues. Given the unpredictable nature of dining out, it is important for individuals with diabetes to remain vigilant about food safety, such as by choosing establishments known for their commitment to hygiene. As dining out continues to rise, understanding how individuals with diabetes perceive and manage these risks is increasingly significant *(15)*, as their perceptions and behaviors are shaped by psychological factors, including beliefs about their susceptibility to illness.

To effectively address these concerns and improve food safety practices among individuals with diabetes, we utilize the Health Belief Model (HBM) *(22, 48)*. The HBM is a valuable framework for understanding and predicting health behaviors, including those related to food safety *(44)*. Several studies *(6, 7)* have applied the HBM to evaluate food safety behaviors among vulnerable populations, such as older adults and individuals with chronic illnesses like diabetes. These studies highlight the importance of perceived susceptibility—the belief that one is at high risk of foodborne illness. Other research *(37)* has also applied the HBM to explore food safety behaviors in young adults, underscoring the importance of self-efficacy, or the confidence in one's ability to perform actions that ensure food safety. Positive attitudes toward food safety are similarly influential; research *(14, 41)* suggests that individuals with diabetes who hold such attitudes are more proactive in seeking information about safe food handling and making informed dining choices. In the context of the HBM, attitudes shape how individuals perceive food safety, particularly when eating out. By applying the HBM to food safety knowledge, perceived susceptibility, self-efficacy, and attitudes, we gain a comprehensive understanding of how these factors influence the food safety perceptions of individuals with diabetes when consuming food away from home.

Despite the severe complications that foodborne pathogens can pose for individuals with diabetes, this group remains underrepresented in food safety research compared to other vulnerable populations. Many individuals with diabetes are unaware of their increased vulnerability to foodborne infections, which can lead to an optimistic bias that puts them at greater risk *(16)*. Previous studies have highlighted gaps in food safety knowledge and practices among this population, but few have focused specifically on their perceptions and concerns regarding food safety when dining out. As dining out increases exposure to foodborne pathogens, understanding these perceptions is essential for developing effective interventions. By examining the food safety knowledge and perceptions of individuals with diabetes in the context of dining out, we can provide valuable insights for health professionals and individuals living with diabetes. Health professionals can use this information to create educational programs that enhance their patients' awareness of safe dining practices, such as checking restaurant inspection results, identifying high-risk foods, and recognizing signs of improper food handling *(4, 28)*. Additionally, identifying demographic differences in food safety awareness can help public health agencies tailor

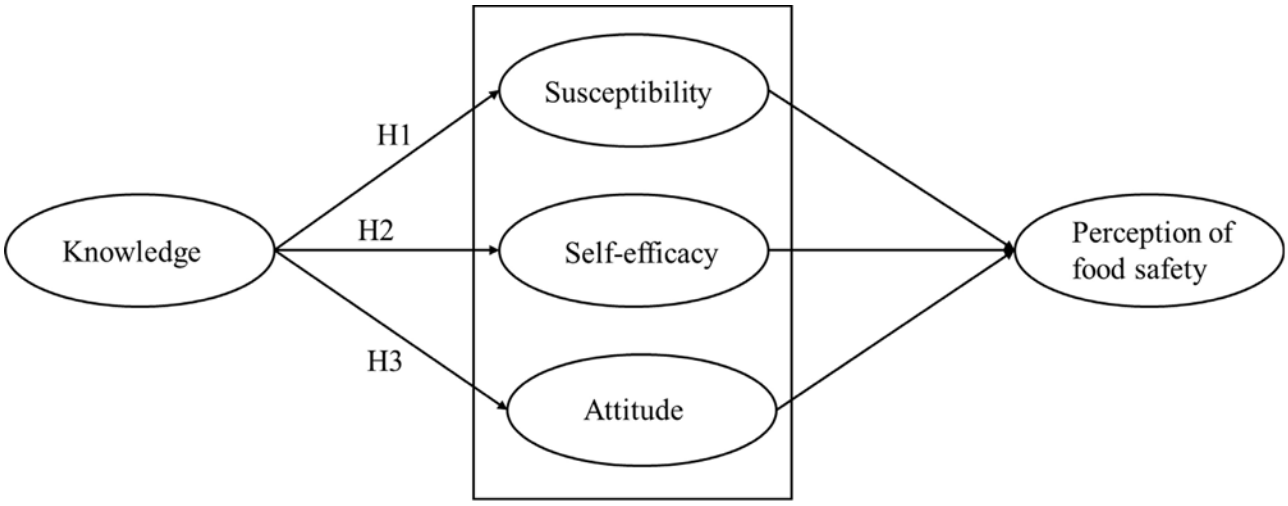

Figure 1. The mediation analysis model.

information to more effectively reach various subgroups within the diabetic population. Ultimately, these efforts can empower individuals with diabetes to make safer food choices, reduce their risk of foodborne illnesses, and improve their overall health and quality of life. Based on the literature review, we propose the following hypotheses (see *Fig. 1*).

***H*$_1$**: Perceived susceptibility is hypothesized to mediate the association between food safety knowledge and food safety perceptions.

***H*$_2$**. Perceived self-efficacy is hypothesized to mediate the association between food safety knowledge and food safety perceptions.

***H*$_3$**. Attitude toward food safety is hypothesized to mediate the association between food safety knowledge and food safety perceptions.

This study was conducted to explore critical aspects of food safety knowledge and perceptions among individuals with diabetes through three research questions: (1) Does food safety knowledge among diabetic consumers vary based on factors such as gender, family history of diabetes, and past experiences with food poisoning? (2) What are the primary food safety concerns for individuals with diabetes, particularly when dining out? (3) What potential mediators influence the relationship between food safety knowledge and perceptions of food safety? To address these questions, the objectives of this study are to: (1) assess the food safety knowledge of individuals with diabetes by evaluating their responses to knowledge-based items and determine whether these levels differ based on the aforementioned factors; and (2) empirically examine the relationship between food safety knowledge and perceptions of food safety, focusing on the mediating roles of self-efficacy, perceived susceptibility to foodborne illness, and attitudes toward food safety. By fulfilling these objectives, the study aims to provide valuable insights to inform educational interventions and public health strategies that improve food safety practices among individuals with diabetes.

METHODS AND MATERIALS

Sample and data collection

Prior to data collection, the University Human Subjects Institutional Review Board (IRB) (IRB#2023–0756) approved all study-related materials, including the survey questionnaire and research protocol. The sample comprised individuals with diabetes or prediabetes, aged 18 to 70, from across the United States. Additional screening questions were used to determine respondents' eligibility for study participation, based on the Prediabetes Risk Test provided by the American Diabetes Association and the Centers for Disease Control and Prevention (CDC). Only respondents who met these criteria were eligible to complete the remaining survey questions. In addition, to ensure response validity, a time-based attention check was conducted. The online survey was developed using Qualtrics, and data were collected over a two-month period, from December 2023 to January 2024, via Amazon Mechanical Turk (MTurk). MTurk provides reliable social science data from a diverse, nationwide sample *(5)* and is recognized for its ability to obtain participants with demographic and geographical diversity, enhancing the generalizability of the findings. Several studies *(9, 12)* have used MTurk for data collection in health-related research, particularly in studies examining health behaviors and perceptions among individuals with diabetes. A total of 413 participants were recruited and received $5 as an incentive for completing the survey.

To assess food safety knowledge, respondents answered a total of 10 questions adapted from da Cunha et al. *(10)*, with additional support from public health guidelines *(54)*

and prior literature on consumer food safety behavior in the home *(62)*, to ensure the items reflected risks relevant to high-risk populations. To minimize guessing, each question offered three possible responses: yes, no, and "do not know." Each correct answer was awarded 1 point, while incorrect or "do not know" responses received 0 points. The total score for each respondent was calculated by summing the points from all questions. Therefore, individuals' total food safety knowledge scores ranged from 0 (the lowest knowledge score) and 10 (the highest knowledge score). Indicators used to measure individuals with diabetes' concerns about food safety when dining out were derived from Liu and Lee *(31)*. Self-efficacy was assessed using two items adopted from previous studies *(25, 46)*. Susceptibility was measured with three items derived from Lee et al. *(29)*, and attitudes were measured using three items derived from Odeyemi et al. *(40)*. Perceived safety of foods was assessed using three items adopted from Knight et al. *(26)*. Perceived safety of foods was assessed using three items adopted from Knight et al. *(26)*. All items were measured using a seven-point Likert scale (1 = strongly disagree to 7 = strongly agree) and were reviewed by experts in food safety and diabetes-related nutrition to ensure the content validity and appropriateness for individuals with diabetes. Lastly, respondents' demographic information was collected, including gender, age, income, education, and marital status.

Data analysis

All data analyses were performed using SPSS 29.0. Descriptive statistics including mean, standard deviation, and percentage were used to summarize the data. An independent sample *t*-test was used to determine whether there was a significant difference in food safety knowledge depending on gender, family history of diabetes, and food poisoning experience. Confirmatory factor analysis (CFA) was used to test the structural validity of the scale. To test the proposed model indicating the relationship between the level of knowledge (independent variable) and perceived safety of foods (dependent variable) through susceptibility, self-efficacy, and attitudes (mediators), hierarchical regression method and the PROCESS Macro (23, Model 4) were used. This method performs multiple regressions and bootstrapping to test parallel mediations. To calculate bias-corrected bootstrap confidence intervals, 5,000 bootstrap samples were used *(23)*.

RESULTS

Sample

Table 1 shows the characteristics of our sample. The mean age of respondents was 35.48 years. In terms of education, over half of the respondents (56.8%) were college graduates. Regarding household income, 50% of participants reported earning between $40,001 and $80,000. Marital status varied, with 7.7% of respondents being single and 88.3% being married. The gender distribution was relatively balanced, with 46.6% male and 53.4% female respondents. In terms of ethnicity, 83.8% of respondents identified as Caucasian, 2.5% as African American, and 8% as Asian, 5.2% as Hispanic, and 2.7% as other ethnicities. A significant majority (88.2%) reported a family history of diabetes, while 11.8% did not.

Diabetic consumers' food safety knowledge

The food safety knowledge assessment section of the survey revealed significant gaps among consumers. While 60% correctly identified that adornments (e.g., jewelry) can cause contamination, 40% were unaware of this risk. Only 31.5% of respondents knew that freezing water does not eliminate diseases. Most consumers (86.6%) were aware of proper hand sanitization methods. Knowledge of cross-contamination was nearly split, with 52.2% correctly identifying it as a risk. Additionally, 60% recognized the dangers of using expired milk, but a majority (67.4%) incorrectly believed that spoiled food always smells bad. Regarding undercooked meat, 58.9% of respondents identified it as a risk. Only 29.4% knew that washing vegetables with vinegar is insufficient for safety, and 70.8% were unaware of safe food defrosting methods. Lastly, 55.6% of respondents knew that illness among food handlers poses a contamination risk.

The level of food safety knowledge *(Table 2)* varied significantly by gender (t=2.202, p=0.028), with males (M = 5.098) exhibiting higher scores than females (M 4.725). Additionally, the level of food safety knowledge differed based on family history of diabetes (t=2.819, p <0 .05). Respondents with a family history of diabetes (M=4.995) demonstrated higher levels of food safety knowledge compared to those without a family history of diabetes (M=4.240). Finally, food safety knowledge also varied by personal experience with foodborne illness (t=2.191, p<0.05). Respondents who had experienced food poisoning (M=4.989) showed higher levels of food safety knowledge compared to those who had not (M=4.340).

Diabetic consumers' food safety concerns

This study evaluated the food safety concerns of individuals with diabetes when dining out, using measurement items derived from Liu and Lee *(31)*. The highest-rated concern was the use of fresh ingredients (M=5.39). Other significant concerns included employees wearing gloves (M=5.37), appropriate lighting (M=5.35), and employees' personal hygiene (M=5.29). Cleanliness of non-food contact surfaces (M=5.26) and restrooms (M=5.25), and the health symptoms of employees (M=5.24) were also identified as important. Serving food at the correct temperature (M=5.27), as well as the cleanliness of serving utensils (M=5.23) and tableware (M=5.16), were similarly important. Overall, these findings show that individuals with diabetes are particularly concerned about cleanliness

TABLE 1. Sample characteristics

Characteristics	n	%
Gender		
Male	194	47.1
Female	218	52.9
Religion		
No religion	6	1.5
Christianity	269	66.6
Roman Catholicism	78	19.3
Islamism	23	5.7
Judaism	20	5.0
Hinduism	8	2.0
Age	35.48 years	
Annual household income		
≤ $ 20,000	8	2.0
$20,001–$40,000	79	19.5
$40,001–$60,000	115	28.3
$60,001–$80,000	88	21.7
$80,001–$100,000	102	25.1
≥ $ 120,001	14	3.4
Education		
Less than high school	2	0.5
High school graduate or GED	38	9.4
Some college	11	2.7
College graduate	230	56.8
Post graduate degree	124	30.6
Ethnicity		
White	336	83.8
African American	10	2.5
Asian	32	8.0
Hispanic	21	5.2
Others	2	0.5
Marital status		
Single	31	7.7
Married	354	88.3
Divorced/separated	2	0.5
Widowed	5	1.2
Live-in partner	9	2.2

Continued on the next page.

TABLE 1. Sample characteristics (cont.)

Characteristics	n	%
Region		
Pacific	28	6.9
Mountain	24	5.9
West North Central	68	16.7
West South Central	116	28.6
East North Central	70	17.2
East South Central	63	15.5
Middle Atlantic	20	4.9
South Atlantic	15	3.7
New England	2	0.5

TABLE 2. Descriptive statsitics and independent *t*-test results of food safety knowledge

		Mean	Std. deviation	*t*-Test for eqaulity of means		
				t	df	Sig. (2-tailed)
Gender	Male	5.098	1.717	2.202	410	0.028*
	Female	4.725	1.717			
Family history of diabetes	Yes	4.995	1.708	2.819	405	0.005**
	No	4.240	1.741			
Food poisoning experience	Yes	4.989	1.673	2.191	59.18	0.032*
	No	4.340	2.000			

Note: *$p < .05$, **$p < .01$, ***$p < .001$.

and food safety in restaurants, with a strong emphasis on ingredient quality.

Measurement model

Confirmatory factor analysis (CFA) was conducted to evaluate the construct validity of the measurement model *(1, 21)*. The results indicated an acceptable model fit. The χ^2 estimate was 121.968, df = 38, *p*-value = 0.000. The results for other fit indices also indicated an adequate model fit (CFI = 0.973, TLI = 0.961, AGFI = 0.911, RMSEA = 0.073) *(52)*. The CFA results indicated that the fit indices for the four-factor model met the standard criteria. Cronbach's alpha was used to measure the internal consistency of items scales. All latent variables had Cronbach's alpha values greater than 0.85, indicating good reliability for the measurements *(39)*. In addition to an acceptable model fit, all standardized factor loadings of indicators on latent constructs were above 0.70, supporting convergent validity *(1)* *(Table 3)*. According to the standards suggested by Fornell and Larcker *(18)*, the average variance extracted (AVE) scores for all constructs were above 0.50, which demonstrates a good level of convergent validity *(3, 18)*. Additionally, the square root of the AVE for each variable was higher than its correlation coefficients with any other constructs, indicating good discriminant validity *(18)* *(Table 4)*.

TABLE 3. Assessment of measurement model

Variables	Items		Loadings	Cronbach's alpha	AVE
Perception of food safety	PS1	Foods you eat at restaurants are safe.	0.881	0.911	0.773
	PS2	Foods you eat at restaurants are hygienic (e.g., no infectious diseases).	0.860		
	PS3	Foods you eat at restaurants are clean (e.g., no parasites or insects).	0.896		
Self-efficacy	SE1	I am confident in my ability to protect myself from foodborne illness when dining out.	0.911	0.856	0.753
	SE2	I am confident in the effectiveness of my protection against foodborne illness while I am dining out.	0.822		
Susceptibility	SUS1	I know many diabetic individuals who have suffered from a foodborne illness.	0.821	0.886	0.723
	SUS2	There is a high probability of diabetic individuals encountering foodborne illnesses in the future.	0.856		
	SUS3	I have a belief that the chances of diabetic individuals experiencing foodborne illnesses in the future are high.	0.873	0.886	
Attitude	ATT1	Washing hands with soap can prevent food poisoning.	0.868		0.723
	ATT2	If there is only one chopping board, it should be washed after using it to prepare raw meat/poultry/seafood.	0.823		
	ATT3	Thermometer should be used to check if a food is thoroughly cooked.	0.859		

Note: AVE = Average Variance Extracted.

TABLE 4. Discriminant validity of the measurement

	Perception of food safety	Self-efficacy	Susceptibility	Attitude
Perception of food safety	(0.879)*			
Self-efficacy	0.616	(0.868)*		
Susceptibility	0.196	0.429	(0.850)*	
Attitudes	0.552	0.823	0.411	(0.850)*

*square root of AVE

TABLE 5. Hierarchical regression results

Dependent variable	Perception of food safety			
	M1	M2	M3	M4
Independent variable				
Knowledge	0.225***	0.130***	0.116**	0.117**
Mediating variables				
Self-efficacy		0.639***	0.486***	0.499***
Attitude			0.209**	0.221**
Susceptibility				-0.057
Model statistics				
R^2	0.063	0.318	0.331	0.333
F	27.404***	95.237***	67.034***	50.645***
ΔR^2	0.063	0.255	0.013	0.002

Note: *$p < .05$, **$p < .01$, ***$p < .001$.

Hypotheses testing

As shown in *Table 5*, hierarchical regression analysis demonstrated significant improvements in the model's explanatory power with the sequential addition of mediators. Initially, knowledge explained 6.3% of the variance in food safety perceptions (R^2=0.063; F(1,410)=27.404, p<.001). In Model 2, the inclusion of self-efficacy as the first mediator substantially increased the explained variance to 31.8% (R^2=0.318; F(2,408)=95.237, p<.001), highlighting its strong mediating role. The further addition of attitude in Model 3 improved the model's predictive capability, bringing the explained variance to 33.1% (R^2=0.331; F(3,407)=67.034, p<.001). In Model 4, the introduction of susceptibility slightly increased the explained variance to 33.3% (R^2=0.333; F(4,406)=50.645, p<.001). However, the non-significant p-value (p=0.251) for susceptibility indicates that it does not mediate the relationship between food safety knowledge and food safety perceptions. Overall, the findings emphasize the importance of self-efficacy and attitude as key mediators, while susceptibility appears to have a negligible impact in this context.

TABLE 6. Mediating effects

Paths	Estimate	SE	LLCI	ULCI
Total effect	0.2249	0.0376	0.1503	0.2995
Direct effect	0.1167	0.0376	0.0429	0.1906
Total indirect effect	0.1082	0.0261	0.0569	0.1598
Ind1: Knoweldge-susceptibility-perception of food safety	-0.0053	0.0051	-0.0161	0.0044
Ind2: Knoweldge-self-efficacy-perception of food safety	0.0740	0.0218	0.0336	0.1189
Ind3: Knoweldge-attitude-perception	0.0396	0.0168	0.0102	0.0759

Figure 1 presents the PROCESS analysis model used to test the parallel mediation model. The level of knowledge was entered as the independent variable, with susceptibility, self-efficacy, and attitude as three parallel mediators (Model 4), and perceived safety of foods as the dependent variable. The macro computed bias-corrected bootstrap confidence intervals for the indirect effects from 5,000 bootstrap samples. The results of the mediation analysis indicated that susceptibility was not a significant mediator in the relationship between knowledge and perceived food safety (indirect effect = -0.0053, 95% CI = [-0.0161, 0.0044]). Thus, the indirect path from knowledge to perceived food safety through susceptibility were not supported ***(H1 was not supported)*** *(Table 6)*. In contrast, the results showed the indirect effects of self-efficacy (indirect effect = 0.0740, 95% CI = [0.336, 0.1189]) and attitude (indirect effect = 0.0396, 95% CI = [0.0102, 0.0759]) were significant, supporting the hypotheses that self-efficacy and attitude serve as mediators in the relationship between knowledge and perceived food safety ***(H2 and H3)***. The significant indirect effects suggest that higher levels of knowledge are associated with greater perceived food safety through increased self-confidence and more positive attitudes.

DISCUSSION AND CONCLUSIONS

Unlike the findings of previous studies *(40, 43)* examining food safety knowledge among healthy adults, this study found that males exhibited higher food safety knowledge than females, particularly among individuals with diabetes. Considering the context of our study population, individuals with higher health risks, this disparity may be explained by several factors. For example, in the United States, men have a higher prevalence of diabetes compared to women, which may lead to a greater interest in understanding health risks and seeking more information related to food safety to mitigate these risks. Furthermore, this observation is supported by studies *(36)* indicating that male patients with diabetes are more likely than their female counterparts to seek diabetes-related information, potentially leading to enhanced knowledge and better diabetes management, including increased awareness of foodborne illness risks.

The findings of this study are consistent with previous literature suggesting that individuals with a family history of diabetes tend to possess greater knowledge about diabetes-related health issues, including food safety *(45)*. This increased food safety knowledge may result from greater exposure to health education from professionals, particularly regarding diabetes management through healthy eating and proper food handling practices. Family members with diabetes often share information or advice about food safety practices, contributing to improved understanding and vigilance regarding dietary practices. Moreover, as previous studies *(30, 50)* have shown, individuals often trust and prefer food safety information provided by close family members, considering these interpersonal sources are more credible.

The findings of this study align with those of Osaili et al. *(42)*, who demonstrated that experiences with food poisoning can heighten awareness of hygiene practices, likely leading to improved food safety knowledge and behaviors aimed at preventing future illness. Additionally, our results are consistent with previous studies *(2, 30)*, which found a positive correlation between prior experiences with foodborne illness and food safety knowledge among low-income families. This finding is particularly relevant to our research, as low-income families represent a vulnerable population with heightened health risks, including food insecurity. Similarly, individuals with diabetes, another vulnerable group, may experience more severe health outcomes from foodborne illnesses due to weakened immune systems and potential complications related to their condition. Consequently, personal experiences with foodborne illness may increase awareness of food safety and motivate individuals to seek information, thus, enhancing their food safety knowledge.

Consistent with previous studies, the findings of this study further clarify the relationship between food safety knowledge and behaviors, particularly highlighting how health-related behaviors are mediated by self-efficacy *(34, 35, 57)* and attitude *(27)*. Moreover, as noted in earlier research *(8, 47)*, the findings of this study confirm that knowledge alone is insufficient to change food safety behaviors. We suggest that, rather than solely increasing knowledge, promoting a favorable food safety attitude and building confidence may be more effective in translating knowledge into practice, as recommended by prior studies *(20, 59, 63)*. In addition, when designing food safety educational interventions, health professionals and governments should consider strategies that enhance confidence and foster favorable attitudes toward applying food safety knowledge. For instance, food safety training materials could incorporate interactive elements, such as simulations or problem-solving exercises.

Unlike the study by Woreta et al. *(61)*, this study did not find a significant indirect effect of susceptibility in the relationship between food safety knowledge and food safety perceptions. One possible explanation for this finding is that individuals with diabetes may not be aware that they are at increased risk of foodborne illness, as previous studies have asserted *(15, 16)*. People with diabetes often prioritize managing their primary condition and may not fully recognize the increased vulnerability to infections that their condition poses, leading to an underestimation of their risk *(10, 16)*. This is relevant to the concept of optimistic bias, whereby individuals perceive risks to be greater for others than for themselves *(14)*. Such bias among individuals with diabetes can lead to a lack of attention to food safety practices, even when they possess adequate knowledge. Thus, we suggest that educational interventions specifically targeted at individuals with diabetes should emphasize the reasons why they are more susceptible to foodborne illnesses compared to the general population and highlight the specific practices they should follow to protect themselves from severe symptoms, which could exacerbate diabetic complications.

This study has several limitations. First, this study relied on self-reported data from individuals with diabetes, which may have introduced social desirability bias. Because participants may report behaviors they perceive as more socially acceptable rather than their actual behaviors, future studies should consider alternative methodological approaches, such as direct observation and interviews. Second, this study used MTurk for data collection. While it provides demographic diversity, the sample tends to be younger, more educated, and more internet-savvy than the broader diabetic population, which may introduce bias. In addition, several studies *(9, 12)* have effectively used MTurk for data collection in health-related research, but our sample may not fully represent the broader population. Future studies could consider more diverse recruitment strategies, such as partnering with diabetes associations or healthcare providers specializing in diabetes, to enhance generalizability. Third, one of the food safety knowledge items addressing the potential risk of consuming milk one day past the use-by date is context-dependent: the risk may vary with storage conditions and the increased susceptibility of vulnerable groups (e.g., individuals with diabetes). Therefore, future studies should refine such items by explicitly stating storage conditions and the characteristics of the study population. Additionally, our sample had a relatively high proportion of White participants, which may not accurately represent the diverse ethnic composition of the diabetic population. Future research could include a broader range of ethnicities, ensuring more representative and inclusive findings. Fourth, this study primarily used descriptive statistics to report consumers' concerns about food safety when dining out. Future research may explore how each indicator of consumer concern correlates with foodborne illness, such as the relationship between restroom cleanliness, lighting, and the actual risk of foodborne illness. Fifth, this study demonstrated a relatively high level of overall food safety knowledge, which may have resulted from calculating a composite knowledge score. However, we did not examine how specific items, particularly those with common misunderstandings, such as safe defrosting practices differ by demographic or experiential factors. Future research should explore how specific knowledge gaps vary across populations and how they influence actual food safety behaviors. Lastly, this study assessed the perceived functional cues (e.g., "fresh ingredients") that consumers rely on when evaluating food safety and quality. Future research should examine how consumers perceive the risks associated with foodborne outbreaks linked to fresh produce.

ACKNOWLEDGMENT

This research was funded by 2023 Research Enhancement Award, Queens College, CUNY.

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