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Consumer's risk perception of foodborne diseases and high-risk food safety practices in domestic kitchens

RESEARCH ARTICLE

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Abstract

Food safety incidents caused by foodborne diseases is the most prominent food safety problem in the world, and especially in China. In order to analyze consumers' risk perception of foodborne diseases, the present study has expanded previous work by conducting a survey in Wuxi, Jiangsu Province. 834 valid questionnaires were collected. The survey showed that most of the respondents were not familiar with the pathogens. Only 53.24% of the respondents stated that they always separated raw and cooked food during storage and handling. The study provides analysis of individual characteristics who perceived low risk of foodborne diseases, that is, lower education level and lower income. The government should effectively popularize knowledge about food safety, and guide consumers in developing correct eating habits and behaviors, thereby further improving consumers' understanding and risk perception of foodborne diseases.

Keywords: risk perception, foodborne diseases, influencing factors, food safety practices, multivariate ordinal logistic regression model

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1. Introduction

Food safety risks are a common problem throughout the world (Chen *et al.*, 2017; Shan *et al.*, 2013). In terms of impact scope and intensity, food safety incidents caused by foodborne diseases is the most prominent food safety problem in the world, and especially in China. The World Health Organization estimates that 2.2 million people die from foodborne or water-borne diseases worldwide each year (Xu *et al.*, 2014). One of every 6.5 people in China gets ill due to foodborne pathogens contaminated food every year (Redmond and Griffith, 2003). Foodborne diseases not only affect the health of consumers and reduce overall social welfare, but also increase public health expenditure and cause significant economic losses. In China, the direct and indirect economic losses caused by foodborne diseases were estimated to be 13.2 billion yuan (Xu, 2013). In the UK, foodborne diseases cause an annual economic loss of 1.8 billion pounds and result in 200,000 hospitalizations and 500 deaths (Food Standards Agency, 2011). The statistics from the US Department of Agriculture show that foodborne diseases caused by 14 major pathogenic bacteria cost the US losses of 14.1 billion dollars annually (Hoffmann *et al.*, 2012). Therefore, foodborne diseases have become the focus of public health and safety (Kim, 2009).

Consumers represent the endpoint of the food safety chain and, thus, have been referred to as the ‘final line of defense’ (Hall *et al.*, 2008) in the prevention of foodborne illness (Jevšnik *et al.*, 2008). However, many consumers, even those at high risk for foodborne diseases, are not aware that they or their families are vulnerable to foodborne diseases (Buffer *et al.*, 2013). It has been estimated that 50 to 87% of foodborne illness outbreaks are associated with the home (Clayton *et al.*, 2003). Nevertheless, the actual data on foodborne diseases data may be seriously underestimated due to the absence of monitoring and reporting of foodborne illnesses in domestic kitchens (Mao *et al.*, 2010).

Most cases of foodborne diseases are often the result of consumers’ behaviors that are completely preventable, such as consuming raw food products and engaging in unsafe food preparation practices (Kohl *et al.*, 2002; Oliver *et al.*, 2005). Understanding consumer’s food risk perception and food handling in the home is critical in reducing foodborne illness (Bakhtyary *et al.*, 2016; Hoang *et al.*, 2005). The purpose of this study was to investigate consumers’ risk perception of foodborne diseases in domestic kitchens, as well as which main influencing factors are important for the prevention of foodborne diseases, which are the most closely related to the greatest potential risks to public health, and for improving food safety risk prevention and control in China.

2. Literature review

Based on a systematic literature review, factors which influence consumers’ risk perception of foodborne diseases are described in the following paragraphs.

2.1 Individual characteristics that affect consumers’ risk perception of foodborne diseases

Present research has shown that different individual characteristics have different levels of influence on consumers’ risk perception of foodborne diseases. It is generally believed that their risk perception of foodborne diseases is affected by different genders. Female consumers have a higher perception of foodborne diseases than that of male consumers (Lin *et al.*, 2005). Similarly, a study in the year 2000 on 1,092 adults in the UK found that women were more worried about food issues than men (Miles *et al.*, 2013). Risk perception also increased with age (Miles *et al.*, 2013). Some studies have found that people aged 65 years or older, pregnant women, children younger than five years, and people with impaired immune systems are at high risk of foodborne diseases (Carol *et al.*, 2013), and have different perceptions of foodborne diseases. In addition, income and education also influence consumers’ risk perception of foodborne diseases. Consumers with low education and income have a lower perception of various pathogens than those with higher education and income (Lin *et al.*, 2005). It may be because consumers with low education and income have limited understanding of food safety information.

2.2 Relationship between consumers' knowledge of pathogens and their risk perception of foodborne diseases

Many studies of consumers' risk perception of foodborne diseases have shown that food safety training can increase consumers' risk perception of foodborne diseases (Pichler *et al.*, 2014). For example, in 2001 Lin *et al.* (2005) did a study on 4,482 American adults and concluded that awareness of microbial pathogens was positively associated with food safety perceptions and awareness of potentially risky foods, food safety hazards, and food safety behaviors. Relative to consumer's educational background, specialized training of food safety knowledge can deepen consumer's understanding of foodborne diseases and improve their food safety risk perception (Cunha *et al.*, 2012). In particular, training to properly handling and cooking food can help to change consumers' attitudes and improve their perception of foodborne diseases (Gomes-Neves *et al.*, 2011). Food safety instruction, even at the most basic level, benefited people's food safety perception and food-handling behavior after intervention (Kendall *et al.*, 2017). However, there is no definite correlation between consumers' risk perception of foodborne diseases and their education. This may be due to the fact that primary and secondary education rarely involves specialized food safety training (Cunha *et al.*, 2012).

2.3 Hygiene and eating habits

Handling and preparation of food by consumers at home is the last process of the food supply chain (Byrd-Bredbenner *et al.*, 2010). Their improper food safety behaviors may undermine the efforts to improve food safety management in the upstream and downstream supply chain (Kennedy *et al.*, 2005). Storage is one of the main aspects of food preparation at home. A study from Ireland indicated that one or more of the following pathogens were detected in more than half of refrigerators: *Staphylococcus aureus*, *Salmonella*, *Escherichia coli*, *Listeria*, and *Yersinia* (Kennedy *et al.*, 2005). In addition, food cooking is also the aspect where improvement is most needed. The US Healthy People 2020 initiative states that only 37% of consumers fully cook raw meat and poultry (United States Department of Health and Human Services, 2010).

2.4 Dietary preferences

For some consumers, taste is one of the main factors determining food choices (International Food Information Council Foundation, 2012). Due to fear of changing the original texture and taste of food by heating, they often choose to eat semi-cooked meat or soft-boiled eggs (Fischer *et al.*, 2007). Consumers with these food preferences are susceptible to foodborne diseases caused by *Salmonella*, *Listeria*, and other pathogens.

Consumers are responsible for storing, handling, and cooking food in domestic kitchens. Food storage (time/temperature), contaminated equipment, food from unsafe sources, poor personal hygiene, and inadequate cooking are the most common factors contributing to foodborne diseases outbreaks (Gould *et al.*, 2006; Sanlier, 2009). Investigating consumers' risk perception of foodborne diseases and analyzing their food safety behaviors is one of the most effective methods to reduce economic and other losses caused by food safety incidents (Roseman and Kurzynske, 2006). Researchers around the world have carried out extensive research on consumer's risk perception of foodborne diseases and food safety behaviors. Nevertheless, the present relative research still has some limitations. For example, seldom studies have intensively examined consumers' current perception and behaviors regarding foodborne diseases in China. Only a few studies have been conducted in China in this field, but they just focused on simple statistical description and a summary of the present situation. In addition, whether the research results from other countries are applicable to China, it needs systematic in-depth research.

3. Materials and methods

3.1 Theoretical model

In this research, the effects of different influencing factors (independent variables) on ordered multi-classification variables (dependent variables) were analyzed. If the multiple classification results are simply combined into two categories for binary logistic regression, a large amount of data will be lost. The model took the order into account. Even if the value is different, the parameter estimation of this model is the same, thus avoiding the difference of the model parameter estimation caused by using the different assignments of the linear probability model. In the current study multiple ordered logistic regression analysis was used, which is a cumulative logit model. According to the different perception levels, four (Y-1) logistic regression models can be fitted. This model can check whether there are significant differences in the effects of different sequences of independent variables on the independent variables.

In this paper, the dependent variable was 'the value of consumer risk perception' that, from 1 to 5, represents strongly disagree, disagree, neutral, agree, strongly agree, constructing a probability expression based on logistic function:

$$P(Y = j / X_i) = \frac{1}{1 + e^{-(\alpha_j + \beta X_i)}} \quad (1)$$

Where, X_i stands for i index, Y is the actual observation value, assigned values are 1, 2, 3, 4, 5, representing different risk perception degrees of consumers. Taking a set of probabilities as independent variables, a cumulative probability distribution model was constructed:

$$\text{Logit}(P_j) = \ln[P(Y \leq j) / P(Y \geq j+1)] = -\alpha_j + \beta X \quad (2)$$

Where, P_j is the probability that the perception of a risk belonged to a certain degree, With characteristic argument $P_j = P(Y=j)$, $j=1,2,3,4,5$; $X=(x_1, x_2, \dots, x_n)^T$. β is the regression coefficient of the model and α_j is the intercept term of the model. After the parameter estimates of α_j and β were obtained, the probability of the $Y=j$ could be evaluated as follows:

$$P(Y \leq j / X_i) = \frac{e^{-(\alpha_j + \beta X_i)}}{1 + e^{-(\alpha_j + \beta X_i)}} \quad (3)$$

3.2 Data sources and processing

In this study, in July and August 2016 a questionnaire survey was conducted among a random sample from Wuxi, Jiangsu Province, China, by trained investigators from the Institute for Food Safety Risk Management of Jiangnan University, to examine consumers' risk perception and behaviors regarding foodborne diseases. Respondents were randomly recruited by selecting every third consumer coming into view (Jacowitz and Kahneman, 1995). Specifically, the survey was carried out in shopping malls, large and medium-sized supermarkets, markets of agricultural products, and food stores in different geographical areas in Wuxi. The instrument was based on the questionnaires used by Byrd-Bredbenner *et al.* (2010) and Frewer *et al.* (1994). A total of 850 questionnaires were distributed, and 834 valid questionnaires were recovered, representing a recovery rate of 98.1%.

■ Demographics of respondents

Table 1 shows the demographics of the respondents. Of the 834 respondents, 44.2% were male, and 55.8% were female; 83.4% were adults younger than 45 years, and 12.9% were aged between 45 and 59 years. In addition, most respondents had no children and only one child in their family, accounting for 42.1% and 42.4%, respectively. The respondents generally had high education levels: 29.1% have a bachelor's degree,

Table 1. Demographics of respondents.

Item	Description	Number of respondents	Effective proportion
Gender	Male	369	44.24
	Female	465	55.76
Age	18-29	483	57.91
	30-44	213	25.54
	45-59	108	12.95
	60 years or older	30	3.60
Marital status	Married	483	57.91
	Unmarried, widowed, or divorced	351	42.09
Education	$x \leq 9$	177	21.22
	$9 < x \leq 12$	174	20.86
	$12 < x \leq 16$	462	55.4
	$x > 16$	21	2.52
Annual family income	$x \leq 50,000$ yuan	144	17.27
	$50,000 \text{ yuan} < x \leq 80,000$ yuan	255	30.58
	$80,000 \text{ yuan} < x \leq 100,000$ yuan	153	18.34
	$x > 100,000$ yuan	282	33.81
Presence of children under 18 years of age in the family	Yes	351	42.09
	No	483	57.91

and 26.3% had a junior college degree. Besides, 21.2% of the respondents had junior high school or lower education, 20.9% had high school education (including secondary vocational school), and 2.5% had a graduate degree. In terms of personal income, respondents with a personal income of 30,000-50,000 yuan accounted for the highest proportion at 36.3%, followed by those with a personal income of 30,000 yuan or lower and 50,000-100,000 yuan, accounting for 21.2% and 20.5%, respectively. Only 2.2% had a personal income of more than 150,000 yuan. In terms of family income, most respondents had a family income of more than 100,000 yuan and between 50,000 and 80,000 yuan, accounting for 33.8% and 30.6%, respectively.

■ Information and knowledge

Respondents were asked the following: have you heard of *Campylobacter*, *Escherichia coli*, *Listeria*, or *Salmonella*? Most of the respondents were not familiar with the pathogens. Overall, 40.29% of the respondents stated that they knew about one of the pathogens, 23.02% had heard of none of them, 28.06% knew about two of them, and only 8.63% of respondents knew about three or more of them. This suggests that most respondents had varying levels of knowledge of the pathogens that cause foodborne diseases. They generally had a superficial knowledge, which is far from enough to prevent foodborne diseases. Therefore, training for consumers on related knowledge is extremely deficient at present.

■ Hygienic practices

The vast majority of respondents (74.82%) claimed that they cooked at home at times. Besides, 7.91% and 17.27% said they cook at home all the time or never cook at home, respectively. In addition, 67.99% of the respondents washed the chopping boards and knives every time after cutting the meat, while 21.94% and 10.07% claimed 'often' or 'sometimes', respectively. More than half of the respondents stated that they always separated raw and cooked food during storage and handling, while 24.10% and 22.66% claimed 'often' or 'sometimes', respectively. This indicates that a significant number of respondents had a low awareness of food hygiene.

■ Dietary preferences

The survey results show that 60.43% of the respondents had ever eaten undercooked meat or seafood. Besides, 29.49% of the respondents reported they had eaten raw oysters or other raw seafood, 5.76% and 3.24% had eaten raw eggs and raw fish, respectively, and only 1.08% had never eaten these foods. This shows that the vast majority of consumers has eaten undercooked meat, seafood, or eggs, and has insufficient knowledge of the possible resulting foodborne diseases. This also prompts the relevant government departments to continue to educate the public about the possible hazards from pathogens contained in undercooked meat or seafood.

3.3 Variable description

There are many factors influencing consumers' risk perception of foodborne diseases. Based on the previous research results, individual characteristics, information and knowledge, hygiene and dietary habits, and dietary preferences were selected as explanatory variables of the multivariate ordinal logistic regression model, and consumers' risk perception of foodborne diseases was selected as the independent variable. The variables of the model are defined as shown in Table 2.

3.4 Results

In this study, consumers' risk perception of foodborne diseases was analyzed by a multivariate ordinal logistic regression model. Moreover, data on the factors influencing these risk perceptions were analyzed using SPSS 19.0 (Chicago, IL, USA). The results are shown in Table 3.

Table 2. Variables used in the multivariate ordinal logistic regression model.

Variable name	Variable definition and assignment	Mean	Standard deviation
Opinions on whether foodborne diseases are a major risk, Y	Interval variable; strongly disagree=1, disagree=2, neutral=3, agree=4, strongly agree=5	3.86	1.44
Gender, X_1	Dummy variable; male=1, female=0	0.44	0.50
Age, X_2	Continuous variable; actual age (years)	32.24	11.11
Marital status, X_3	Dummy variable; married=1, unmarried or widowed, divorced=0	0.58	0.49
Education, X_4	Continuous variable; specific years of education (years)	13.49	2.82
Annual family income, X_5	Continuous variable; specific family annual income (10,000 yuan)	8.01	1.93
Frequency of cooking, X_6	Interval variable; never=1, sometimes=2, often=3, always=4	2.18	0.81
Washing chopping boards and knives after cutting the meat, X_7	Interval variable; sometimes=1, often=2, always=3	2.58	0.67
Storing and handling raw and cooked food separately, X_8	Interval variable; sometimes=1, often=2, always=3	2.26	0.83
Length of time for leaving prepared food at room temperature, X_9	Continuous variable; hours of storage at room temperature	2.21	1.47
Did you and your family ever get ill due to eating food prepared at home?, X_{10}	Interval variable; never=1, rarely=2, sometimes=3, often=4	1.38	1.01
How many of these pathogens have you heard of: <i>Campylobacter</i> , <i>Escherichia coli</i> , <i>Listeria</i> , and <i>Salmonella</i> ?, X_{11}	Continuous variable; number of pathogens heard of	1.39	0.51

Table 3. Model estimates of major factors influencing consumers' risk perception of foodborne diseases.¹

Variable	Estimated coefficient	Standard deviation	Wald value	P-value
Gender, X_1	-0.003	0.140	0.001	0.982
Age, X_2	-0.004	0.008	0.240	0.624
Marital status, X_3	0.034	0.171	0.039	0.844
Education, X_4	-0.018	0.029	0.384	0.535
Annual family income, X_5	0.113***	0.037	9.159	0.002
Frequency of cooking, X_6	-0.060	0.105	0.330	0.566
Washing chopping boards and knives after cutting the meat, X_7	0.122	0.109	1.246	0.264
Storing and handling raw and cooked food separately, X_8	0.454***	0.091	24.839	0.000
Length of time for leaving prepared food at room temperature, X_9	-0.058	0.047	1.530	0.216
Have you and your family got ill due to eating food prepared at home?, X_{10}	0.561***	0.104	28.815	0.000
How many of these pathogens have you heard of: <i>Campylobacter</i> , <i>Escherichia coli</i> , <i>Listeria</i> , and <i>Salmonella</i> ?, X_{11}	0.440***	0.073	36.139	0.000
Intercept term α_1	0.949	0.639	2.209	0.137
Intercept term α_2	1.671	0.638	6.852	0.009
Intercept term α_3	2.316	0.640	13.088	0.000
Intercept term α_4	3.067	0.644	22.669	0.000
Cox & Snell	0.144			
Nagelkerke	0.154			
McFadden	0.057			
χ^2 test	129.209 ($P=0.000<0.001$)			

¹ *** indicates $P<0.01$.

The results are discussed below in terms of individual characteristics, hygiene and eating habits, experience of foodborne diseases, and cognition of pathogens.

■ Individual characteristics

Gender, age, marital status and education were not associated with perceived risk of foodborne diseases. The estimated coefficient of annual family income was 0.113, with a significance level of 0.002. It indicates that consumers' risk perception of foodborne diseases is significantly affected by their annual family income. This is consistent with the view of Lin *et al.* (2005) that low-income consumers have a lower perception of various pathogens than high-income consumers. This may be due to the fact that high-income consumers have higher requirements for food safety and nutrition, follow higher standards, and have a better knowledge of food safety risks. Moreover, high-income groups are generally highly educated, have higher scientific literacy, are more sensitive in perceiving foodborne diseases, and are more skilled and faster in searching and mastering relevant food safety knowledge.

■ Health and eating habits

The frequency of cooking, the cleaning of cutting tools and chopping boards, and the length of time to store food at room temperature were independent of the risk perception of food-borne diseases. The estimated coefficient of separate storage and handling of raw and cooked food was 0.454, with a significance level

of 0.000. This suggests that consumers who are accustomed to storing and handling raw and cooked food separately are more likely to believe that foodborne diseases is a significant risk. This demonstrates that consumers with good hygiene and eating habits have higher risk perception of foodborne diseases. Therefore, this group of consumers would like to store and handle raw and cooked food separately.

■ *Experience of foodborne diseases*

Did you and your family ever get ill due to eating food prepared at home? The estimated coefficient of this factor was 0.561, with a significance level of 0.000. This suggests that if consumers and their families got ill due to eating food prepared at home and have experienced the suffering of foodborne diseases, they are more sensitive to the risk of food borne diseases and are more likely to believe that foodborne diseases are a significant risk.

■ *Knowledge of pathogens*

The estimated coefficient of knowledge of *Campylobacter*, *Escherichia coli*, *Listeria*, and *Salmonella* was 0.440, with a significance level of 0.000. Consumers who know well about the pathogens are more inclined to believe that foodborne diseases are a significant risk. Moreover, the better they know about the pathogens, the more likely they believe that foodborne diseases are a significant risk. This suggests that mastering professional food safety knowledge can increase consumers' risk perception of foodborne diseases. This corresponds to what Gomes-Neves *et al.* (2011) and Pichler *et al.* (2014) found.

4. Conclusions and suggestions

Results of this study indicate that consumers' risk perception of foodborne diseases is significantly affected by their annual family income, storage and handling of food habits, experience of getting ill due to eating home cooked food, and knowledge of pathogens. This conclusion is instructive as to how the government understands and improves consumers' risk perception and relating behaviors regarding foodborne diseases. The Chinese government can improve consumers' risk perception of foodborne diseases in two ways. First of all, the government should construct a multidimensional food safety education system for consumers through a wide range of channels, including the internet, microblogging, WeChat, newspapers, magazines, television, broadcast, and other medias, in order to effectively publicize food safety knowledge, eliminate consumers' misunderstandings, and guide them in developing correct eating habits and food safety behaviors. Second, the government should actively coordinate the departments of education to bring consumer food safety education into the basic education system, in order to normalize and systematize food safety education, thereby further enhancing consumers' risk perception of foodborne diseases.

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