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Information interventions and health promotion behavior: evidence from China after cadmium rice events

RESEARCH ARTICLE

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Abstract

Based on the panel data of 777 consumers before and after the information intervention, this paper explores the effectiveness of information intervention methods that enable consumers to adopt health promotion behavior. Using the intervention methods of real testing-information, general news information, and integrated information, a difference-in-difference method is used to conduct an empirical research on the rice consumption behavior of Chinese residents. It is evident from the analysis that the three information interventions do not change the quantity of rice consumed by Chinese residents, consumers only can reduce risks by avoiding purchasing rice from where cadmium rice incidents have occurred frequently. Results of regression analysis indicate that the effect of the integrated information intervention is more effective. Consumers' responses to information interventions are highly heterogeneous, and the effects of interventions are mainly reflected in consumers with a high degree of risk for eating cadmium rice. The value of this paper is that it not only fills the research gap in the literature on the impact of food testing information on consumer behavior, but also supplements the research on consumer behavior after the food safety crisis related to staple foodstuffs.

Keywords: information interventions, food safety, consumer behavior, health promotion, China
JEL code: C23, D12, I12

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1. Introduction

Due to the rapid growth in industries and agriculture, many countries have experienced the problem of heavy metal pollution of arable land in history, and heavy metal pollution has posed a serious threat to the environment and food security (Sarwar *et al.*, 2017). Heavy metal elements are bio-toxic and endanger human health when they enter the human body through diet (Wu *et al.*, 2021). In the mid-twentieth century, Japan observed an incident in epidemiological surveillance they refer to as 'Itai-itai disease' caused by eating rice that is grown in soil with a high cadmium content (Nogawa *et al.*, 2004). In Thailand, rice pollution caused by the increase of cadmium and zinc content in the soil also posed a public health hazard (Simmons *et al.*, 2005). Since the start of China's reform and opening-up policy, which began in 1978 and was co-current with the growth of industry, mining, and the rapid expansion of cities in China, the problem of heavy metal pollution in China's arable land has become increasingly serious. According to the national communique of the soil pollution survey by the Ministry of Environmental Protection of China and the Ministry of Land and Resources in 2014, the total over-standard rate of soil in China was 16.1%. Soil pollution is high in some regions, with heavy metals being the main pollutants, and the quality of cultivated land soil was particularly worrisome (MEP, 2014).

Cadmium is a heavy metal with the highest concentration in Chinese soil (Yang *et al.*, 2018). A large number of studies have shown that excessive cadmium in the human diet can seriously damage health. Cadmium poisoning not only causes damage to human bones and kidneys, but also causes reproductive system disorders and respiratory diseases (e.g. pneumonia), and even causes teratogenesis and cancer (Godt *et al.*, 2006; Waalkes *et al.*, 1988). Rice is one of the staple foods loved by the Chinese people. However, rice is a typical cadmium-affected crop. Rice with excessive cadmium has become the main source of cadmium intake for Chinese residents (Song *et al.*, 2017). Given the dual challenges of ensuring enough quantity of food and the quality of food, the practical solution of what to do with cadmium content that exceeds the standard becomes increasingly complicated.

The cadmium rice incidents have aroused widespread public attention in China, and the Chinese government has attached great importance to monitoring and solving the problem of this pollution. On May 16, 2013, the Guangzhou Municipal Food and Drug Administration announced on its official website that sampling inspection results of the first quarter of that year revealed that the percentage of cadmium content of rice and rice-products exceeded the standard rate are 44.4%. Most of this contaminated rice was produced in Hunan province. Responding to this issue, the Food and Agriculture Department of Hunan Province sealed and processed the contaminated rice, and then strengthened the monitoring. Later, the Hunan provincial government launched a pilot project predicated on 'VIP'[1] technology restoration for heavy metal-contaminated arable land to reduce cadmium content in rice that is grown there. In November 2017, rice with excessive cadmium content was uncovered in Jiujiang City, Jiangxi Province. Following this, in 2018 China issued the 'law of the People's Republic of China on the prevention and control of soil pollution', which initiated the safe use of agricultural land plan that ensured the safety of agricultural products. Although the Chinese government has made significant efforts to eliminate cadmium pollution, cadmium rice incidents still occur. For example, in April 2020, a batch of substandard rice noodles was found during a sampling inspection in Xiongxian County, Zhaotong City, Yunnan Province. After tracing the source, 99.42 tons of rice contaminated with cadmium were also found in the local market. Therefore, the solution to the problem of cadmium rice cannot solely rely on government supervision and legal regulation, policymakers must give play to the self-regulatory power of the market, and through consumer purchase behavior to encourage producers to reduce the production of cadmium rice.

Rational consumer behavior is the driving force to resolve food safety issues. The rational consumption behavior of consumers is the most direct and effective check and balance for food companies, and it is a reasonable supplement to government supervision. Information plays a significant role in consumers'

[1] 'V' refers to biological measures such as 'variety'; 'I' refers to agricultural measures such as 'irrigation'; and 'P' refers to adjustment of 'PH value'.

decision-making process (Tu *et al.*, 2020). However, consumers often have incomplete information and limited information processing-capacities (Böcker and Hanf, 2000), which causes consumers to make unreasonable choices (Verbeke *et al.*, 2007). Consequently, providing an information intervention is hypothesized to be able to reduce information asymmetry and thus affect consumer decision-making (Nemati and Penn, 2020). Consumers mainly obtain food safety information from the media (Liu *et al.*, 1998), but Bakir (2005) points out that when individuals rely on the media to obtain information, it is common that over-amplify risks. Testing information can enable consumers to know their real consumption risks.

This paper designed three information intervention methods: (1) a rice testing information intervention; (2) a general news information intervention; and (3) an integrated information (testing information and general information) intervention. Based on the survey data before and after the information intervention, the changes in rice consumption quantity and consumption structure of consumers after cadmium rice incidents were analyzed. The contribution of this paper includes the following three aspects: first, this paper is the first time that rice-testing information is provided to consumers in order to evaluate the impact of testing information on their consumer behavior and make up for the lack of knowledge on the part of consumers for their risks; second, this paper explores the health promotion behavior adopted by consumers after an information intervention is implemented once a cadmium rice incident occurs, filling the research gap on consumer behavior after a staple food has safety issues; third, this paper analyzes the differential response of various risk correlations and types of consumers after information interventions are implemented, and the results show that consumers' responses to information interventions are heterogeneous.

The remainder of this article is organized as follows. Section 2 is the literature review. Section 3 is the research design, introducing the information intervention process, constructing a difference-in-difference model to analyze the changes in consumer behavior, and describes the data. Empirical results are presented and analyzed in Section 4. Section 5 concludes this article and provides several policy implications.

2. Literature review

Information asymmetry is a common cause of food safety problems and the failure of the safe-food market. For this reason, various governments attribute significant importance to reducing information asymmetry to guide consumers to purchase safe food effectively. Food safety information is important for consumers' food purchasing decisions and behaviors, and the absence of full or unbiased information makes consumers overestimate or underestimate food safety risks (Rudisill *et al.*, 2012), which leads to 'irrational behavior' that causes unsafe consumption. To prevent consumers from falling into panic after food safety incidents, and to urge the government to adopt correct information communication strategies, scholars have conducted extensive studies on the impact of food incidents and information intervention on consumer behavior.

2.1 The impact of food safety incidents on consumer behavior

Researchers have carried out a series of studies on consumer behavior changes after the presence of a food safety crisis related to meat and vegetables. Several studies have shown that most consumers are risk-avert (Gordon, 2010; Turvey *et al.*, 2010; Yeung and Morris, 2001). When a food safety incident occurs, consumers will alleviate perceived risk by changing their consumption behaviors, and by adopting defensive or health-promotive strategies: first, by reducing the purchase of the offending products and then by increasing their consumption of substitutes. Burton and Young (1996) discovered that mad cow disease caused British consumers to reduce their beef consumption and increase their consumption of poultry and pork. After the avian flu broke out in Egypt, the demand for chicken was reduced substantially, which generated a price reduction (Hassouneh *et al.*, 2012). Similarly, after spinach was contaminated by *Escherichia coli* O157:H7 in 2006, American consumers' expenditures on spinach declined, and consumers turned to other green leafy vegetables as alternatives (Arnade *et al.*, 2009); second, consumers also changed their preference of origin and purchase-channels of products. Lim *et al.* (2013) discovered that American consumers preferred to consume domestic beef rather than imported beef to reduce the risks associated with eating beef. Indrawan

et al. (2018) found that consumers' purchase behavior and poultry market channels-choices were altered due to the outbreak of highly pathogenic avian influenza.

2.2 The impact of information intervention on consumer behavior

The impact of information on forming risk perceptions is significant in the demand adjustment that is observed after unexpected food safety incidents (Liu *et al.*, 1998). Incomplete information causes consumers to have biased risk perception and irrational consumption behavior after the impact of food safety incidents. It can be challenging for consumers to assess food risks on their own, and so they need to rely on information that is provided by producers, retailers, and the government to make purchasing decisions (Sutherland *et al.*, 2020). Therefore, effective risk communication strategies are essential for consumers to reduce risks and adopt correct purchasing behaviors. Information interventions can convey multiple risk information (Lobb *et al.*, 2007). They will help the government and enterprises discover better information communication strategies that promote consumers purchasing behaviors (Haab *et al.*, 2010).

Several researchers have analyzed the role of food safety information in consumer decision-making: these studies have shown that both positive and negative information related to food risks has an impact on consumer behavior (Wessells *et al.*, 1996; Zhou *et al.*, 2016). Hu *et al.* (2009) found that negative food safety information affected consumer decision-making and behavior, but positive information did not affect consumers' behavior. The connection between individuals and food safety issues affects the level to which consumers perceive risk (Petty and Cacioppo, 1979). Compared to general risk information, consumers pay more attention to individual risk information. Rudisill *et al.* (2012) found that the geographic proximity of consumers to the risk of bird flu has an influence on consumer behavior. Testing information can enable consumers to know their consumption risks and reduce perceived risk-bias. Existing studies have analyzed the impact of household drinking water testing information on consumer behavior (Bennear *et al.*, 2013; Madajewicz *et al.*, 2007).

Existing literature has analyzed consumer demand and purchasing behavior after meat and vegetables food safety issues, and combined information intervention to carry on further research on consumer behavior after food safety incidents (e.g. Heiman and Lowengart, 2011; Zhou *et al.*, 2016). However, there is little research on consumer behavior after staple foods have food safety problems. Existing information intervention research focuses on analyzing the impact of positive and negative food safety information on consumer behavior (e.g. Hu *et al.*, 2009; Wessells *et al.*, 1996). There is a lack of research on providing consumers with testing information on the food they currently consume. Consumers' risk perceptions are often inconsistent with their own real risk-levels. Consequently, besides providing general risk information, this paper designs other information intervention methods that provide rice-testing information or a mixture of the two information interventions to avoid consumers overestimating or underestimating risks and adopting unreasonable consumption patterns.

3. Research design

3.1 Survey region

The data used in this paper comes from a questionnaire survey conducted in November 2018 and in March 2019. This survey was fielded in four Chinese provinces: Hunan, Jiangxi, Jiangsu, and Fujian. From Supplementary Table S1, we can see that the sown area and output of paddy rice in Hunan and Jiangxi demonstrates they are the primary rice-growing regions of China, and these provinces have a large discharge of cadmium pollutants in wastewater, ranking high in China. Cadmium pollution in Jiangsu and Fujian is relatively less. Therefore, we divided the four provinces into two types: high-risk regions (Hunan and Jiangxi) and low-risk regions (Jiangsu and Fujian). Residents in high-risk regions have a higher cadmium rice incident Baidu search index. The higher the Baidu search index shows that people search the more. This shows that consumers in high-risk regions are more concerned than consumers in low pollution regions. We

chose rice consumers from these four provinces as respondents. Respondents ate two rice meals a day on average, which was consistent with the provinces where rice was the staple food as selected in our study.

3.2 Information intervention

The information intervention includes the following components (Figure 1): first, consumers were surveyed in November 2018. After the baseline survey, we conducted information interventions on three experimental groups. Finally, we completed the follow-up survey in March 2019. The entire experimental process is from November 2018 to March 2019.

■ *Information intervention method designs and survey strategy*

This paper carried out information interventions using three methods in order to observe how the transmission of various information will affect the consumption behavior of rice consumers. In our paper, the sample was divided into four groups (Table 1). Three groups were experimental groups with different interventions, and the fourth group was the control group. Group A (rice testing group): our research team took rice samples from the rice consumed in the respondents' households at that time, and we sent the rice samples to the College of Natural Resources and Environment of Hunan Agricultural University for unified testing. Content of cadmium in the rice samples was determined by atomic absorption spectrometry with wet digestion. After three months, our enumerators informed consumers of the cadmium content of their rice samples and whether or not this content exceeded the standard limit, so that consumers understand their consumption risk.[2] An example of the test result: 'the test result of your rice sample is 0.26 mg/kg, and the Chinese standard is 0.2 mg/kg. The test result of your rice sample is unqualified; the latest standard of the International Codex Alimentarius Commission is 0.4 mg/kg. According to the standard, the results show that the cadmium content of your rice

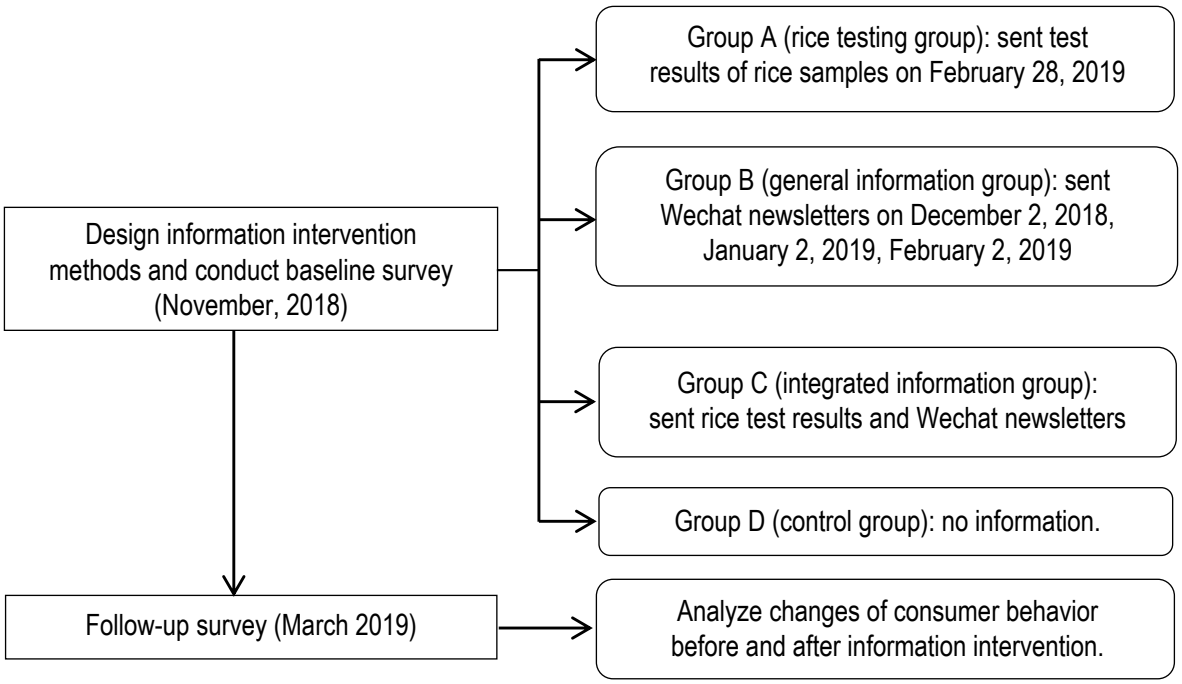

Figure 1. Flow chart of information interventions.

[2] Codex Alimentarius Commission limits that rice contains less than 0.4 mg of cadmium per kilogram. China's latest national food safety standard GB 2762 stipulates that rice contains less than 0.2 mg/kg of cadmium.

Table 1. Description of information intervention methods.

Group	Information intervention method
Group A (rice testing group)	Detect the cadmium content in the rice currently consumed by the respondents' households and send the information about cadmium content of their rice samples to the respondents.
Group B (general information group)	Sent Wechat newsletters to the respondents on the second of each month from the end of 2018 until the beginning of 2019 for continuous general information intervention.
Group C (integrated information group)	Sent both rice test results and WeChat newsletters for integrated information intervention.
Group D (control group)	No intervention.

does not exceed the international standard.' Group B (general information group): the research team provided general risk-information to the respondents, and the enumerators sent Wechat newsletters to the respondents on the second of each month from the end of 2018 until the beginning of 2019: the Wechat newsletters described a cadmium rice incident in 2013, informed Group B's respondents of Guangzhou's contaminated rice from Hunan Province,[3] described a newly emerging incident of cadmium rice that was found in Jiangxi Province,[4] popularized the hazards of eating rice with excessive cadmium content.[5] The Wechat newsletters conveyed general risk information to rice consumers. After these articles were published, we reminded respondents to read the article many times. In the follow-up survey, we asked respondents whether they had read Wechat newsletters and the number of times they read them. The results showed that all respondents read the articles. The data in the follow-up survey shows that the respondents' cognitive level of the cadmium rice incident has increased significantly, proving that they are actually treated. Group C (integrated information group): respondents received individual risk information (i.e. rice sample testing results) and general risk information (i.e. the Wechat newsletters). The integrated information enabled the respondents to understand rice products had excessive cadmium risk, and made them aware about whether their own rice consumption had risk factors.

The research team recruited 64 undergraduates from local colleges as enumerators. We surveyed 204 consumers in each province, with a total of 816 respondents. The reasons for choosing to survey 204 consumers in each province are: each province includes 3 experimental groups and 1 control group, with 4 enumerators in each group. In the control group, each surveyor was responsible for investigating 12 respondents, and there were 144 respondents in the three experimental groups, while the surveyor in the control group was responsible for investigating 15 respondents, and the control group had 60 respondents in total. Therefore, there are a total of 204 respondents in each province. In the baseline survey conducted in November 2018, enumerators interviewed respondents four aspects: (1) basic information of respondents; (2) consumption behavior of staple foods; (3) the degree of concern about cadmium rice incidents; and (4) information capabilities. At the beginning of the questionnaire, we asked whether the respondent was the decision-maker of rice purchase in the household. If the respondent's answer was yes, the surveyor would continue the questionnaire. If the answer was no, the surveyor would immediately stop. Therefore, the respondents are all decision-makers of household consumption, and their responses to the information can represent the responses of their households. For follow-up, researchers added the WeChat of the respondent for tracking and communication.

[3] The article can be found at: https://mp.weixin.qq.com/s/IrX-6FuBfAQzuwksbaxoFA (in Chinese)
[4] The article can be found at: https://mp.weixin.qq.com/s/6dy3m5Zx2PKtqmjsD5nLtA (in Chinese)
[5] The article can be found at: https://mp.weixin.qq.com/s/lU7yIxGSo_WbygV2IGQCmg (in Chinese)

■ *Follow-up survey*

In the follow-up survey in March 2019, the same respondents were asked for their staple food consumption behavior to compare and analyze changes in consumption behavior before and after the information intervention was implemented. The survey lasted for one month and it was completed at the end of March 2019. In order to ensure the effectiveness of the intervention, we reminded the experimental groups' respondents to check the Wechat newsletters through WeChat. In the follow-up survey, to obtain complete data and reduce data missing, the enumerators have repeatedly contacted respondents to complete the follow-up survey. Finally, the survey was completed and the needed information obtained. All the questionnaires were sent back to Nanjing Agricultural University. Respondents from all four groups received about $3.07.[6] Due to missing and invalid data in some questionnaires, we finally got 777 valid samples.

3.3 Empirical model and variables

The rice consumption behavior of residents includes consumption quantity and consumption structure, two aspects: first, the quantity of rice consumption includes the average daily frequency and weight of rice consumed by the respondents' households, the frequency of rice purchases in the past month, as well as the average weight of purchased rice each time; second, the consumption structure of rice products includes the price of rice that respondents usually pay, the brand origin of rice that respondents typically consume (i.e. including whether or not it is produced in an area where cadmium rice incidents occur frequently),[7] and the main purchasing-channel used to acquire rice (i.e. whether it is a formal supermarket or not). The difference-in-difference method was used to analyze the influence of information intervention methods on consumers' rice consumption behavior, and the differences between the results of various information intervention methods were compared. The empirical model in this paper is set as follows:

$$Y_i = \beta_0+\beta_1 T_j D+\beta_2 D+\delta_i+\varepsilon_i \quad (1)$$

In Equation 1, i represents the surveyed consumer. Y_i represents the consumption behavior of the respondent. Information variables are used to reflect whether and what kind of information intervention was accepted by residents. T_j is the dummy variable for information intervention type, j=1,2,3: when the respondent received the rice testing information T_1=1; when the respondent received general risk information T_2=1; when respondents were intervened by rice testing information and general information T_3=1; when the respondent did not receive any information (i.e. control group) T_j=0. D is a time dummy variable (D=0 means before intervention, D=1 means after intervention). δ_i is the individual fixed effect. ε_i is a random variable that accounts for unobservable characteristics. The coefficient β_1 represents the change in the average value of the consumption behavior of the residents in the experimental group before and after the information intervention, and minus the change in the average value of the consumption behavior of the residents in the control group, before and after the information intervention. It is the net effect of the information intervention on consumptive behavior.

3.4 Descriptive statistics

Table 2 provides a statistical description of our data. The respondents in the sample were urban consumers in China, and the proportion of women exceeded 60%. About 90% respondents were between the ages of 20 and 60, with an average age of 38. The average number of years of education of the respondents was more than 14, which indicates a high level of education in this sample. This observation of high educational achievement on the part of the respondents can be accounted for due to the fact that the regions we chose to

[6] Respondents received 20 RMB.

[7] Hunan Province is one of the largest rice production provinces in China. Li *et al*. (2014) found that cadmium pollution in the soil of Hunan Province is relatively high campared to other regions. Since 2009, the cadmium content in rice from Hunan Province has repeatedly exceeded the standard.

Table 2. Variable definitions and descriptive statistics.

Variables	Definition	Mean	SD[1]
Frequency of rice consumption	How often a family ate rice per day on average (times)	2.15	0.61
Weight of rice consumption	The weight of rice eaten by the family a day on average (kg)	0.81	0.56
Frequency of rice purchase	The frequency of rice purchase in the past month (times)	1.23	0.86
Weight of rice purchase	The weight of rice eaten by a family a day on average (kg)	14.35	14.04
Price of rice purchase	The usual price of rice (kg)	7.98	6.98
Brand origin of rice purchase	The origin of the brand of rice bought in the past month was an area where cadmium rice incidents occur frequently (yes = 1; otherwise = 0)	0.08	0.27
Channel of rice purchase	The main channel for buying rice was supermarkets (yes = 1; otherwise = 0)	0.71	0.46
Gender	Male = 1, Female = 0	0.37	0.48
Age	Age (years)	38.27	12.84
Education	Years of education	14.62	3.90
Occupational background	Personal or family member's occupational background is related to medicine (yes = 1; otherwise = 0)	0.16	0.36
Personal annual income	Respondent's 2018 personal annual income (per 10,000 yuan)	6.45	5.63
Family size	Family resident population	3.58	1.36
The proportion of family in labor force	Percentage of family in labor force (%)	67.18	25.58
Family structure	Percentage of the elderly, pregnant women, children, or babies in the family size (%)	29.55	27.48
Rice testing information	Received rice testing information (yes = 1; otherwise = 0)	0.24	0.43
General risk information	Received general risk information (yes = 1; otherwise = 0)	0.22	0.41
Rice testing and general risk information	Received rice testing and general risk information (yes = 1; otherwise = 0)	0.24	0.43

[1] SD = standard deviation.

investigate are provincial capital cities. The average annual income of the respondents in 2018 was about 65,000 yuan. The average family size was 4 persons. We compared the respondents' average age and personal annual income with the residents of the respondent's city. The results show that our sample is basically consistent with the local population in terms of demographic and consumption characteristics. It can be said that the survey sample is representative.

In terms of consumption, a respondent's family ate rice 2.15 times a day on average, and the average daily weight of rice consumed exceeded 1.6 kg. On average, every household bought rice in the past month. Usually, the weight of each purchase exceeded 14 kg. Regarding the consumption structure of rice products, the average price of rice purchased by respondents was about 8 yuan per kilogram. The proportion of rice purchased from Hunan Province was 8.17%. Over 70% of consumers purchased rice from regular supermarkets. In our sample, 168 consumers received general risk information, whereas 187 consumers got rice sample testing information, 188 respondents received two types of information intervention, and 234 respondents did not receive any information.

4. Results and discussions

4.1 Treatment effects on consumption quantity of rice

The quantity of rice consumption includes the frequency and weight of rice consumed and purchased by consumers. For the four dependent variables of rice consumption, a mixed ordinary least square (OLS) regression model was used and individual fixed effects were fixed (Table 3). From the model estimation results, whether it is simply providing rice testing information or general information, or providing integrated information, these interventions did not significantly alter the quantity of rice consumption. After meat, vegetables, or other foods have safety issues, consumers reduce their consumption of the offending product and increase consumption of substitutes to reduce their consumption risks (Arnade *et al.*, 2009; Yang and Goddard, 2011). However, consumers did not reduce the risk of consuming cadmium rice by replacing the staple food with alternatives. The reason is that rice, as the staple food of Chinese residents, is a daily consumption necessity. In China, consumers have a long-term dietary preference for rice.

4.2 Treatment effects on consumption structure of rice

Rice consumption structure includes price, origin, and the channels used to purchase rice. The mixed OLS regression model was also used and the individual fixed effects were fixed. From Table 4, we found that the provision of rice testing information and/or general risk information did not significantly change consumers' purchasing price of rice, nor did it change the purchase channels consumers use to acquire rice. However, consumers changed the brand of origin of rice, and reduced their consumption of rice produced in areas where cadmium rice incidents occurred frequently. From the model estimation results, the integrated information intervention most significantly reduced the prevalence of consumers purchasing rice produced in areas where cadmium rice incidents occurred frequently, which indicates that the integrated information was more effective than single rice testing information or general risk information. Browning *et al.* (2018) shown that when facing media information about food safety, consumers tend to 'over-react' or have a 'lack of reaction' due to risk perception bias. When only rice testing information was provided, consumers experienced deviations in their consumption behaviors because they did not know the health effects of

Table 3. Difference-in-difference (DID) estimation results of rice consumption quantity.[1]

Variables	Frequency of rice consumption	Weight of rice consumption	Frequency of rice purchase	Weight of rice purchase
Rice testing DID	-0.007	0.007	-0.011	0.089
	(0.03)	(0.03)	(0.06)	(0.54)
General risk DID	0.017	-0.000	-0.009	0.284
	(0.03)	(0.03)	(0.06)	(0.56)
Rice testing and general risk DID	-0.031	-0.018	-0.019	0.394
	(0.03)	(0.03)	(0.06)	(0.54)
Time dummy variable	0.013	-0.001	-0.021	-0.346
	(0.02)	(0.02)	(0.04)	(0.36)
Individual fixed effects	Yes	Yes	Yes	Yes
Constant[2]	2.985***	1.501***	2.015***	10.031***
	(0.17)	(0.13)	(0.31)	(2.76)
F statistics	12.371	16.145	6.861	25.019
R-squared	0.926	0.942	0.874	0.962
Observation	1,554	1,554	1,554	1,554

[1] Standard errors in parentheses.

[2] *** indicate statistical significance at the 1% significance level.

Table 4. Difference-in-difference (DID) estimation results of rice consumption structure.[1,2]

Variables	Price of rice purchase	Brand origin of rice purchase	Channel of rice purchase
Rice testing DID	0.134	-0.057***	-0.035
	(0.53)	(0.02)	(0.03)
General risk DID	-0.141	-0.044**	-0.039
	(0.55)	(0.02)	(0.03)
Rice testing and general risk DID	0.449	-0.062***	-0.003
	(0.53)	(0.02)	(0.03)
Time dummy variable	-0.340	0.009	0.051***
	(0.35)	(0.01)	(0.02)
Individual fixed effects	Yes	Yes	Yes
Constant	4.241	0.018	-0.006
	(2.72)	(0.10)	(0.13)
F statistics	5.610	6.765	10.699
R-squared	0.850	0.872	0.915
Observation	1,554	1,554	1,554

[1] *** and ** indicate statistical significance at the 1 and 5% significance levels, respectively.

[2] Standard errors in parentheses.

excessive cadmium. The integrated information intervention enables consumers to understand their own individual consumption risk and general health risk. It reduced the risk-perception bias of consumers, and most significantly changed consumer behavior.

4.3 Heterogeneity analysis

Based on the above estimation results, this paper set up models 1-3 for analysis (Table 5). We carried out a heterogeneity analysis of the degree of risk correlation for the effect of an information intervention on whether a respondent ate rice originating in an area where cadmium rice incidents occur frequently. In Table 5, we found that compared to not distinguishing the cadmium content in rice, when only provided rice testing information, consumers did not significantly reduce their consumption of rice produced in areas where cadmium rice incidents occurred frequently with the increase in cadmium content. However, when provided rice testing information and general risk information, consumers significantly reduced their consumption of rice produced in areas where cadmium rice incidents occurred frequently. This is consistent with previous conclusions that an integrated information intervention is most effective in promoting consumers' safe consumption and reducing consumers' risk levels.

The intervention effect on whether consumers consume rice originating in an area where cadmium rice incidents occur frequently is reflected in residents who ate rice from this area in the base period. All three information interventions significantly reduced these consumers' consumption of rice produced in areas where cadmium rice incidents occurred frequently. This is consistent with the conclusion of a study by Rudisill *et al.* (2012), which demonstrated that when consumers felt that they were facing higher risks, or when risks were specific to these consumers, they were more likely to take preventative measures to reduce their risks. And the observed effects of the integrated information intervention are stronger than only providing rice testing information or general news information.

The intervention effect is mainly reflected in residents who live in a high-risk area. The integrated information intervention is more effective. Hunan and Jiangxi provinces have relatively high cadmium pollution, and cadmium rice incidents have occurred there before, so consumers are at a high risk of consuming cadmium

Table 5. Analysis of heterogeneity of risk correlation-degree.[1,2,3]

Dependent variable: brand origin of rice purchase	Model 1	Model 2	Model 3
Rice testing DID×log (cadmium content)	-0.004		
	(0.10)		
Rice testing and general risk DID×log (cadmium content)	-0.367***		
	(0.12)		
Rice testing DID×whether the consumer ate rice from an area where cadmium rice incidents occur frequently in the base period		-0.429***	
		(0.04)	
General risk DID×whether the consumer ate rice from an area where cadmium rice incidents occurred frequently in the base period		-0.375***	
		(0.04)	
Rice testing and general risk DID×whether the consumer ate rice from an area where cadmium rice incidents occurred frequently in the base period		-0.530***	
		(0.04)	
Rice testing DID×whether the consumer lives in a high-risk area			-0.075***
			(0.03)
General risk DID×whether the consumer lives in a high-risk area			-0.080***
			(0.03)
Rice testing and general risk DID×whether the consumer in a high-risk area			-0.105***
			(0.03)
Rice testing DID	-0.063	-0.009	-0.019
	(0.17)	(0.02)	(0.02)
General risk DID	-0.044**	-0.009	-0.009
	(0.02)	(0.02)	(0.02)
Rice testing and general risk DID	-0.661***	-0.003	-0.009
	(0.20)	(0.02)	(0.02)
Time dummy variable	0.009	0.009	0.009
	(0.01)	(0.01)	(0.01)
Individual fixed effects	Yes	Yes	Yes
Constant	0.018	0.000	0.000
	(0.10)	(0.08)	(0.10)
F statistics	6.817	11.021	6.994
R-squared	0.874	0.918	0.877
Observation	1,554	1,554	1,554

[1] *** and ** indicate statistical significance at the 1 and 5% significance levels, respectively.

[2] Standard errors in parentheses.

[3] DID = difference-in-difference.

rice in these areas. Information interventions have increased their perception of consumption risks and reduced their consumption of rice originating in areas where cadmium rice incidents occur frequently.

From the model estimation results, it has been observed that the three information intervention methods are more effective for consumers who have a higher risk-correlation with the consumption of cadmium rice, and the integrated information is more effective.

This paper further extends the empirical analysis by carrying out a series of heterogeneity analyzes of individual and family characteristics for the effect of the information intervention on whether the respondents ate rice originating in an area where cadmium rice incidents occur frequently (Table 6). For the variable of gender, we find that the effect of these interventions on women is greater than that of men. Women tend to collect more information when purchasing food (Gracia *et al.*, 2007), and they are more sensitive to food safety information. For the variable of education level, the effect of rice testing information is most statistically reflected in residents who have a high school degree or below, and the effect of other two interventions is

Table 6. Analysis of the heterogeneity of personal and family characteristics (difference-in-difference (DID)).[1,2]

Dependent variable: brand origin of rice purchase	Gender		Education		Family structure	
	Female	Male	High school or below	University or above	Without sensitive people	With sensitive people
Rice testing DID	-0.067***	-0.004	-0.035	-0.049**	-0.020	-0.059**
	(0.02)	(0.03)	(0.04)	(0.02)	(0.03)	(0.03)
General risk DID	-0.053**	-0.062*	-0.086**	-0.039	-0.046	-0.065***
	(0.02)	(0.03)	(0.03)	(0.02)	(0.03)	(0.02)
Rice testing and general risk DID	-0.091***	-0.014	-0.027	-0.082***	-0.056*	-0.064***
	(0.02)	(0.03)	(0.03)	(0.02)	(0.03)	(0.02)
Time dummy variable	0.020	-0.012	0.000	0.013	-0.011	0.021
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Individual fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.024	0.008	0.018	0.018	0.016	0.019
	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)
F statistics	6.811	6.697	6.271	7.078	7.079	6.535
R-squared	0.874	0.873	0.865	0.878	0.879	0.869
Observation	982	572	558	996	554	1000

[1] ***, **, and * indicate statistical significance at the 1, 5 and 10% significance levels, respectively.

[2] Standard errors in parentheses.

reflected in residents who have a bachelor's degree or above. Rice testing information is more intuitive and more relevant to resident's risks. Thus, it has a stronger effect on residents with lower education levels. Families with higher education levels are better able to understand the meaning of information (Brown *et al.*, 2017). General information enables families to understand that rice has risk. Furthermore, integrated information provides more risk information, and so the effect of the intervention is more significant. Regarding the family structure, the information intervention most significantly affects families with members who are elderly, children, pregnant women, or baby. This finding is consistent with the results of previous studies (Boccaletti and Nardella, 2000).

5. Conclusions and policy implications

Our research aims to find effective information interventions to provide consumers with relevant advice to prevent food safety risks. Although cadmium-contaminated rice should be banned from the market. But rice in China cannot currently be fully traced. There are still large numbers of smallholder farmers producing rice. Despite the many measures taken by the Chinese government, cadmium-contaminated rice still finds its way into the market. This requires the government to strengthen food safety publicity, and also requires consumers to take measures to prevent risks after they understand their own risk levels. Based on the panel data of 777 consumers before and after information interventions, this paper uses the difference-in-difference method to analyze the effect of the rice testing information and/or general news information intervention on consumers' behavior. The contribution of this research is that it is a unique attempt to carry out information intervention research based on real food testing results, which is rarely done. This article not only fills the research gap in the literature on the influence of food testing information on consumer behavior, but also complements the research on consumer behaviors after food safety crises related to staple foodstuffs.

The regression results show that all information interventions have no significant effects on the quantity of Chinese residents' consumption of rice. Consumers did not significantly reduce the amount of rice consumed, and they did not switch to other staple food. However, information intervention had an impact on the consumption structure of rice products. Consumers reduced their consumption of rice produced in areas where cadmium rice incidents occurred frequently. The integrated information intervention's effect is greater than single information. Compared with only providing testing information or news information, providing the integrated information enables consumers to access more complete risk information. In addition, the effect of the information intervention is primarily reflected in consumers with a high degree of risk correlation with cadmium rice consumption. Consumers' responses to information interventions are highly heterogeneous.

This paper provides the following recommendations for the government to improve the effectiveness of food safety risk communication strategies for consumers in the future (i.e. in order to reduce the incidence of foodborne illness and motivate producers to reduce the production of substandard rice). The first is to remediate and govern soil contaminated by heavy metals, strengthen supervision over sites of rice production, and block the production and circulation of cadmium rice. Chinese residents' demand for rice is inelastic and thus they can only adjust their rice products' consumption structure. Consequently, the most important point is to stop the production of cadmium rice from the source, and repair the soil contaminated by heavy metals. Second, while the Chinese government disseminates information related to the health risks of eating contaminated rice, it also needs to coordinate with the work of food safety testing apparatuses. Professional rice testing services are provided by third-party institutions and they enable consumers to understand the risk level of their own consumption. Based on the current cost of rice testing, it is not feasible to provide rice testing for every consumer. Instead, third-party institutions can conduct rice testing for producers, and the government can release testing results in time to promote safe food consumption among consumers and avoid foodborne diseases. Finally, the Chinese government needs to disseminate food safety knowledge among consumers who are susceptible to the risk of cadmium rice consumption, and provides diverse food safety knowledge education for different consumers. This will help consumers avoid consumption risks in the long-run and improve the health of the public.

Supplementary material

Supplementary material can be found online at https://doi.org/10.22434/IFAMR2021.0094

Table S1. Information on rice production and cadmium pollution in the four provinces.

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Conflict of interest

No conflict of interest exists in the submission of this manuscript.

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