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Does Internet use improve rural residents' behavior of food safety?

by Jingsi Peng and Shi Min

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Does Internet use improve rural residents' behavior of food safety?

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Abstract

This paper evaluates the use of the Internet by rural residents in China and explores the effects of Internet use on improving residents’ food safety behavior. Based on 1080 sample data from three provinces in Central China, we use an endogenous switching regression model and counterfactual analysis to evaluate the impact of Internet use on food safety behavior of rural residents, and explore the possible impact channels. The results show that the use of Internet can significantly improve the food safety behavior of rural residents in China, and the potential impact channels include food safety knowledge acquisition and food safety knowledge level. This paper provides empirical evidence on the role of Internet use in food safety behaviors in rural China and has important implications to improving residents' food safety behaviors in the information age.

Keywords: Food safety behavior; Internet use; Rural residents

Introduction

Food safety is one of the most influential social issues, related to domestic public health and international market trade. The increase in food demand and the diversification of demand types promote the food industry into a period of rapid development and urge consumers to pay more and more attention to safety attributes such as food sources, production processes, and additive content (Marklinder and Eriksson 2015, Hsu et al. 2016, Hassan et al. 2018, Hsu, Chiao-Chen et al. 2019). The World Health Organization (WHO) and Food and Agriculture Organization (FAO) define a food commodity as safe when free from all hazards, which may make food injurious to the health of the consumers whether for chronic or acute consequences (FAO, 2003). According to the estimation of WHO, almost one in 10 people gets sick every year because of eating contaminated food, resulting in 420000 deaths, of which children under five years old account for 30% of the deaths from foodborne diseases, and pointed out that food safety behavior is an important factor in causing foodborne diseases (WHO 2015). In the United States, the annual economic loss caused by food safety incidents amounts to $10-83 billion per year (Losasso et al. 2012). The global public health problems and international trade problems caused by food safety can't be ignored.

The large population and rapid economic growth promote China into an important global food consumer and exporter in the world. In 2019, China's per capita food consumption was 374.2 kg, and food exports amounted to 432.42 billion yuan, reaching 48.19% of primary products (NBS 2020). In recent years, China has strengthened the supervision and punishment of food safety, but food safety incidents still occur frequently (Xue and Zhang 2013, Dong and Li 2016). According to data from the National Health Commission of the People's Republic of China, 844 food poisoning incidents occurred between 2011 and 2015, resulting in 32,151 people being poisoned, of which 623 died (PRC 2016). Food safety incidents pose threats and damages to people's health, as well as serious social consequences. From the perspective of consumers, their food safety behavior (FSB) plays an important role in avoiding food safety problems (Ergönül 2013, Liu and Niyongira 2017, Young et al. 2018).

Food safety involves all aspects of life, and correct FSB can effectively improve the food safety status of the household. Most experts believe that the household, as the last link in the food supply chain, is the last line of defense against foodborne illness (Nesbitt et al. 2014, Murray et al. 2017), but consumers ignore their role in preventing foodborne diseases and underestimate the incidence rate of food borne diseases and the frequency of serious consequences (Cody and Hogue 2003, Esfarjani et al. 2018). About 40% of the reported foodborne outbreaks in Europe are caused by food safety behaviors (WHO, 2003), and improper practices in family kitchens are the main causes of foodborne outbreaks (Da Cunha et al. 2014; Omari et al. 2018; Hessel et al. 2019). The FSB of consumers in the purchase directly determines the effectiveness of subsequent food processing. When buying food, consumers often need to pay attention to factors such as shopping channels, country of origin, food packaging, shelf life, product preservation and other factors, which directly determines the effectiveness of the subsequent food processing; the combination of temperature and time is very pivotal when food is stored (Marklinder and Eriksson 2015), but consumers usually only hear or taste to judge whether the food is deteriorated; in addition to cleaning and cutting raw materials, food processing also includes sterilizations, thawing, prevention of cross contamination etc.(Hassan et al. 2018); as the most critical part of FSB, the frequency of hand washing, cleaning cooking tools, and the degree of raw and cooked eggs and meat in the process of food preparation are worthy of attention (Bearth et al. 2014). FSBs are embodied in the links of purchase, storage, processing, preparation, etc., but the specific details are often only known to the parties concerned, which is beyond the scope of official inspections by the departments that ensure food quality (Husain et al. 2016). Exploring the status and influence mechanism of consumer FSBs in the Internet age is of great significance to avoiding food safety issues.

The rapid development of information and communication technology fosters increasing people to use the Internet, which has a wide-ranging impact on agricultural production and rural residents' lives in all countries in the world. In a survey of German rural residents, 93% of respondents use Internet for agricultural purposes, and most of the respondents think these tools such as weather forecasting and pest identification are useful (Bonke et al. 2018). The crop nutrition assessment system based on Internet applications tested by Paleari et al. (2019) in Italy can derive the nitrogen nutrition index, which helps to improve the economic and environmental sustainability of agricultural activities. In Africa, 60% of the population uses Internet, which can lower search costs, improve coordination between agents, increase market efficiency, and create new job opportunities for rural and urban areas (Aker and Mbiti 2010). In rural households in the Mekong region of Southeast Asia, the possession of smartphones has increased the mobility of villagers in the non-agricultural sector, reduced the motivation of workers to emigrate, and has a positive impact on household income (Hartje and Hübler 2017). Moreover, many studies in rural China show that Internet use promotes the economic transformation of rural families and has a positive impact on family income (Ma et al. 2018, Ma et al. 2020, Min et al. 2020).

Recent government and industrial reports show that Internet, particularly the mobile internet, is increasingly used in rural China. According to the 46th China Statistical Report on Internet Development issued by China Internet Information Center in September 2020, as of June 2020, the number of Internet users in rural China is 285 million, an increase of 3,063 from March 2020, accounting for 30.4% of the total Internet users; the Internet penetration rate in rural areas is 52.3%, an increase of 6.1% from March 2020; the proportion of Internet users using mobile phones is 99.2% (CNNIC 2020). China has a large rural population, but rural residents have less knowledge about food safety in their education and daily life, and are more vulnerable to food safety issues (Yang and Qiu 2014). Through the mobile Internet with stronger dissemination capabilities, food safety information can be widely disseminated and bring about changes in the FSB of rural residents. The Internet has changed the traditional mode of obtaining food safety information, increasing the ability of rural residents to obtain information while promoting information diffusion and information sharing (Moreno et al. 2013, Araniti et al. 2017).

However, to date, few studies have examined the actual application of Internet in rural China and quantified their impact on the FSB. This study takes the use of Internet among rural residents in China as a case. This is due to considering two aspects of Internet. First, the Internet supports access to various platforms, further enhancing the flow of information, including food safety-related knowledge, events, discussions, etc. (Shin et al. 2011, Shimamoto et al. 2015, Araniti et al. 2017), influencing residents' FSBs through multiple channels. Second, with the popularization of smart phones, the use of the Internet is not restricted by region and time, which is the main choice for Internet users in rural China (Min et al. 2020). At present, as the most important channel for residents to obtain information, its impact of the Internet on Residents' food safety knowledge is worth exploring.

The aim of this paper is to study the impact of Internet use on the food safety of rural residents and analyze the possible impact channels. In this study, an endogenous switching regression (ESR) model was applied to household-level data to account for unobserved factors that simultaneously affect Internet use and FSB. Additionally, a counterfactual analysis is employed to estimate the treatment effects of Internet use on the FSB. The estimation results of our empirical models indicate that the use of Internet among rural residents has significant impacts on the FSB by promoting obtaining food safety knowledge and increasing food safety knowledge. The findings of this study imply that strategies for improving the FSB of rural residents should take into account the role of internet-based platforms. This study also complements empirical evidence on the impacts of Internet on food safety in rural areas in developing countries.

This paper is organized as follows. Section 2 is a theoretical analysis of the impact of Internet use on FSB. Section 3 introduces the methods used to assess the impact of Internet use on the FSB of rural residents. Section 4 shows the data sources and descriptive statistics used in this study. Section 5 briefly introduces the determinants of Internet use, the treatment effect of Internet use on food safety behaviors, and possible influence channels. The last part summarizes this study.

Conceptual framework

Internet use can effectively improve FSB, and the specific framework is shown in Figure 1. With the access to Internet information, the traditional thinking, knowledge and cognitive viewpoint system of rural residents will be expanded and updated (Heimonen 2009, Nakatani and Ohno 2013), which will help to stimulate their subjective initiative and improve their attitudes towards food safety knowledge acquisition (FSKA). Food safety knowledge level (FSKL) is an important factor affecting FSB (Mullan et al. 2013), while the Internet greatly reduces the information barrier, reduces the communication cost of residents, promotes the information sharing among residents (Bickart and Schindler 2010), and improves the FSKL of residents. Therefore, we hypothesize that Internet use improves residents' FSB by improving residents' FSKA and FSKL.

The first path is that Internet use has improved the residents FSKA. As an important information dissemination channel, the Internet provides various types of information for consumers at the end (Renahy and Chauvin 2006, Drake et al. 2017, Howerton 2019), and consumers' FSKA determine the effectiveness of this information. Faced with a variety of food safety information, Välimäki et al. (2007) found that most patients are willing to accept Internet information and think it is very beneficial to their health, and Taylor et al. (2001), Gao et al. (2013) confirms that many residents actively search for health information through the Internet. In rural areas in the southern United States, 33% of teenage mothers actively search for health information on the Internet and share them with others every few weeks, and the information found on the website changes their health behaviors (Logsdon et al. 2015). Accepting information willingly and obtaining information actively helps consumers improve their food safety behaviors.

The second path is that the Internet use has an indirect effect of promoting FSB by increasing residents' FSKL. FSKL involves many aspects such as food purchase, raw material storage, raw material processing, food preparation, kitchen hygiene, etc., and the lack of relevant knowledge may become an obstacle that hinders consumers from changing risk behaviors (Angelillo et al. 2001). Consumers with high FSKL often pay attention to shopping channels, country of origin, food packaging, shelf life, product preservation, etc. when purchasing food (Behrens et al. 2010), which directly determines whether the subsequent food behavior is effective. As the pace of life accelerates, many families will prepare more food at one time for consumption next time, and proper FSKL of raw material storage can ensure food safety (Marklinder and Eriksson 2015). Raw material processing includes washing and cutting raw materials, sterilizing, thawing, preventing cross contamination, etc., and FSKL plays an important role in this process (Bearth et al. 2014). As the most critical part of food safety behavior, consumers' FSKL affects the frequency of hand washing, cleaning of cooking tools, and the degree of rawness of eggs and meat during food making (Maughan et al. 2017, Hassan et al. 2018). In addition, the lighting, ventilation and cleaning frequency of the kitchen are also a reflection of the residents' FSKL (Byrd-Bredbenner et al. 2007, Scott and Herbold 2010), which has a significant impact on the residents' FSB.

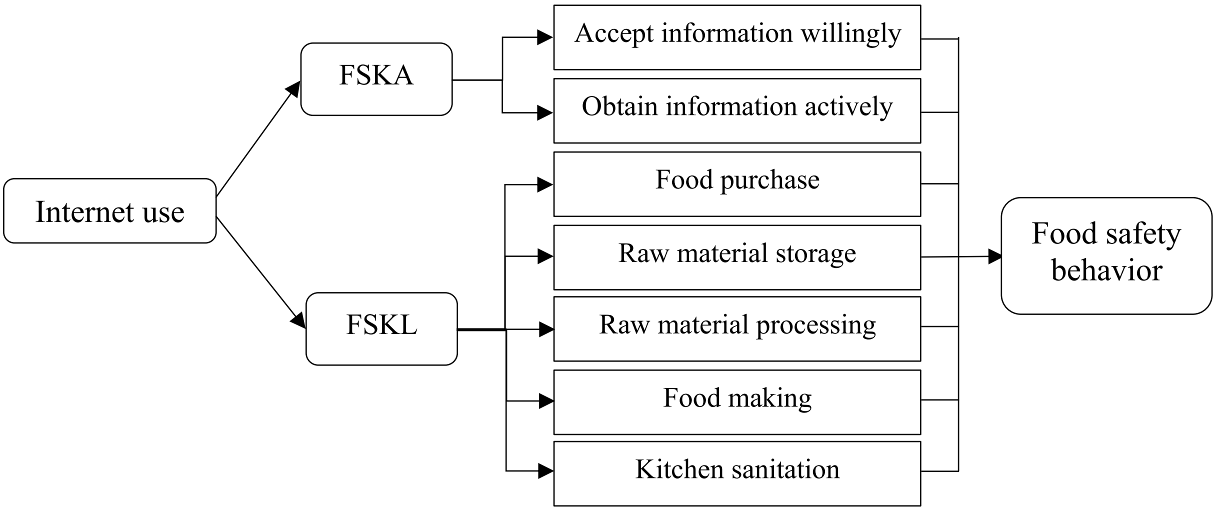

Figure 1. Improvement ways of Internet use on food safety behavior.

Model specification

To estimate the impact of Internet use on the FSB of rural residents in China, we must consider that Internet use may be subject to endogeneity. First of all, our data comes from rural households randomly selected from three provinces in Central China, and the sample selection bias caused by their different characteristics may cause endogeneity. Second, there may be an inverse relationship between the Internet use and the FSBs of rural residents, which will result in biased estimation results because of endogeneity. Moreover, the unobserved heterogeneity of rural residents may affect Internet use and FSB, leading to inconsistent estimates of the impact of Internet use on FSB.

Following previous studies (Asfaw et al. 2012, Abdulai and Huffman 2014, Shiferaw, et al. 2014, Ma et al. 2018a, Ma et al. 2018b, Min et al. 2020, Ma et al, 2020), an endogenous switching regression (ESR) model can take into account both observed and unobserved heterogeneity to achieve consistent estimation, which can effectively solve the above problem. To make further estimation to determine the impact of Internet use on FSBs, we estimate the differences in the FSBs of rural residents in the two regimes of Internet use and non-Internet use, and conducted counterfactual analysis to derive the average treatment effect of Internet use. In the ESR model, the decision to use Internet and its impact on FSBs can be modeled in a two-stage treatment framework. In the first stage, the decision of rural residents to use Interne is modeled and estimated using a probit mode. In the second stage, the relationship between the outcome variables and Internet use along with a set of explanatory variables is estimated using the ordinary least squares (OLS) model with selectivity correction.

The ESR model

Referring to the studies of Ma et al. (2018a), Ma et al. (2018b), Min et al. (2020), Ma et al, (2020), We assume that in rural households, the decision of family members to use the Internet is determined by the characteristics of the household head and the characteristics of the household, and specify the following linear function:

$$I_i^* = \gamma Z_i + v_i \text{ with } I_i = \begin{cases} 1, & if \ \ I_i^* \geq 0 \\ 0, & otherwise \end{cases} \tag{1}$$

where I_i^* is a latent variable which represents the possibility of a household using the Internet, which is determined by the observed binary variable I_i that takes the value 1 for Internet users and 0 for non-Internet users. Z_i is a vector of independent variables including the characteristics of the household head and household; γ is a vector of parameter to be estimated, and v_i is an error term.

Given the Internet use Eq. (1), the two outcome regimes for Internet users and non-Internet users in the ESR model can, respectively, be specified as:

$$\text{Regime1: } FSB_{1i} = \alpha_1 + \textstyle\sum_{j=1}^{n} \beta_{1j} X_{1ij} + \mu_{1i}, \quad if \ \ I_i = 1 \tag{2a}$$

$$\text{Regime2: } FSB_{0i} = \alpha_0 + \textstyle\sum_{j=1}^{n} \beta_{0j} X_{0ij} + \mu_{0i}, \quad if \ \ I_i = 0 \tag{2b}$$

where FSB_{1i} and FSB_{0i} define the outcomes including FSB for Internet users and non-Internet users; β_1 and β_0 are parameters to be estimated; μ_1 and μ_1 are error terms.

The estimation of β_1 and β_0 using ordinary least squares (OLS) may lead to biased estimates because the expected value of the error term (μ_1 and μ_0) (depending on the selection criteria) is non-zero. Assuming that the error terms in Eqs. (1) and (2) have a trivariate normal distribution with a mean value of zero, the covariance matrix can be specified as:

$$cov(v, \mu_1, \mu_0) = \begin{bmatrix} \sigma_v^2 & \sigma_{v1} & \sigma_{v0} \\ \sigma_{1v} & \sigma_1^2 & \\ \sigma_{0v} & & \sigma_0^2 \end{bmatrix} \tag{3}$$

where $\sigma_v^2 = var(v)$, $\sigma_1^2 = var(\mu_1)$, $\sigma_0^2 = var(\mu_0)$, $\sigma_{v1} = cov(v, \mu_1)$ and $\sigma_{v0} = cov(v, \mu_2)$. The variance of σ_v^2 can be assumed to be equal to 1 since the β coefficients in the selection model are estimable up to a scale factor. The covariance between μ_1 and μ_0 is not defined since FSK_1 and FSK_2 are not observed simultaneously (Maddala 1983). The error term in the selection Eq. (1) is correlated with the error terms of the FSB functions (μ_1 and μ_0), so the expected values of μ_1 and μ_0 conditional on the sample selection is non-zero:

$$E(FSB_{1i}|I_i = 1) = \sigma_{1v}\frac{\phi(z_i\alpha)}{\Phi(z_i\alpha)} = \sigma_{1v}\lambda_{i1}$$

$$E(FSB_{0i}|I_i = 0) = -\sigma_{0v}\frac{\phi(z_i\alpha)}{1-\Phi(z_i\alpha)} = \sigma_{0v}\lambda_{i0}$$

where $\phi(.)$ is the standard normal probability density function, $\Phi(z_i\alpha)$ is the standard normal cumulative density function, $\lambda_{i1} = \frac{\phi(z_i\alpha)}{\Phi(z_i\alpha)}$ and $\lambda_{i0} = \frac{\phi(z_i\alpha)}{1-\Phi(z_i\alpha)}$. Where λ_{i1} and λ_{i0} in Eqs. (2a) and (2b) are the Inverse Mills Ratios (IMR) computed from the selection equation to correct for selection bias in a two-step estimation procedure i.e., endogenous switching regression. The standard errors in Eqs. (2a) and (2b) are bootstrapped to account for the heteroskedasticity arising from the generated regressors (λ).

Estimating treatment effects

After estimating the expected outcome values of Internet users and non-Internet users in actual and counterfactual scenarios, the average treatment effect on the treated (ATT) and the average treatment effect on the untreated (ATU) can be calculated. The expected value in the real and hypothetical scenario defined as:

Internet users with use (observed in the sample):

$$E(FSB_{1i}|I_i = 1) = \beta_{1j}X_{1ij} + \sigma_{\mu 1v}\lambda_{1i} \tag{4a}$$

Non-Internet users without use (observed in the sample):

$$E(FSB_{0i}|I_i = 0) = \beta_{0j}X_{0ij} + \sigma_{\mu 0v}\lambda_{0i} \tag{4b}$$

Internet users had they decided not to use (counterfactual):

$$E(FSB_{0i}|I_i = 1) = \beta_{0j}X_{1ij} + \sigma_{\mu 0v}\lambda_{1i} \tag{4c}$$

Non-Internet users had they decided to use (counterfactual):

$$E(FSB_{1i}|I_i = 0) = \beta_{1j}X_{0ij} + \sigma_{\mu 1v}\lambda_{0i} \tag{4d}$$

Eqs. (4a) and (4b) represent the actual expectations observed from the sample, while Eqs. (4c) and (4d) are the counterfactual expected outcomes. Using these conditional expectations, the following mean FSB outcome difference can be calculated.

The expected change in Internet users' FSB, the effect of treatment on the treated

(ATT) is calculated as the difference between (4a) and (4c):

$$\text{ATT}= E(FSB_{1i}|I_i = 1) - E(FSB_{0i}|I_i = 1)$$
$$= (\beta_{1j} - \beta_{0j})X_{1ij} + (\sigma_{1\nu} - \sigma_{0\nu})\lambda_{1i} \quad (5a)$$

The expected change in Non-Internet users' FSB, the effect of treatment on the treated (ATT) is calculated as the difference between (4b) and (4d):

$$\text{ATU}=E(FSB_{1i}|I_i = 0) - E(FSB_{0i}|I_i = 0)$$
$$= (\beta_{1j} - \beta_{0j})X_{0ij} + (\sigma_{1\nu} - \sigma_{0\nu})\lambda_{0i} \quad (5b)$$

Identification strategy and key variables

To identify the ESR model, it is important for the Z variables in the selection model to contain a selection instrument. "The broadband penetration rate in a village" is the instrumental variable used for the identification of the impact of Internet use on FSB outcome variables. The broadband penetration rate of a village can reflect the development of local broadband Internet, which may greatly influence the use of Internet by rural residents in the village, but the state of the Internet infrastructure is unlikely to influence the outcome variable directly or correlated with the unobserved errors of Eqs. (2a) and (2b). Following previous studies (Falco, Veronesi et al. 2011, Shiferaw, Kassie et al. 2014, Manda, Gardebroek et al. 2015, Ma and Abdulai 2016, Min, Waibel et al. 2017), an instrumental variable can be verified by falsification test. According to this test, a variable is used as a selection instrument if it affects the use of Internet but does not affect the FSB of rural households that do not use Internet. We employ the falsification test to further examine the exogenous restrictions and validate the proposed IV; the results in Table A1 in the appendix confirm the validity of the proposed IV empirically.

Data and descriptive statistics

The data used in this study comes from a household survey conducted by the School of Economics and Management of Huazhong Agricultural University in three provinces in Central China in 2019. The data included 1,080 rural residents in 18 counties, 54 townships, and 108 villages in Henan, Hunan, and Hubei. Based on the agricultural production information of all counties in each sample province in 2018, such as the total agricultural production value, the number of agricultural labor force and the area of arable land, cluster analysis is performed in each province, and multi-stage stratified sampling procedure was employed. Firstly, 6 sample counties are selected from each province; secondly, 6 sample townships are selected from each sample County, and 2 sample villages are selected from each sample township; finally, using simple random sampling method, 3 sample households are randomly selected from the large planting households, and 7 sample households are randomly selected from other rural residents. In the end, there are a total of 1080 sample households in the three provinces. Table A2 in the appendix presents the distributions of these sample households by province, county and village.

The data was collected using a pre-tested structured questionnaire by experienced senior undergraduates, masters and doctoral students who participate in unified training and pre-investigation and have good knowledge of the farming systems. To ensure that the survey is carried out strictly in a scientific way, the surveys in each sample county are led and managed by professional teachers from Huazhong Agricultural University. In the survey, supplementary surveys of other members of the household were carried out in the form of telephone interviews for the information of migrant workers and the information that needs to be verified. The household data was collected through the face-to-face interview between student investigators and rural residents; the village surveys were completed through the interview of the team leader to the village secretary, the village director or the village accountant.

The survey covered a wide range of variables that influence internet use and FSB at household and village levels. The key socioeconomic data collected at the household level, in addition to the basic statistical characteristics of the household head's age, gender, education level, health status, work status, household income, household size, farm size etc., also include the use of the Internet (Internet broadband, wireless fidelity and mobile internet), the proportion of time spent on Internet activities (news, social, entertainment, online shopping, etc.), mobile phone usage (package type, communication fee), food safety Knowledge (whether you have read food safety-related books, whether you actively understand or collect food safety-related knowledge, opinion judgments), FSBs (purchasing attitude, food handling, scrubbing frequency, kitchen conditions), and food safety promotion effect. The survey also collected village level variables, such as which year the village was connected to the network cable, how many households connected to the network cable, how many households did not have a mobile phone signal, public transportation conditions and public health conditions to capture spatial heterogeneity and unobserved policy variability.

Descriptive statistics of key variables

The detailed definitions and statistics of all variables used in the regression are summarized in Table 1. Referring previous studies regarding the impacts of ICTs or smartphone use in rural China (Ma et al. 2018, Min et al. 2020), the independent variables include the characteristics of the household head and household. Column 2 provides the definition and description of all variables, while columns 3-6 list the average, variance, minimum and maximum values of all variables. From the perspective of household heads, we noticed that most of the household heads are male, and the average length of education is 7 years (junior high school), which is roughly consistent with the research of (Ma et al. 2020); our interviewees are rural residents, whose average age is 57 years old, which reflects the aging problem in rural areas to a certain extent (Zhong 2011); about one-third of the household heads participated in non-agricultural work, and most rural residents maintained a traditional production method based on planting. From the perspective of households, the per capita annual income of households is more than 10,000 yuan, the average household sharing income and expenditure population is 4-5, and more than two-thirds of households use the Internet, which is slightly higher than the national data reported by CNNIC (CNNIC 2020). Since we control the fixed effects at the province level, all potential explanatory variables at the province level are omitted.

Table 1

Summary and description of key variables.

Variables	Definition and description	Mean	Std. Dev.
Household heads			
Gender	Gender of the household head (1=Male; 0=Female)	0.874	0.332
Age	Age of the household head	56.606	9.630
Education	Education of the household head (In years)	7.081	3.135
Health	Health of the household head (1=very unhealthy; 2= unhealthy; 3=average; 4=healthy; 5= Very healthy)	2.35	1.081
Off-farm work	Work type of the household head (1=Off-farm work; 0=Farm work)	0.324	0.468
FSB	Food safety behavior (Measured by test score)	44.133	7.607
Households			
Household income	Per capita income of family members (Unit: Thousand Yuan)	12.859	17.880
Household size	Number of family members	4.405	1.967
Farm size	Per capita farm size of family members	1.962	6.797
Bus to county	whether there are buses to county (1=Yes; 0=No)	0.485	0.500
Public trash can	Number of public garbage cans in the village	84.781	157.662
Internet use	Whether the household uses the Internet (1=Use; 0=Non-use)	0.740	0.439
Penetration	Internet penetration rate in a village	0.6398	0.1645
Observations		1080	

The indicators of FSB of rural residents

To measure the FSB of rural residents in China, we design a questionnaire with 14 questions. As a household food decision-maker, each respondent completed 14 tests on FSB, including Food purchase, Raw material storage, Raw material processing, Food making, Kitchen sanitation, as shown in Table A3 in the appendix. Referring to Turnbull-Fortune and Badrie (2014), Gündüz et al. (2017)'s study, we scored the residents according to the standardization degree of FSBs. For example, the scoring rules for the frequency of residents washing hands before each meal are: 1 for never, 2 for rarely, 3 for occasionally, 4 for often, and 5 for always. The higher the FSB score, the more standardized the residents' FSB. On the whole, the FSB of rural residents in Hubei is the most standardized, followed by Hunan. The survey results are shown in Table A4.

The use of Internet and its correlation with FSB

We use broadband, WiFi and mobile web to measure whether the household uses the Internet. "Broadband use" refers to whether a household has broadband Internet access, "WiFi use" indicates whether the household connects to the Internet via WiFi, and " Mobile web use" refers to whether the household uses the mobile web to surf the Internet. When a rural resident uses any of the three methods to access the Internet, we believe that the resident uses the Internet. The proportion of households using the Internet in Henan Province, Hubei Province, and Hunan Province were 72.78%, 74.44%, and 74.72% respectively, and the total proportion was 73.98%.

Table 2 shows the differences between the key variables between Internet users and non-Internet users. First, we noticed that age, education level, health status, non-agricultural employment probability, household income, household size and number of public garbage cans have significant differences between households using and not using the Internet. Specifically, in the households using the Internet, the age of the head of household is significantly lower than that of the households not using smart phones, while the education level, non-agricultural employment probability, household income household size and number of public trash cans are significantly higher than those of the families not using smart phones. Most importantly, compared to households that do not use the Internet, the FSBs of households using the Internet are much more standardized.

Table 2

The difference between households that do and do not use Internet.

Variables	Internet use=1		Internet use=0		Diff.(1-0)
	Mean	Std. Dev.	Mean	Std. Dev.	
Gender	0.867	0.339	0.893	0.309	-0.026
Age	54.322	9.069	63.103	8.108	-8.782***
Education	7.641	2.965	5.488	3.063	2.153***
Health	2.254	1.065	2.623	1.082	-0.369***
Off-farm work	0.373	0.484	0.185	0.389	0.188***
Household income	14.899	19.869	7.057	7.819	7.842***
Household size	4.588	1.841	3.883	2.208	0.706***
Farm size	1.975	7.804	1.927	2.118	0.047
Bus to county	0.483	0.500	0.492	0.501	-0.009
Public trash can	93.062	170.142	60.748	110.783	32.324***
FSB	44.991	7.333	41.694	7.851	3.297***

Note: Mean-comparison test, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Empirical results

In this section, we present and discuss the results estimated from the empirical model. First, we discuss the determinants of Internet use, which are estimated based on Eq. (1) using a probit model. Second, we propose and discuss the treatment effects of Internet use on FSB, which are estimated using the Eqs. (5a) and (5b) within an ESR model framework. Finally, we analyze the possible impact channels of the Internet use on FSB by exploring the possible impact channel of Internet use on the attitude towards food safety knowledge acquisition (FSKA) and food safety knowledge (FSKL).

Estimation results

Table 3 shows the ESR results of the FSB controlling the province fixed effect and using the robust standard error of the village clustering. The results of the Wald chi2 tests are shown at the bottom of the Table 3. They are always significantly different from zero, which indicates that the specifications of the empirical model are statistically valid. In addition, the chi2 test (rho1 = rho2 = 0) results show the joint dependence of the equations for Internet use and FSB. However, there is a significant difference between Rho1/0 and 0, indicating that there is a selection bias, which will skew the effect of Internet use on FSB.

The estimated results of the selection equation for Internet use are shown in the second column of Table 3. As we expected, the broadband penetration rate in the village had a significant positive impact on Internet use in rural China. Therefore, promoting the development of broadband Internet in rural areas may have a positive external impact on promoting Internet use for rural residents. Education level, non-agricultural employment, household income and household size significantly affect Internet use, increasing the probability of Internet use by 8.5%, 22.6% and 2.8% respectively; but the increase of age and farm size reduces the probability of Internet use by 5.6% and 1%. Hartje and Hübler (2017), Sylvester (2016), Michels et al. (2019)'s research results show that age, education, and family size are determinants of Internet use; Ma et al. (2018) proposed that rural residents with higher education and larger farm size are more likely to use smart phones, which may be the result of regional differences; Poushter (2016) also found that young and well-educated people are more likely to use the Internet in a survey of Internet use in about 40 countries. However, variables such as gender and health status are not significant, which are completely different from previous studies (Ma et al. 2018a, Ma et al. 2018b, Min et al. 2020).

In the FSB model of household members, there are differences in the influencing factors of FSB between households using and not using the Internet. For households using the Internet (column 3), independent variables such as education level, health status and number of public garbage cans are significantly correlated with FSB of household members. Bai et al. (2014), Turnbull-Fortune and Badrie (2014) emphasize the importance of education in FSB; Worsley et al. (2013) also pointed out that food safety problems are positively correlated with men's body mass index, which may be because people with poor health will pay more attention to FSB to ensure their diet health; Mai et al. (2010) pointed out that each provincial and regional government has the responsibility of public health to protect citizens from food borne diseases, and the number of public garbage cans to a certain extent reflects the importance of village cadres on food safety, which may affect the food safety behavior of individual rural residents. This result shows that Internet use and these independent variables have an interactive impact on FSB. For households that do not use the Internet (column 4), education level and health status of household head, household income and household size have a significant impact on FSB. No matter whether the family uses the Internet or not, rural residents with high education and good health always have more standardized FSB, which is consistent with the view that students with higher education level have more standardized food safety behavior and dietary behavior can improve residents' health status (Losasso et al. 2012; Turnbull-Fortune and Badrie 2014). Other important variables are different for households using and not using the Internet.

Table 3

Estimation results of the ESR.

Variables	Internet use	Internet use=1	Internet use=0
Penetration	3.143***		
	(0.224)		
Gender	-0.098	-0.635	0.854
	(0.140)	(0.847)	(1.861)
Age	-0.056***	-0.011	-0.034
	(0.006)	(0.039)	(0.066)
Education	0.085***	0.335**	0.552**
	(0.020)	(0.104)	(0.187)
Health	0.020	-0.638**	-1.667***
	(0.056)	(0.278)	(0.475)
Off-farm work	0.226*	-0.358	1.026
	(0.123)	(0.600)	(1.356)
Household income	0.028***	0.021	-0.102**
	(0.007)	(0.013)	(0.048)
Household size	0.119**	-0.001	0.564**
	(0.039)	(0.153)	(0.219)
Farm size	-0.010**	-0.021	0.342
	(0.005)	(0.021)	(0.218)
Bus to village	0.048	0.208	1.296
	(0.064)	(0.729)	(0.987)
Public trash can	-0.000	0.003*	0.003
	(0.000)	(0.002)	(0.005)
Province fixed effects	Controlled	Controlled	Controlled
_cons	0.645	43.138***	39.498***
	(0.560)	(2.381)	(4.934)
Rho1/0		-0.384**	-0.027
		(0.185)	(0.186)
N	919		
Log-likelihood	-3435.8219		
Wald Chi2	79.68***		
Chi2 (rho1=rho0 = 0)	5.55**		

Note: Robust standard errors are in parentheses; * p < 0.10, ** p < 0.05, *** p < 0.01.

Estimating treatment effects

Based on the estimation results of the ESR models (Table 3) and Eqs. (5a) and (5b), we conduct a counterfactual analysis to simulate the impact of Internet use on the FSB of rural residents. As we can see from the second raw of Table 4, both Internet users and non-Internet users would benefit from Internet use, and non-Internet households would benefit the most from adoption. Specifically, Internet use significantly increased the FSB score by 1.433; for those households who do not use the Internet, the FSB score would increase by 4.890 if they choose to use the Internet. These are the average treatment effect on the treated (ATT) and the average treatment effects on the untreated (ATU) which are both statistically significant. This shows that the use of the Internet can indeed significantly improve the FSB of rural residents, and if households that do not use the Internet use the Internet, the effect of improving FSB will be more obvious.

We also conducted a heterogeneous analysis of the impact of Internet use on FSB in terms of education, age, household income, and off-farm work. First, we rank the three variables of education, age and income from small to large, and find the 33% quantile and 67% quantile. Then, we divide all the variables less than 33% into group 1, those between 33% and 67% into group 2, and those more than 67% into group 3. Thus, we get three groups of education, age and income. For off-farm work, we divided the samples into two groups according to whether they participated in off-farm work. The grouping interval and sample proportion are shown in Table 4.

The simulated ATTs and ATUs have some observable characteristics, and reveal the heterogeneity of the impact of Internet use on FSB. For the variable of education, household heads with high education years have a greater impact on FSB using the Internet than household heads with low education years, and the higher the education years, the greater the difference in this effect. This is consistent with the study of Chen et al. (2018). Residents with a higher education level have a more correct understanding of FSB (Bai et al. 2014, Turnbull-Fortune and Badrie 2014), and are more motivated to use the Internet to improve FSB. On the other hand, the rural residents with low education lack basic food safety knowledge (Liu and Niyongira 2017), and the information transmitted on the Internet will have an impact on their subjective consciousness. Differences in education levels are usually a distinguishing feature that leads to differences in the digital divide, especially in terms of Internet use (Deursen et al. 2011).

At the same time, we also focus on the impact of the age, off-farm work of the household heads and household income on FSB. The four variables all significantly affect the Internet use of residents, so we focused on the impact of Internet use on FSB of rural residents with different education, age, income, and non-agricultural employment. The effect of Internet use on the improvement of FSB is affected by the age of household heads, and it is more helpful to promote young household heads to regulate FSB. Deursen et al. (2011) found that the elderly lacked Internet skills related to media, and access to Internet information was restricted, which led to the Internet use to have a greater impact on young people's FSB. The results clearly show that off-farm work has a positive and significant impact on FSB, and the improvement effect of Internet use on FSB of rural residents who do not participate in non-agricultural work is more obvious. This is different from the result that Min et al. (2020) found that Internet use promotes the non-agricultural employment of rural residents, which may be because they do not engage in other jobs in their spare time, increasing the time of using the Internet. For the variable of income, the results of ATT and ATU are both significant, indicating that the use of the Internet has a greater impact on high-income households, which may be because high-income households have more Internet channels to obtain food safety information (Zimmerman, 2018). These results generally confirm that Internet use can promote household income and play an active role in improving the level of household economic stability of rural residents (Hübler and Hartje, 2016)

Table 4

Treatment effects of Internet use.

Variables	ATT	ATU	Percent (%)
All samples	1.443***	4.890***	100%
Education (3 quantiles)			
a. Edu≤6	1.719***	5.119***	43.28%
b. 6<Edu≤9	1.178***	4.416***	41.52%
c. Edu>9	1.564**	4.762***	15.20%
Diff.(b-a)	-0.541***	-0.703	
Diff.(c-a)	-0.155***	-0.357	
Age (3 quantiles)			
a. Age≤52	1.720***	5.464***	33.46%
b.52<Age≤61	1.245***	5.011***	33.46%
c. Age>61	1.241***	4.725***	33.09%
Diff.(b-a)	-0.475	-0.453	
Diff.(c-a)	-0.479	-0.739	

Off-farm work			
a. Yes	0.339	4.659***	32.34%
b. No	2.124***	4.936***	67.66%
Diff.(b-a)	1.786***	0.277	
Household income (3 quantiles)			
a. Hincome⩽5	0.381**	4.509**	35.22%
b. 5<Hincome⩽11.7	0.874***	4.547***	31.70%
c. Hincome>11.7	2.707***	6.864***	33.09%
Diff.(b-a)	0.493**	0.038	
Diff.(c-a)	2.326***	2.355***	

Note: Robust standard errors are in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Possible impact channels

Food safety knowledge acquisition

Confirming that the use of the Internet has significantly improved the FSBs of residents, we analyzed the possible impact channel of the Internet on FSB. According to a survey conducted by Välimäki et al. (2007) in a hospital in southern Finland, most discharged patients believe that using the Internet to deliver health information to patients is very important or extremely important, and about one in ten people prefer to obtain health information from professional literature or the Internet. Taylor et al. (2001) found in a survey of patients and their families in rural and urban genetic clinics that nearly half (47%) of patients had used the Internet to obtain health information before making an appointment, and this behavior was largely self-initiated. According to the survey data of 32,139 adults in the National Health Interview Study (NHIS), Amante et al. (2015) found that 3.63% of people reported using online health chat rooms, and 43.55% would actively search for health information on the Internet. Xiong and Zuo (2019) surveyed the elderly who use the Internet, and the results show that the improvement of mobile Internet literacy and mobile Internet information literacy significantly improve the quality of information obtained among the elderly. Logsdon et al. (2015) found that in rural areas in the southern United States, 33% of adolescent mothers would actively search for health information on the Internet and share it with others, and 46% of adolescent mothers changed their health behaviors because of information found on the Internet.

Many studies have shown that users will actively obtain health information from the Internet when the Internet is available. Therefore, we assume that Internet use will improve residents' attitudes towards food safety knowledge acquisition (FSKA), and measure it by asking whether residents will obtain information actively. food safety knowledge. Similarly, the use of the Internet may be affected by endogeneity, so we employ the endogenous switching probit (ESP) model that can obtain an unbiased estimate of FSKA. To make further estimation to determine the impact of Internet use on FSKA, we estimate the differences between FSKA of rural residents in the two regimes of Internet use and non-Internet use, and conducted a counterfactual analysis to derive the average treatment effect of Internet use.

Table 5 shows the factors that affect the FSKL of Internet users and non-users and the estimated results of the selection equation for Internet use are shown in the second column of Table A5. In the model for the FSKA of household members, for households using the Internet (column 2), independent variables such as education level of the household head, household income and farm size are significantly related to the FSKA of household member. Among them, farm size has a negative impact on FSKA, contrary to the view that farm size promotes smart phone use and household income (Ma et al. 2018b, Ma et al. 2020), which may be due to regional differences. In addition, the age and education level of the household head significantly affect the FSKA of household members who do not use the Internet (column 3). Regardless of whether the family uses the Internet or not, rural residents with a high level of education are always more inclined to learn or collect food safety knowledge, which is consistent with Losasso et al. (2012) and Turnbull-Fortune and Badrie (2014). For households with and without Internet, other important variables are different.

In the counterfactual analysis, as we can see from the last column of Table 6, both Internet users and non-users will benefit from use, and users will benefit more from adoption. Specifically, Internet use significantly increased the probability of FSKA by 29.7 percentage points; for those households who do not use the Internet, the probability of FSKA would increase by 3.8 percentage points if they choose to use the Internet. This shows that the Internet use can indeed enable them to actively acquire food safety knowledge, and the improvement effect of FSKA is more obvious when users use the Internet.

Table 5

Estimation results of the ESP.

Variables	Internet use=1	Internet use=0
Gender	0.045	0.210
	(0.148)	(0.306)
Age	-0.003	0.022*
	(0.006)	(0.013)
Education	0.087***	0.096**
	(0.018)	(0.034)
Health	-0.059	-0.024
	(0.055)	(0.086)
Off-farm work	0.159	-0.361
	(0.118)	(0.262)
Household income	0.006**	0.011
	(0.003)	(0.013)
Household size	0.037	-0.057
	(0.027)	(0.044)
Farm size	-0.026*	-0.047
	(0.016)	(0.046)
Bus to village	-0.081	-0.001
	(0.099)	(0.162)
Public trash can	0.001	-0.001
	(0.000)	(0.001)
Province fixed effects	Controlled	Controlled
_cons	-0.698	-2.522**
	(0.436)	(0.900)
N	919	
Log-likelihood	-925.3598	
Wald Chi2	464.47***	
Chi2 (rho1=rho0 = 0)	1.00	

Note: Robust standard errors are in parentheses; * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 6

Treatment effects of Internet use on FSKA

Outcome variables	ATT	ATU
FSKA	0.297***	0.038*
(1=Yes; 0=No)	(0.005)	(0.007)

Note: Standard errors are in parentheses.

Food safety knowledge level

Residents' FSB largely reflect their food safety knowledge level (FSKL) (Cody and Hogue 2003, Dharod et al. 2004), and based on the previous results, we speculate that Internet use may increase residents' FSKL. Consumers' awareness of food safety is a major issue related to healthy lifestyles and disease prevention, and health awareness has a high positive impact on consumer behavior (Losasso et al. 2012, Hansen et al. 2018, Alemayehu et al. 2021). Whether consumers are willing to change behaviors that do not meet safe food storage and preparation practices is closely related to consumers' FSKL. Zhu and Qin (2015) confirmed that residents' food safety knowledge of livestock and poultry products has a significant impact on their purchase decisions, and urban residents obtain food safety information through television and newspapers. Personal contact with food safety related information will affect their food safety concept, and Ha et al. (2019) pointed out that TV and radio programs are important media to share food safety knowledge with consumers. In the information age, residents who use the Internet pay more attention to food safety (Zhang et al. 2019), and the Internet is the best way to spread food safety knowledge (Nesbitt, et al. 2014).

Internet usage significantly improved the residents' FSB, and FSB was affected by FSKL, so we assume that Internet usage improves FSB by increasing residents' FSKL. To understand the FSB of rural residents, we refer to Zhu and Qin (2015), Gündüz et al. (2017), Chen et al. (2018)'s practice to ask respondents to make correct and false judgments on six food safety issues, as shown in Table A6 in the appendix. If the resident judges correctly, one point is added, and the resident judges incorrectly, no score is given. The higher the FSKL score, the higher the residents' food safety knowledge. Similarly, the use of the Internet may be affected by endogeneity, so we choose an ESR model that can obtain unbiased estimates. To make further estimates to determine the impact of Internet use on FSKL, we conducted a counterfactual analysis to analyze the difference between FSKL in the context of Internet users and non-users.

Table 7 shows the factors that affect the FSKL of Internet users and non-users (the third column of Table A5 shows results from the first stage of ESR). In the FSKL of household members, for households using the Internet (column 2), independent variables such as gender and education level are significantly related to the FSKL of household members. This result illustrates the interactive influence of the use of the Internet and these independent variables on FSKL. In addition, the age and educational level of the head of the household significantly affect the FSKL of household members who do not use the Internet (column 3). Gündüz et al. 2017, Chen et al. (2018) also found that there is a significant correlation between consumers' FSKL and education level. The results also show that regardless of whether the family uses the Internet or not, male heads of households always have a higher FSKL. But Lange et al. (2016)

pointed out that boys who rarely cook at home have a higher FSKL, which is different from the higher FSKL of men in our results. This may be because we paid attention to the important variable of Internet use. Other important variables are different for households who use and do not use the Internet.

In the counterfactual analysis, as we can see from the last column of Table 8, both Internet users and non-users will increase FSKL from their use, and households using the Internet will increase FSKL even more. The finding suggests that Internet use significantly increased the FSKL by 1.62; for those households who do not use the Internet, the FSKL would increase by 0.722 if they choose to use the Internet. The ATT and ATU estimates account for the observed and unobserved factors that lead to sample selection bias, both of which are statistically significant. This is consistent with research results of Nesbitt et al. (2014), Zhu and Qin (2015).

Table 7

Estimation results of the ESR.

Variables	Internet use=1	Internet use=0
Gender	0.478**	0.290
	(0.167)	(0.221)
Age	-0.005	0.026
	(0.007)	(0.054)
Education	0.026	0.028
	(0.022)	(0.099)
Health	0.027	-0.103
	(0.058)	(0.072)
Off-farm work	0.060	-0.224
	(0.131)	(0.360)
Household income	0.003	-0.008
	(0.003)	(0.033)
Household size	0.030	-0.045
	(0.029)	(0.135)
Farm size	-0.004**	0.014
	(0.002)	(0.045)
Bus to village	0.034	-0.092
	(0.121)	(0.169)
Public trash can	-0.000	0.000
	(0.000)	(0.001)
Province fixed effects	Controlled	Controlled

_cons	1.106** (0.502)	-1.057 (2.509)
N	919	
Log-likelihood	-1921.343	
Wald Chi2	53.42***	
Chi2 (rho1=rho0 = 0)	3.88**	

Note: Robust standard errors are in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 8

Treatment effects of Internet use on FSKL.

Outcome variables	ATT	ATU
FSKL	1.632*** (0.016)	0.722*** (0.020)

Note: Standard errors are in parentheses.

Concluding remarks

The Internet use, which has a wide-ranging impact on residents' lives, has been extensively spreading in China, even in rural regions. The Internet enhances the flow of information by supporting the access of multiple platforms, and affects the food safety behavior of residents through multiple channels. This study examined the possible effects of Internet use on the FSB of rural residents in China by evaluating the use of Internet in rural areas. We use household survey data from three provinces (Henan, Hunan, and Hubei) in Central China, and apply a ESR model and counterfactual analysis to explore the use of Internet by rural residents and their impact on FSB. This is the first comprehensive study to identify the statistical association between Internet use and FSB and to further explore possible impact channels.

Our findings show that Internet use and FSB are significantly related. With respect to the factors that influence rural residents' decisions to use Internet, the empirical results indicated that the decision of rural households to use the Internet is related to age and education level of household head, family income, and family size. We also showed that the FSB of rural residents who use the Internet is affected by their education level, health status, and family income, while the FSB of residents who do not use the Internet is affected by their education and household size. Regardless of whether the family uses the Internet or not, rural residents with a high level of education always have a more standardized FSB. In a counterfactual analysis, for households who use the Internet, the process from never using the Internet to using the Internet increases their FSB scores by 2.486; if the households who do not use the Internet uses the Internet, their FSB scores increase by 4.867. In addition, Internet use may improve food safety behaviors by encouraging residents to actively collect food safety knowledge and improving food safety knowledge.

This paper provides specific directions for improving the food safety behavior of rural residents. The main finding is that the use of Internet has significantly improved the FSB of rural residents, and if households who do not use the Internet use the Internet, the effect of improving FSB will be more obvious. However, considering the relatively high popularity of smartphones among rural residents, the further promotion of Internet may be limited. Hence, strategies for promoting the FSB of rural residents in the future should consider the spread of food safety information on the Internet, and consider providing more types of information for rural residents using Internet. Furthermore, the findings of this study to some extent support the concept of “Internet plus food safety”. We would like to recommend the government to design and promote more specific measures regarding “Internet plus Agriculture”, such as “Internet plus food industry system”, “Internet plus food safety supervision”, and “Internet plus food sales”, which may play a substantial role in improving food safety behavior.

Finally, there are some limitations in this study. First, this study uses the cross-sectional data of rural residents in 2019. Future research can use the panel data to examine the changing trend of rural residents' Internet use and FSB. Second, this research only focuses on whether the Internet is used or not, and does not focus on the intensity and scope of Internet use, which may have more policy implications and require a comprehensive analysis in future research. Finally, the impact of Internet use and FSB in this study are limited to FSKA and FSKL, while more possible channels can be explored in future study, such as the promotion of food information sharing and the increase of food event discussion.

Appendix

Table A1

Falsification test for the validity of the proposed IV for Internet use.

Variables	Internet use	FSB	FSKA	FSKL
Penetration	3.064***	0.979	0.348	0.671
	(0.214)	(3.255)	(0.531)	(0.562)
Other variables	Controlled	Controlled	Controlled	Controlled
Province fixed effects	Controlled	Controlled	Controlled	Controlled
_cons	0.690	39.429***	-2.223	0.183
	(0.549)	(4.634)	(0.882)	(0.708)
N	919	235	235	235
F/Wald chi2	458.93***	6.79***	30.50***	1.72*
R-squared/Pseudo R2	0.330	0.235	0.078	0.090

Note: Robust standard errors are in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A2

Sample distribution of data used in this study.

Province	Number of sample county	Number of sample town	Number of sample village	Number of sample household
Henan	6	18	36	360
Hubei	6	18	36	360
Hunan	6	18	36	360
Total	6	54	108	1080

Table A3

Questions Concerning FSB.

Please answer the frequency of the following household food safety behaviors.

Q1: Wash hands before every meal.
1=Never; 2=rarely; 3=occasionally; 4=often; 5=always.
Q2: The frequency of eating leftovers from the night.
1=Every meal; 2=every Day; 3=every few days; 4=every week; 5=never.
Q3: Pay attention to the production date and shelf life when buying food.
1=Never; 2=rarely; 3=occasionally; 4=often; 5=always.
Q4: Pay attention to raw materials and ingredients when buying food.
1=Never; 2=rarely; 3=occasionally; 4=often; 5=always.
Q5: Pay attention to food safety label when buying food.
1=Never; 2=rarely; 3=occasionally; 4=often; 5=always.
Q6: Pay attention to storage when buying food.
1=Never; 2=rarely; 3=occasionally; 4=often; 5=always.
Q7: Cut raw and cooked food at home with different knives.

1=Yes; 0=No.
Q8: Cut raw and cooked food at home with different cutting boards.
1=Yes; 0=No.
Q9: Washing frequency of cooking boards at home.
1= More than a week; 2=Every week; 3=Every few days; 4=Every Day; 5=Every meal.
Q10: The frequency of boiling or other disinfection of the cutting board.
1= More than a week; 2=Every week; 3=Every few days; 4=Every Day; 5=Every meal.
Q11: The frequency of kitchen waste disposal.
1=More than a week; 2=Every week; 3=Every few days; 4=Every Day; 5=Every meal.
Q12: The state of light in the kitchen.
1=Very bad; 2=Bad; 3=In general; 4=Good; 5=Very good.
Q13: The ventilation in the kitchen.
1=Very bad; 2=Bad; 3=In general; 4=Good; 5=Very good.
Q14: The frequency of thorough scrubbing in kitchen.
1=Every year; 2=Every half year; 3=Every quarter; 4=Every month; 5= Every week; 6=Every 2-3 days; 7=Every day; 8=Every meal.

Source: Books related to food safety.

Table A4

Food safety behavior scores.

Province	Obs	Mean	Std. Dev.	Min	Max
Henan	360	42.117	7.836	20	64
Hubei	359	46.206	7.419	25	62
Hunan	360	44.081	7.007	24	62
Total	1079	44.133	7.607	20	64

Table A5

The estimated results of the selection equation for Internet use.

Variables	Internet use	
	FSKA	FSKL
Penetration	3.046***	2.946***
	(0.226)	(1.073)
Gender	-0.128	-0.145
	(0.147)	(0.153)
Age	-0.056***	-0.055***
	(0.006)	(0.007)

Education	0.087***	0.087***
	(0.021)	(0.020)
Health	0.023	0.007
	(0.056)	(0.065)
Off-farm work	0.218*	0.212*
	(0.127)	(0.125)
Household income	0.029***	0.028***
	(0.008)	(0.008)
Household size	0.122**	0.118**
	(0.039)	(0.042)
Farm size	-0.011**	-0.011**
	(0.004)	(0.004)
Bus to village	0.033	0.034
	(0.064)	(0.066)
Public trash can	-0.000	0.000
	(0.000)	(0.000)
Province fixed effects	Controlled	Controlled
_cons	0.734	0.790
	(0.557)	(0.867)

Table A6

Questions Concerning FSKL.

Do you strongly agree, agree, neutral, disagree or strongly disagree with this statement?	True/ False
Q1: Drinking ice water and drinks often can lead to kidney deficiency.	F
Q2: Straight cucumber is sprayed with medicine; curved cucumber is natural.	F
Q3: Crayfish are genetically modified and never eaten by foreigners.	F
Q4: MSG is poisonous when heated.	F
Q5: According to the theory of human acid-base constitution, eating alkaline food is healthier.	F
Q6: Eating a lot of foods containing vitamin C can prevent and treat colds.	F

Source: Books related to food safety.

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