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EDITED BY
José Antonio Teixeira,
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REVIEWED BY
Sidra Jabeen,
University of Agriculture, Faisalabad, Pakistan
Brunella Arru,
University of Sassari, Italy

*CORRESPONDENCE
Jinkyung Choi
✉ choijk@pknu.ac.kr

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Perceived risk and risk reduction behaviors in fish and seafood consumption

Soyoung An[1], Thomas Eck[2] and Jinkyung Choi[1]*

[1]Department of Food Science and Nutrition, Pukyong National University, Busan, Republic of Korea, [2]Department of Hospitality and Tourism Management, Sejong University, Seoul, Republic of Korea

This study aimed to explore what risk factors consumers perceive when consuming fish and seafood at a time when treated wastewater was being discharged. Moreover, this study attempted to examine what risk reduction behaviors consumers take to minimize these risk factors. The data was collected online for one week in September 2023 and 334 responses from Korean consumers were used for the analysis. Five risk dimensions were identified: biochemical risk, hygiene risk, environmental risk, value risk, and socio-phycological risk were identified. Higher levels of perceived risks were identified in female respondents and four dimensions of risk (except hygiene risk) showed a significant relationship with risk reduction behavior. Such risk reduction behavior significantly influenced the intention to consume seafood. Practical and theoretical implications were also suggested from the findings of this study.

KEYWORDS

perceived risk, risk reduction behavior, consumption intention, fish and seafood consumption, sustainable consumption

1 Introduction

Fish and seafood are accessible and affordable sources of animal protein and micronutrients. They play a significant role in nutrition and food security, especially for countries located in coastal areas (Golden et al., 2016). Fish and seafood account for the highest percentage of Koreans' per capita food consumption. The annual consumption of fish and seafood per capita in South Korea increased from 52.8 kilograms in 2001 (Yun and Kim, 2022) to 65.6 kilograms in 2021 (Haps, 2022). Compared to the global average consumption of fish and seafood per capita, at 19 kilograms in 2021, it can be said that Koreans are highly dependent on fish and seafood consumption (Yun and Kim, 2022). In fact, rice used to be the staple food in South Korea; however, the consumption of fish and seafood has increased, and now Koreans consume more fish and seafood than rice (Haps, 2022). As the consumption of fish and seafood by Koreans increases, interest in the safety of fish and seafood consumption is also increasing. Since the Fukushima nuclear accident in 2011, most consumers have shown high concerns about consumption of aquatic products, with a preference for domestic products and avoidance of imported ones from Japan (Ryu and Kim, 2017). To make the matter worse, at the time when the discharge of treated wastewater began in August 2023, Korean consumers became increasingly anxious about consuming fish and seafood. This led to panic buying of aquatic products and even campaigns to boycott fish and seafood consumption (Park, H., 2023). To calm these chaotic situations and ease consumer anxiety, local governments, particularly in coastal areas in South Korea created an organization dedicated to the discharge of treated wastewater from the Fukushima nuclear power plant in Japan and tried to come

up with countermeasures related to the discharge of treated wastewater more recently to establish safety production management measures for fish and seafood (Jung J., 2023). Despite these efforts, public anxiety about the discharge of treated wastewater from nuclear power plants has become serious with time. This suggests that at a time when discharging treated wastewater from nuclear power plants has already started, countermeasures are urgently needed considering consumer perceptions toward consuming fish and seafood. It may be more complicated than expected for consumers to consume fish and seafood given that the fish and seafood bought for home consumption and purchased at restaurants can be impacted. Additionally, consumer concerns could influence fish and seafood consumption at places such as Busan, Yeosu, and Jeju, which are famous for coastal tourism in South Korea and may be a challenge for the tourism and food service industries in those places. Therefore, for more sustainable consumption of aquatic products such as fish and seafood, it is necessary to find out what risk factors consumers perceive when purchasing fish and seafood, and which of these risk factors are perceived as the most significant.

Consumers perceive various risks according to the setting, which indicates that the risk consumers perceive may not be limited to physical problems and may be related to other aspects such as social, financial, and psychological characteristics (Siddique, 2012). For example, after the discharge of treated wastewater, consumers may perceive a substantial risk of harmful ingredients in fish and seafood or feel risk factors such as the financial burden of purchasing imported products. Moreover, past research has suggested that to understand thoroughly such risks, individuals' characteristics such as nationality, gender, and age should be further examined about those perceived risks (Lepp and Gibson, 2003). Therefore, this study attempted to examine whether there are differences in risks perceived when consuming fish and seafood depending on gender, age, and consumer place of residence to fully understand these risks in a Korean fish and seafood consumption setting.

According to Reisinger and Mavondo (2006), individuals not only perceive various risks but also respond to those risks differently. Consumers could take simplifying actions such as purchasing well-known brands or clarifying actions such as searching for information (An et al., 2023). As a strategy to reduce the risks toward fish and seafood consumption in this study, consumers could inquire about government safety inspection of fish and seafood items, search for information on them, or even stop consuming those products. Therefore, research that investigates the characteristics of consumers who directly consume fish and seafood is needed to reflect what consumers are most concerned about when consuming fish and seafood at a time when the discharge of treated wastewater just began. Also, what actions consumers will take in response to those risks, and whether they are willing to continuously consume fish and seafood is also a relevant consideration. It is difficult to foresee how the discharge of treated wastewater will affect both the fisheries and food industries (e.g., fisheries, food and beverage, tourism industry) since this treated wastewater release is a long-term event that differs from the temporary discharge caused by the previous accident in 2011.

Studies on perceived risks related to food have focused on different topics: food trucks (Yoon and Chung, 2018; Loh and Hassan, 2022), chicken and pork meat purchases (Yeung and Morris, 2001a; Nam et al., 2019), street foods (Seo and Lee, 2021), locally produced foods (Palau-Saumell et al., 2021), and modified foods (Klerck and Sweeney, 2007). Despite the importance of research on the risks perceived by consumers, research into the consumption of fish and seafood after the discharge of treated wastewater from nuclear power plants remains unexplored. The results of this study can be used as a basis for establishing appropriate countermeasures and efficient decision-making by policymakers. By investigating and analyzing risks perceived by consumers due to Japan's discharge of treated wastewater, this study helps to further understanding of consumer perceived risks and can be beneficial for the preparation of future risks related to the fisheries industry and can help enhance understanding of sustainable fish and seafood consumption preferences of consumers.

2 Literature review

2.1 Perceived risk

Bauer (1967) was the first to introduce the idea that consumption carries risks in the field of behavioral studies. This research noted that consumer behavior poses a risk, which means that every behavior a consumer completes has unpredictable and diverse consequences. Sometimes, these consequences can even be unpleasant. Since Bauer (1967) introduced the theory of perceived risk in academia, it has been widely used in different fields of study related to consumer choice such as marketing, tourism, restaurant services, and food sciences. Perceived risk is defined as consumers' perception of uncertainty about unfavorable and negative outcomes (Bauer, 1967). One of the most active areas of research on perceived risk in academia is tourism. In the tourism literature, different types of risk dimensions have been introduced. Roehl and Fesenmaier (1992) pioneered research into perceived risk and identified seven dimensions in their study. The dimensions were equipment, physical, satisfaction, financial, time, psychological, and social risks and these were identified from the viewpoint of leisure risks. Sönmez and Graefe (1998) identified three additional types of risk: health, political instability, and terrorism risks. The results of the study indicated that safety issues related to a destination are a strong predictor for tourists to avoid traveling to a destination. Various risk perception dimensions have since been identified by researchers in different settings. In a food tourism setting, An et al. (2023) identified three risk dimensions namely physical risk, communication risk, and food performance risk. In their study, physical risk includes infections or diseases coming from food consumption or health-related issues that respondents may experience when participating in food tourism. Communication risk is defined as a communication-related issue that respondents may experience when ordering food at a restaurant. Food performance risk was related to the concern that the food will not taste good or that the food order will not meet expectations when ordering food at a food tourism site.

The results indicated that all three dimensions of perceived risk were a strong predictor of three facets of the theory of planned behavior namely attitude, social norms, and perceived behavioral control. Even though there is sufficient empirical evidence that indicates individuals perceive risk in different ways depending on the circumstances, the subject of the perceived risk of consumers in fish and seafood consumption after treated wastewater is released remains in need of exploration.

2.2 Risk reduction behavior and consumption intention

Risk reduction behavior is referred to as actions that consumers can take to reduce their perceived risk (An et al., 2023). High risk perceptions among consumers often will result in actions being taken to decrease potential risks. Strategies that are employed will vary based on the acceptance of a perceived risk to the consumer (Dowling, 1986). In terms of food related risk reduction behavior, Yeung et al. (2010) proposed 17 risk reduction strategies to reduce risk of microbiological contamination in chicken meat such as buying popular brand products or the same brand from the same stores. Ha et al. (2021) examined Hanoi consumer's perceived food risk and their risk reduction strategies. The results indicated that consumers with very high-risk perception tend to seek information about food safety and purchase foods from supermarkets while consumers with low perceived food risk tend to supply their own food. More recently, An et al. (2023) examined tourists' perceived risk when considering travel to Jeju Island for food tourism. To reduce their perceived risk, respondents tended to search for information about food tourism in Jeju, choose a well-known restaurant, and learn the Korean language for a simple conversation as a risk reduction strategy. In this study, risk reduction strategy is defined as an effort of consumers to reduce levels of perceived risks on consumption of fish and seafood.

In general, behavioral intention is referred to as a consumer's expected or planned future action (Swan, 1981). Therefore, consumers' intentions regarding fish and seafood consumption will be a decisive factor in explaining consumers' acceptance of these products and will drive their consumption decisions (Loh and Hassan, 2022).

2.3 Hypotheses

2.3.1 Perceived risk and gender, age, and residence of consumers

Previous studies in various fields have studied whether respondents would perceive risks differently according to demographic characteristics. Each researcher drew slightly different results. However, higher risk perceptions have been identified among individuals who are older (Nino et al., 2021; Siegrist et al., 2022) and among females (Lepp and Gibson, 2003; Canally, 2004; Kim et al., 2009; Kovačić et al., 2020). Moreover, past studies (Kellens et al., 2011; O'Neill et al., 2016) have suggested that the closer individuals live to a hazard area, the higher the level of risk they perceive because they are more vulnerable to the risk or damage. Based on the findings of the previous studies mentioned above, three hypotheses were proposed:

H_1: Female respondents will perceive significantly higher risk across all dimensions of risk when consuming fish and seafood.

H_2: Older respondents will perceive significantly higher risk across all dimensions of risk when consuming fish and seafood.

H_3: Respondents living in areas close to Japan will perceive all risk factors significantly higher than those who do not.

2.3.2 Perceived risk and risk reduction behavior

Literature has confirmed that consumers' perceived risk is expected to influence consumers' behaviors (An et al., 2023). Bauer (1967) proposed that consumers tend to create strategies to lessen risk to mitigate possible negative situations when a potential risk that may produce bad outcomes emerges. The more the perception of risk is above a level of tolerance, then the more likely it is that a consumer will take action to decrease the identified risk. In fact, researchers have examined risk as an antecedent of risk reduction behavior (Ha et al., 2020; Seong et al., 2021). Yang et al. (2020) found that Chinese consumers who perceived higher risk tend to find food safety information through social media. Similarly, Ha et al. (2020) confirmed that consumers with higher food risk tend to show higher levels of intention to seek food safety information via the internet and participated more in supermarket purchases rather than self-supply of food. Based on the literature related to perceived risk dimensions and risk reduction strategies, five hypotheses were proposed. The hypotheses were proposed as follows:

H_4: will have a positive effect on risk reduction behavior.

H_5: Hygienic risk will have a positive effect on risk reduction behavior.

H_6: Environmental risk will have a positive effect on risk reduction behavior.

H_7: Value risk will have a positive effect on risk reduction behavior.

H_8: Socio-Psychological risk will have a positive effect on risk reduction behavior.

2.3.3 Risk reduction behavior and intention to consume fish and seafood

While many studies have been conducted in academia on the relationship between diverse antecedent variables and behavioral intentions, research on the relationship between risk reduction strategies and behavioral intentions, especially seafood consumption intentions have remained unexplored. Recently, Seong et al. (2021) examined the relationships of Hallyehaesang National Park Visitors' perception of risk for COVID-19, attitude, subjective norms, perceived behavioral control, coping behavior, and intention to visit. The study identified a significant relationship between coping behavior and intention. Respondents indicated that they would choose trails that were expected to have fewer visitors and minimize time spent where other visitors gathered on trails to reduce their risk of COVID-19. More recently, An et al. (2023) examined perceived risk in the context of food tourism. In their study, a significantly positive relationship was confirmed between risk reduction behavior and behavioral intention. It indicated that

more tourists intended to experience food tourism activities when strategies are devised to minimize the risk they perceive. Based on the findings of previous research, the following hypothesis were proposed:

H_9: Risk reduction behavior will have a positive effect on intention to consume fish and seafood.

3 Materials and methods

3.1 Sampling and data collection

The questionnaire originally was written in English and then was translated into Korean by a researcher fluent in both languages. Linguistic validation of the translated questionnaire was produced by graduate students and professors who were native Korean speakers. Based on the feedback received during this process, the questionnaire was revised, then pilot tested with 15 adults living in South Korea to check ease of response and suitability of questions in the survey questionnaire. The questionnaire was finalized after minor wording changes were made. Data collection proceeded thereafter to examine the proposed research model (see Figure 1).

The population examined for this study was Korean consumers residing in South Korea aged 18 and over. An online survey company named Dooit Survey was the main source used for data collection and respondents were panel members of the survey company. The survey questionnaire included informed consent information and respondents were provided information about the purpose of the research that was being conducted. The data was collected online for 1 week in September 2023, and 362 completed responses were collected. During the data screening process, 28 responses were removed due to incomplete questionnaires and the screening of outliers. Thus, the remaining 334 questionnaires were used for further analysis.

3.2 Construct measurement

All measurement items used in this research were drawn from prior studies given that previous researchers had examined measurement validity and reliability. The perceived risk of consuming fish and seafood among consumers was measured using 19 items drawn from previous studies (i.e., Stone and Grønhaug, 1993; Chang, 2011; Choi et al., 2013; Jung, 2019). The 10 items measuring risk reduction behavior were drawn from previous studies (Yeung and Morris, 2001b; Lee, 2012). Three items were drawn from past studies to measure consumers' intention regarding fish and seafood consumption (Seong et al., 2021). A five-point Likert scale was used to measure the items related to perceived risk, risk reduction behavior, and fish and seafood consumption intention (wherein 1 = strongly disagree and 5 = strongly agree). The questionnaire also included questions about demographic information of respondents and their general experiences with fish and seafood consumption (Lee, 2012).

3.3 Data analysis

It was confirmed that there was no missing data in the data set, which led to the check for outliers by examining Z-scores and Mahalanobis distance (Tabachnick et al., 2019). Firstly, exploratory factor analysis (EFA) was conducted to extract salient dimensions of perceived risk, risk reduction behavior, and fish and seafood consumption intention. Confirmatory factor analysis (CFA) was then performed to test reliability and validity of the measurement model. Use of SPSS 27 and AMOS 27 was employed to proceed with testing of the research hypotheses using *T*-test, ANOVA, and structural equation modeling (SEM).

4 Results

4.1 Profile of respondents

According to the results, a half of the respondents (51.5%) were female. The ages of the respondents showed a relatively even distribution. Among them, those in their 30s showed the highest rate with 27.8%, followed by those in their 40s with 26.9%. As for the education level of the respondents, most hold an undergraduate degree, and about half of the respondents (47.9%) were found to be office workers. Most respondents' monthly income was in the range of $30,000 to $40,000, and 51.2% of respondents were married. In terms of seafood consumption experience, about 47% of respondents consume fish and seafood four times per month, followed by those who consume fish and seafood once or twice per week (37% of respondents). Most of the respondents consume fish and seafood at home (70.1%), and most respondents (67.1%) check the origin of the fish and seafood when they consume it. Moreover, most respondents (94%) were found to be aware that treated wastewater had been released from Japan, and more than half of the respondents (60%) were found to live in inland areas of South Korea.

4.2 Exploratory factor analysis

EFA was performed with Varimax rotation to understand fundamental construct dimensions for the perceived risk, risk reduction behavior, and intention to consume fish and seafood variables. The Kaiser-Meyer Olkin (KMO) and Bartlett's test of sphericity were employed to examine the 19 items of the perceived risk variable (see Table 1) to determine EFA suitability. During the EFA analysis, two items (e.g., "I'm worried that the seafood I consume will be unsanitary," "Consuming fish and seafood is economically burdensome") were removed due to cross-loading. As a result, perceived risk was grouped by its five dimensions with the KMO value of 0.949 and Bartlett's $\chi^2 = 3{,}777.58$ (df=105, $p < 0.01$). Those five factors were labeled given the items with high loadings and the joint characteristics other items had in common enabled them to be grouped together. Thus, the first dimension having six items was named "biochemical risk" and the second dimension with two items was named "hygiene risk." The remaining three risks were named "environmental risk," "value risk," and "socio-psychological risk" and had three items, two items, and four items

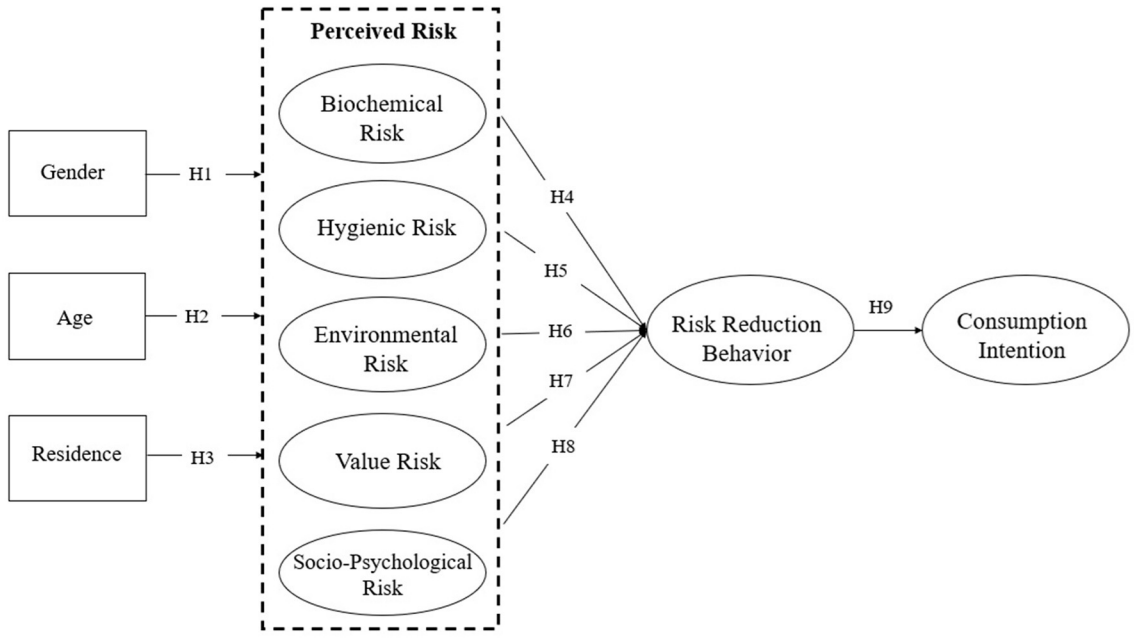

FIGURE 1
Proposed conceptual model.

respectively for each variable. Similarly, EFA was also conducted on all ten items used for risk reduction strategy, four items were removed (e.g., "reducing the consumption of domestic fish and seafood," "reducing the consumption of all imported fish and seafood," "Never consume fish and seafood") due to cross-loading issues found in the data.

The principal component analysis of risk reduction strategy extracted a single factor with an eigenvalue >1 (eigenvalue =4.96, total variance explained = 55.1). The KMO value was 0.895 and Bartlett's χ^2 = 1,324.11 (df=28, $p < 0.01$). For the intention to consume fish and seafood variable, only one factor was extracted by the factor analysis with an eigenvalue >1 (eigenvalue = 2.38, total variance explained = 79.38). The KMO value was 0.714 and Bartlett's χ^2 = 515.46 (df=3, $p < 0.01$). In this research, all 26 items used to measure dimensions of perceived risk, risk reduction strategy, and intention to consume fish and seafood were cataloged by high factor loading values which ranged from 0.683 to 0.927 (>0.50). Moreover, Cronbach alpha coefficients for each factor exceed the cut-off value of 0.7.

4.3 Confirmatory factor analysis

CFA was conducted as a follow up analysis to verify the factorial validity and reliability of the measurement constructs. Table 2 shows the results of CFA and indicates retained factor loadings for all items (ranging from 0.64 to 0.92) that were significant at the $p < 0.001$ level. Values for composite reliability (CR) were in the 0.86 to 0.93 range, and the values for average variance extracted (AVE) ranged from 0.53 to 0.65, exceeding the suggested analytical values of 0.70 for CR and 0.50 for AVE (Fornell and Larcker, 1981). Discriminant validity was acceptable as the square root of the AVEs were greater than the correlations as can be viewed in Table 3 (Hair et al., 2019). The results of CFA showed acceptable model fit: $\chi^2(254) = 700.91$, $p < 0.05$, CFI = 0.93, NFI = 0.91, GFI = 0.90, IFI = 0.93, TLI= 0.91 and RMR = 0.05.

4.4 Testing of hypotheses

4.4.1 Differences between gender and dimensions of perceived risk

An independent sample *T*-test was employed to test perceived risk when consuming fish and seafood after the release of treated wastewater. This test was employed to see if there were differences according to gender in the sample.

According to the results shown in Table 4, females perceived higher risk in all five dimensions of risk compared with males which was statistically significant. Male respondents showed lower levels of perceived risk in consuming fish and seafood compared with female respondents overall, and among the dimensions tested, they perceived value risk the highest and hygienic risk was perceived the lowest by males. Among the five perceived risk dimensions, females perceived biochemical risk the highest, while social-psychological risk was shown to be the lowest. Given this difference between the groups tested, Hypothesis 1 was supported.

4.4.2 Differences between age and dimensions of perceived risk

To examine if respondents with different age groups perceive risk differently, a One-way ANOVA analysis was performed. Results in Table 5 showed that respondents in their 30 s perceived

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TABLE 1 Exploratory factor analysis results.

Variables and items	Factor loading	Eigen value	Variance explained	Cron Bach's α
Biochemical risk				
Potential health problems	0.927			
May get sick	0.915			
Seafood poisoning	0.895	4.74	79.06%	0.947
Worry about long-term risk	0.893			
Exposure to radiation after eating fish and seafood	0.854			
Consuming fish and seafood is not safe	0.849			
Hygiene risk				
May not be fresh	0.904	2.18	72.57%	0.808
Improper storage	0.894			
Environmental risk				
Excessive use of disposables	0.882			
Food waste contamination	0.862	2.23	74.39%	0.828
Water/sewage contamination	0.844			
Value risk				
May not be a good value	0.905			
May not be affordable price	0.881	1.17	67.20%	0.765
Socio-psychological risk				
… Think negatively about consuming fish and seafood	0.845			
… Worried about radioactive	0.817			
… Affect the opinions of people around me	0.782	2.51	62.79%	0.801
Feel psychologically uncomfortable	0.720			
KMO = 0.949, Bartlett $\chi 2$= 3777.58 (df=105, $p < 0.01$)				
Risk reduction behavior				
To check a quality mark	0.807			
To check radiation tested...	0.787			
To find more information about fish and seafood	0.786	4.96	55.10 %	0.890
To check origin of fish and seafood	0.785			
Reduce the consumption of Japanese products	0.753			
Take the advice of my family or friends	0.700			
KMO = 0.895, Bartlett $\chi 2$= 1324.11 (df=28, $p < 0.01$)				
Intention to consume				
Try to consume fish and seafood in the future	0.923			
Recommend consuming fish and seafood to others	0.879	2.38	79.38	0.870
Continue consuming fish and seafood	0.871			
KMO = 0.714, Bartlett $\chi^2 = 515.46$ (df = 3, $p < 0.01$)				

biochemical risk the highest, and those in their 60 s and above perceived biochemical the lowest. In terms of hygienic risk, it was found that those in their 20 s and 30 s perceived hygiene risk relatively high, and those in their 60 s and above perceived that risk the lowest. In addition, respondents in their 50 s perceived value risk the highest and those in their 20 s perceived it the lowest. Lastly, it was found that respondents in their 20 s, 30 s, and 40 s perceived socio-psychological risk relatively high. When looking at the mean value in the results, it was found that there were differences in perceived risk dimensions according to the respondents' age.

TABLE 2 Confirmatory factor analysis.

Factors and Items	Standardized loading	S.E.	Skew.	Kurt.	C.R.
Biochemical risk (CR = 0.86, AVE = 0.56)					
Potential health problems	0.89	N/A	−0.771	0.112	N/A
May get sick	0.92	0.03	−0.657	−0195	26.79
Seafood poisoning	0.87	0.04	−0.873	0.251	23.10
Worry about long-term risk	0.81	0.05	−0.516	−0.456	20.26
Exposure to radiation after eating fish and seafood	0.88	0.04	−0.861	−0.041	24.10
Consuming fish and seafood is not safe	0.83	0.04	−0.394	−0.466	20.88
Hygiene risk (CR = 0.90, AVE = 0.53)					
May not be fresh	0.83	N/A	−0.481	−0.341	N/A
Improper storage	0.92	0.05	−0.700	0.051	18.89
Environmental risk (CR = 0.90, AVE = 0.53)					
Excessive use of disposables	0.76	N/A	−0.379	−0.048	N/A
Food waste contamination	0.72	0.06	−0.462	0.107	12.93
Water/sewage contamination	0.87	0.07	−0.557	0.265	14.77
Value risk (CR = 0.90, AVE = 0.53)					
May not be a good value	0.71	N/A	−0.437	0.215	N/A
May not be affordable price	0.72	0.09	−0.998	1.492	9.95
Socio-psychological risk (CR = 0.93, AVE = 0.65)					
…Think negatively about consuming fish and seafood	0.69	N/A	−0.237	−0.527	N/A
…Worried about radioactive fish and seafood	0.68	0.07	−1.173	1.662	10.95
…Affect the opinions of people around me	0.64	0.09	−0.281	−0.374	13.55
Feel psychologically uncomfortable	0.83	0.08	−0.450	−0.660	10.88
Risk reduction behavior (CR = 0.93, AVE = 0.65)					
Reduce the consumption of Japanese products	0.81	N/A	−0.583	0.183	N/A
Take the advice of my family or friends	0.75	0.05	−1.195	1.239	15.15
To find more information about fish and seafood	0.91	0.07	−1.117	1.401	17.82
To check radiation tested ...	0.78	0.06	−0.396	0.025	15.57
To check origin of fish and seafood	0.74	0.06	−0.448	−0.289	14.61
To check a quality mark	0.75	0.07	−1.146	0.612	14.42
Consumption intention (CR = 0.87, AVE = 0.62)					
Try to consume fish and seafood in the future	0.81	N/A	0.214	−0.284	N/A
Recommend consuming fish and seafood to others	0.79	0.06	−0.122	−0.546	15.45
Continue consuming fish and seafood	0.91	0.07	0.075	−0.578	17.82
Goodness-of-fit statistics: $\chi^2 = 700.91$; $df = 254$; $\chi^2/df = 2.75$; $p < 0.001$; CFI = 0.93, GFI = 0.90, TLI = 0.91, IFI = 0.93, RMR = 0.05					

$p < 0.001$. N/A. In AMOS, one loading, the first item of each construct had to be fixed to 1, thus the C.R. and S.E. could not be calculated for that item.

However, this finding was not statistically significant at the $p < 0.05$ level. Therefore, Hypothesis 2 was not supported.

4.4.3 Differences between residence and dimensions of perceived risk

To examine if respondents with different places of residence perceive risk differently, a one-way ANOVA analysis was performed. According to the results in Table 6, respondents living in Jeju Island (the geographical area closest to Japan among survey respondents), perceptions of both biochemical and hygiene risk were the highest. In terms of environmental risk, respondents living in Gyeongsang-do perceived the highest level of environmental risk among respondents. Respondents living in Seoul tended to perceive higher risk of value than respondents living in other regions, whereas respondents living in Chungcheong-do perceived

TABLE 3 Validity assessment criteria and inter-factor correlations.

Measures	BR	HR	ER	VR	SPR	RRB	IC
BR	**0.75**						
HR	0.72	**0.77**					
ER	0.59	0.58	**0.62**				
VR	0.61	0.53	0.58	**0.51**			
SPR	0.68	0.76	0.59	0.44	**0.50**		
RRB	0.71	0.60	0.52	0.42	0.44	**0.59**	
IC	0.59	0.43	0.17	0.27	0.32	0.43	**0.70**

1. The bold diagonal elements are the square root of the AVE.
2. Off-diagonal elements are the inter-factor correlations.
3. BR, biochemical risk; HR, hygiene risk; ER, environment risk; VR, value risk; SPR, Socio-psychological risk; RRB, risk reduction behavior; IC, intention to consume fish and seafood.

TABLE 4 Gender and perceived risk T-test results.

Dimensions	Mean		SD		t	*p*
	Male	Female	Male	Female		
Biochemical risk	3.384	3.971	1.080	0.776	5.755	0.000***
Hygiene risk	3.188	3.882	1.050	0.793	6.864	0.000***
Environmental risk	3.482	3.791	0.844	0.736	3.592	0.000***
Value risk	3.681	3.966	0.823	0.649	3.403	0.001**
Socio-psychological risk	3.411	3.750	0.879	0.723	3.876	0.000***

*p<0.05; ** p<0.01; *** p<0.001.

the highest levels of social-psychological risk. According to the analysis results, the risk dimensions perceived by respondents did show differences depending on the region that respondents resided in. However, these differences were not statistically significant at the $p < 0.05$ level. Therefore, Hypothesis 3 was not supported.

4.4.4 Structural model testing

SEM was performed to test the research hypotheses concerning the perceived risk dimensions and risk reduction behavior. The model revealed strong model fit overall: $\chi^2 = 614.18$; $df = 268$; $p < 0.001$; CFI = 0.95, GFI = 0.90, IFI = 0.95, TLI = 0.93, NFI=0.91, RMR = 0.05. Results from testing the structural model showed that biochemical risk had a positive effect on risk reduction strategy ($\beta = 0.36$, $t = 3.12$), whereas hygiene risk had no effect on risk reduction strategy ($\beta = -0.06$, $t = -0.79$). Both environmental risk and value risk had a positive effect on risk reduction strategy ($\beta = 0.15$, $t = 2.19$) ($\beta = 0.24$, $t = 2.84$). Moreover, socio-psychological risk had a positive effect on risk reduction strategy ($\beta = 0.27$, $t = 1.99$). Regarding the relationships between risk reduction strategy and intention to consume seafood, a positive relationship was confirmed ($\beta = 0.52$, $t = 8.29$). Thus, except Hypothesis 5, all hypotheses were supported. Table 7 below shows the measured effects of all structural relationships.

5 Discussion

The purpose of this study was to identify the risk factors perceived by Korean consumers when consuming fish and seafood and what kind of efforts are taken to reduce these risk factors. In addition, the study examined whether there are differences in perceived risk factors depending on demographic information such as gender, age, and residential area of consumers.

The results showed that female respondents perceived a higher level of risk for all perceived risk dimensions when compared with their male counterparts (biochemical risk was perceived the highest), which was consistent with previous studies (Lepp and Gibson, 2003; Canally, 2004; Kim et al., 2009; Kellens et al., 2011; Kovačić et al., 2020). Those previous studies have found that the perceived risk by females when traveling to a specific place or in certain situations is higher (e.g., flood risk). Combining the results of previous studies with this one, it can be concluded that females have a higher perception of risk, regardless of location and situation, compared to males. However, current study, no significant differences were found between age, residence, and perceived risk. These results differ from previous studies that showed that consumers who are older (Nino et al., 2021; Siegrist et al., 2022) and live close to the hazard area (Kellens et al., 2011; O'Neill et al., 2016) tend to perceive higher risk levels. Kellens et al. (2011) examined the public perception of coastal flood risks on the Belgian coast. The authors concluded that respondents who live in Ostend, where the flood risk is high, tended to perceive a higher risk than those from Knokke-Heist and De Panne, where the flood risk is low. This finding is consistent with a study conducted by O'Neill et al. (2016), which examined the public perception of flood risks in Bray, Ireland. The difference between the current study and previous ones may be attributed to the different characteristics of the perceived risk objects. Previous studies measured people's perceived risk to flooding, whereas this

TABLE 5 Age and perceived risk One-way ANOVA test results.

Dimensions	Residence	Mean	SD	F	*p*
Biochemical risk	20 s	3.639	0.923	0.351	0.844
	30 s	3.760	0.932		
	40 s	3.715	1.008		
	50 s	3.642	1.072		
	Over 60	3.536	1.037		
Hygiene risk	20 s	3.567	1.003	0.158	0.959
	30 s	3.565	0.984		
	40 s	3.594	0.971		
	50 s	3.492	1.025		
	Over 60	3.457	0.976		
Environmental risk	20 s	3.572	0.842	0.981	0.418
	30 s	3.674	0.801		
	40 s	3.637	0.808		
	50 s	3.760	0.765		
	Over 60	3.406	0.810		
Value risk	20 s	3.769	0.745	0.423	0.792
	30 s	3.844	0.748		
	40 s	3.811	0.766		
	50 s	3.934	0.733		
	Over 60	3.826	0.792		
Socio-psychological risk	20 s	3.616	0.740	0.428	0.788
	30 s	3.613	0.772		
	40 s	3.617	0.887		
	50 s	3.533	0.852		
	Over 60	3.402	0.909		

$p < 0.05$.

study measured consumers' perceived risk when consuming fish and seafood. Therefore, it is necessary to delve more deeply into the distinct characteristics of flood-prone areas and fish and seafood. To be more specific there are various types of fish and seafood (e.g., shrimp, clams, crabs, fish, etc.), and these products are not only eaten by a certain age group but are consumed frequently across all age groups. This may explain why there was no significant difference in perceived risk by age group in this study. Although it is worth noting that respondents living in Gyeongsang-do and Jeju-do, which are geographically closest to Japan (where treated wastewater from nuclear power plants began to be discharged), did have the highest levels of concern pertaining to biochemical and hygiene risks. After the discharge of contaminated water, 78% of Koreans express concerns about the contamination of marine products, with 60% stating reluctance to consume them due to fears of radiation exposure and potential harm to the human body from harmful substances. Given this scenario, the perceived biochemical risk among consumers following the discharge of contaminated water is high, necessitating the implementation of countermeasures (Jung D., 2023). However, there was no statistical difference between regions, and the reason is thought to be related to the characteristics of the distribution process of fish and seafood. Domestic fish and seafood, whether caught in coastal areas or imported, are not usually consumed in one specific place but are distributed throughout the entire country of South Korea. Therefore, the lack of a statistically significant difference in perceptions of risk related to fish and seafood consumption based on area of residence can be interpreted in terms of seafood distribution.

The current research also confirmed a positive relationship between biochemical risk and risk reduction behaviors. This suggests that consumers who perceive greater biochemical risks, such as infection and radiation exposure when consuming fish and seafood, are more likely to seek reassurance through measures such as checking for radioactive testing and seeking additional information about the fish and seafood they intend to consume. These results are in line with previous studies (Ha et al., 2020; Yang et al., 2020). However, no significant relationship was found between hygiene risk and risk reduction behavior. Hygiene-related risks, such as freshness and deterioration of fish and seafood

TABLE 6 Residence and perceived risk One-way ANOVA test results.

Dimensions	Residence	Mean	SD	F	*p*
Biochemical risk	Seoul	3.757	1.062	1.613	0.143
	Gyeonggi-do	3.646	0.949		
	Gangwon-do	3.815	0.910		
	Chuncheong-do	3.739	1.017		
	Gyeongsang-do	3.816	0.863		
	Jeolla-do	3.226	1.086		
	Jeju-do	4.167	0.577		
Hygiene risk	Seoul	3.541	1.018	0.487	0.818
	Gyeonggi-do	3.576	0.897		
	Gangwon-do	3.500	0.829		
	Chungcheong-do	3.571	0.965		
	Gyeongsang-do	3.615	1.048		
	Jeolla-do	3.307	1.152		
	Jeju-do	4.000	0.866		
Environmental risk	Seoul	3.658	0.814	0.312	0.931
	Gyeonggi-do	3.633	0.749		
	Gangwon-do	3.592	0.894		
	Chuncheong-do	3.666	0.989		
	Gyeongsang-do	3.720	0.373		
	Jeolla-do	3.483	1.021		
	Jeju-do	3.444	0.384		
Value risk	Seoul	3.894	0.736	0.666	0.677
	Gyeonggi-do	3.842	0.722		
	Gangwon-do	3.555	1.013		
	Chungcheong-do	3.786	0.751		
	Gyeongsang-do	3.886	0.704		
	Jeolla-do	3.661	0.934		
	Jeju-do	3.666	0.288		
Socio-psychological risk	Seoul	3.580	0.825	0.821	0.554
	Gyeonggi-do	3.550	0.786		
	Gangwon-do	3.694	0.890		
	Chungcheong-do	3.738	0.976		
	Gyeongsang-do	3.693	0.770		
	Jeolla-do	3.355	0.932		
	Jeju-do	3.585	0.520		

$p < 0.05$.

consumed by consumers, are beyond consumers' ability to manage or control. Consumers often find it difficult to determine the freshness of the fish and seafood they are consuming because it has already been packaged or cooked for consumption. When consuming fish and seafood, consumers have very limited control over the freshness and sanitary conditions of the food. This may explain why there was no difference between hygiene risk and risk reduction behavior.

As hypothesized environmental risk was found to influence risk reduction behavior positively, confirming the same finding from prior research (Meijnders et al., 2001; De Dominicis et al., 2015). De Dominicis et al. (2015) selected flooding, an environmental risk, to examine the relationship between flood risk perception and coping behaviors among inhabitants exposed to low and high flood risk areas, such as Rome and Vibo Valentia in Italy. They confirmed that individuals who perceived higher environmental risk tended

TABLE 7 Standardized parameter estimates for the structural model.

Hypothesized path	Standardized estimates	T	R^2	Test result
H_3: BR → RRB	0.358	3.121**	0.465	Yes
H_4: HR → RRB	−0.059	−0.787	0.326	No
H_5: ER → RRB	0.147	2.190*	0.308	Yes
H_6: VR → RRB	0.238	2.842**	0.316	Yes
H_7: SPR → RRB	0.268	1.992*	0.433	Yes
H_8: RRB → IC	0.517	8.285***	0.142	Yes

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
BR, biochemical risk; HR, hygiene risk; ER, environment risk; VR, value risk; SPR, Socio-psychological risk; RRB, risk reduction behavior; IC, intention to consume fish and seafood.

to engage in more preventive behaviors, such as seeking flood risk information, storing useful items, or avoiding risky behaviors. This finding aligns with our own, as consumers tend to make active efforts to mitigate environmental risks or fears by seeking more information about fish and seafood or checking for quality marks and origins of these products. When consumers have value related concerns, such as whether they consume fish and seafood at an appropriate price, they take actions to reduce the risk by asking for advice from family or friends around them or they may seek more information about the price or value of fish and seafood. With the development of technology, consumers can easily compare the prices of products they want to buy on their mobile phones or computers, and in this process, they tend to buy from relatively cheap sellers or find more information online. This finding is supported by prior research (Fuchs and Reichel, 2007).

A significant positive relationship was confirmed between social-psychological risk and risk reduction strategy. Among the respondents in this study, those who perceived that people around them would think negatively about fish and seafood consumption constituted the largest group. Thus, in order to be less influenced by others or to convince them otherwise, respondents actively engaged in risk reduction behaviors. These behaviors included seeking more information about fish and seafood, checking if products have been tested for radiation, or checking the origin of the products. Moreover, the respondents revealed that they also seek advice from family or friends to reduce their social-psychological risk. This finding is in line with a previous study that indicated that among perceived risk factors, social-psychological factors appear to be more important than others, and to reduce these risks, consumers buy reliable brands or seek advice from people around them (Kim et al., 2009). Results from this study demonstrated a strong and positive relationship between risk reduction strategy and intention to consume fish and seafood. This implies that as consumers take various actions to reduce perceived risk factors, their intention to consume fish and seafood increases. Such finds are supported by previous studies (Yeung et al., 2010; Seong et al., 2021). Yeung et al. (2010) examined the effect of perceived risk on risk-reducing strategies and purchase likelihood in the context of microbiological risk in chicken meat. In the study, respondents engaged in behaviors such as choosing a well-known brand and selecting qualified products to mitigate the risks. It was also found that such risk reduction behaviors increased the likelihood of purchasing chicken meat. Similarly, Seong et al. (2021) also confirmed a strong positive relationship between coping behavior and visiting intention. It was found that during the COVID-19 pandemic, visitors engaged in behaviors such as choosing trails with fewer visitors, minimizing the time spent where other visitors gathered on trails, or complying with COVID-19 rules to reduce perceived risks when visiting a national park. The study also confirmed that such coping behaviors played significant roles in increasing visitors' intention to visit a national park.

6 Conclusion

6.1 Theoretical implications

Firstly, the identification of perceived risk in consuming fish and seafood is one of the notable contributions of this study. Since treated wastewater has been discharged, concerns and fears related to fish and seafood consumption by consumers have been increasingly reported throughout the news media (Jung J., 2023; Park, Y., 2023). Given this situation, this study attempted to examine what risk factors consumers perceived when consuming fish and seafood. Additionally, this study confirmed biochemical risk to be the most significant risk factor. This variable measured not only the general health problems that consumers may experience when consuming fish and seafood but also included concerns related to radiation exposure, a type of perceived risk not traditionally measured in the literature. Secondly, this study attempted to examine what actions consumers take to reduce the risk factors perceived when consuming fish and seafood after the discharge of treated wastewater. Interestingly, despite high consumer concerns about the release of treated wastewater and its potential impact on consumers' wellbeing, this has not resulted in a widespread boycott of fish and seafood in South Korea. This emphasizes the need to find ways to ensure that consumers can consume fish and seafood more sustainably (Yun and Kim, 2022).

Lastly, past research suggested that to understand the perceived risks in more detail, demographic characteristics of respondents should also be considered (Lepp and Gibson, 2003). Therefore, in this study, in order to understand the risk factors perceived by Korean consumers in more details, this study tried to examine whether there is a difference in the risk factors perceived by consumers when consuming fish and seafood according to the demographic characteristics of respondents (i.e., gender, age and location of residence).

6.2 Practical implications

6.2.1 Policymakers

Firstly, the results of this study showed that consumers perceive biochemical risk the highest (i.e., infection, radiation exposure, and safety concerns) when consuming fish and seafood and make efforts to reduce it. Therefore, local governments should conduct a thorough radioactivity test on seawater as well as all aquatic products (both domestic and imported) distributed to all regions of the country, and the results should be transparently disclosed to consumers. It could be proposed to select two or more fish markets in each region at the municipal and provincial level, purchase highly consumed fish species, and create a system that conducts radioactivity tests regularly at the Institute of Health and Environment in each province and disclose the results. For consumers to conveniently see the radiation test results for fish and seafood, local governments could also build a mobile app to share the efforts of local governments in relation to the discharge of treated wastewater and proactively share the results of inspections on seafood.

Secondly, in Korea, it is mandatory to mark the place of origin on all products, including marine products. Governments also conduct special inspections to monitor the origin of marine products. However, illegal activities are being committed by fish and seafood vendors, such as deliberately not marking the place of origin of marine products in violation of the law or falsely presenting Japanese products as domestic ones. To eradicate such practices, the government should formulate policies to impose stronger penalties for illegal acts, enabling consumers to avoid confusion regarding the origin of marine products when consuming them. In the current situation of expanding exports of Japanese seafood to Korea after the discharge of contaminated water from nuclear power plants (Park, H., 2023), the Korean government requires stricter and strengthened policies for confirming and punishing information falsely indicating the origin of seafood products.

6.2.2 Practitioners

Firstly, according to the results of this study, consumers are concerned about environmental pollution caused by various wastes generated when consuming fish and seafood. Unlike in the past, Korean consumers these days are increasingly conscious of the impact of their purchases on society and the environment. With serious environmental pollution problems emerging around the world, zero-waste has become an important trend in recent years. As more consumers pursue eco-friendly value consumption, companies are also increasing eco-friendly packaging that can practice zero-waste. For example, the Ministry of Environment of South Korea has presented numerous ways to reduce agricultural packaging waste by presenting "agricultural packaging guidelines" to revitalize eco-friendly packaging in the process of producing and distributing agricultural products. Applying this movement to fish and seafood packaging requires simultaneous efforts from both consumers and retailers to minimize environmental pollution by reducing plastic or unnecessary packaging materials and to ensure sustainable fish and seafood consumption.

Secondly, it is necessary to focus on policies that support the establishment of sanitation facilities in the production market, which is the first step in the distribution of fishery products to alleviate consumers' perceived hygiene risk. Additionally, providing a grade mark indicating the freshness of fish and seafood products will be helpful in lowering the hygiene risk for consumers.

Thirdly, practitioners in the fish and seafood industry should provide consumers with detailed and correct information such as the country of origin, production, and distribution history to ensure hygiene and safety throughout the distribution process. Information such as the indication of the country of origin is systematically stipulated to be provided, but for a long time, merchants have not hesitated to violate the law by failing to indicate the country of origin or providing false information. For a business model more sustainable than the pursuit of immediate profits, constant efforts should be made to provide accurate information to consumers through merchants' associations and seafood wholesalers' and retailers' unions.

6.3 Study limitations and future research

As all studies do, this study also had limitations. Firstly, in terms of methodology, this study employed online survey data collection. Therefore, responses were collected from consumers living in all regions of South Korea. However, the opinions of those who were not internet users or registered to participate in an online panel study were excluded. In addition, the sample of this study was Koreans residing in South Korea. Foreigners residing in South Korea or those living in other countries may have different risk factors perceived when purchasing fish and seafood in connection with the discharge of treated wastewater from nuclear power plants. Therefore, care should be taken when generalizing the results of this study. Since the discharge of treated wastewater is a long-term event, it is necessary to measure and examine the risk factors perceived by consumers when consuming fish and seafood at certain time periods in future studies. Lastly, it is meaningful to examine cultural differences to see if there is a difference between Koreans and other nationalities (both within South Korea and in other countries) pertaining to the risk factors perceived by consumers when consuming fish and seafood.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by Institutional Review Board of Pukyong National University (1041386-202309-HR-100-02). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required from the participants or the participants' legal guardians/next of kin because The data

was collected through online survey company. Only participants who agreed to the survey took the survey. Written informed consent was not obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article because This study collected data through an online survey. Prior to initiating the survey, the participants were informed about the study's purpose, and only those who agreed to participate responded.

Author contributions

SA: Conceptualization, Data curation, Formal analysis, Methodology, Software, Writing – original draft. TE: Resources, Validation, Visualization, Writing – review & editing. JC: Funding acquisition, Investigation, Project administration, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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