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Evaluation of food safety among rural households: A study of measurements, determinants and policy implications

Bewertung der Lebensmittelsicherheit in ländlichen Haushalten: Eine Studie zu Messungen, Determinanten und politischen Implikationen

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Summary

The primary purpose of this study was to explore the rural households' food safety level in Punjab province of Pakistan. The participants were 200 randomly selected rural households. Local knowledge, traditions, culture, and experiences were taken into consideration, and 44 food safety items were developed, and classified considering the World Health Organization's "Five Keys" for food safety. A food safety index was developed based on factor analysis of these keys, namely "Separate," "Keep clean," "Well-cooked," "Keep at safe temperature" and "Safe water and raw material." Before application of ordered logistic regression procedure, the households were clustered into low, medium and high food safety groups. The overall average food safety index score was calculated as 0.59. The results of the regression analysis showed that education level of household-head, education of woman handling and cooking food, off-farm occupation of household-head, operational land, knowledge of foodborne-illness, knowledge of cross-contamination, knowledge of danger-zone, quality of drinking water, development level, drainage system, and house conditions influenced the food safety level significantly. The education programs at local dispensaries in local language, rebuilding roads, maintenance of drainage system, and provision of proper garbage disposing system should be ensured in the rural area to increase food safety level.

Keywords: Determinants of food safety, factor analysis, five keys of food safety, ordered regression, rural households

Introduction

Food safety is a global primary matter due to immense impact on the economy and people's health all over the world (WHO, 2006). What is food safety signifying that "the degree of confidence that food will not cause sickness or harm to the consumer when it is prepared, served and eaten according to its intended use" (FAO/WHO, 2002; Unusan, 2007). The intake of unsafe food causes the major problem of foodborne illnesses that lead millions of people to ill or die. Therefore, it is reported that in developing countries one-third of the total population experienced the foodborne diseases (Lim et al., 2016).

With the development of science, every country is taking food safety precautions to lower the issues related to food and health by improving the sanitary and hygienic condition of food presented to the consumer and by providing awareness about healthy eating to food preparers (Javed, 2106). Similar to other countries, food-related diseases are also rooted in Pakistan and prevalence of various types of pathogens are common in several foods. Permissible data about the foodborne illnesses in Pakistan is difficult to obtain because of the absence of monitoring and infection control (Akhter, 2015).

Additionally, many food safety-related problems and challenges are faced in Pakistan. The main victims of the foodborne diseases were especially children and infants with high morbidity and mortality due to foodborne diseases (Akhtar et al., 2014). Different forms of hepatitis, typhoid, influenza, etc. are some foodborne diseases which are most common in Pakistan. The main causes and modes of infection are not the same for each disease, but the primary source of foodborne illness in Pakistan is poor sanitary conditions, poverty, illiteracy, lack of awareness, and absence of food standard. Similarly, water is also a major source of such diseases (Javed, 2016). In third world countries, the unsafe water is still the primary cause of foodborne diseases (Shiklomanov, 2000).

If food safety rules are followed from production to consumption, the foodborne illnesses will probably be preventable. Thus, food producers will supply pathogen and bacteria free food. The home food preparers are the last line of defence against the foodborne diseases, and they are very critical to take adequate measurements and avert these diseases (Unusan, 2007; Redmond & Griffith, 2003). Limited knowledge of preventing foodborne diseases existed among the home food preparers (Karabudak et al., 2008) and due to misinterpretation of symptoms of foodborne diseases, the actual number of food poisoning cases would not be reported (Lim, 2016).

At home, food can be handled wrongly or ineffectively at many places during preparation, storing and consuming which increase the risk of the foodborne diseases (Mederios et al., 2001). They also reported the root causes of foodborne illnesses at home; contaminated raw food material, improper cooking, and consumption of food with unhealthy and poor hygienic source. Similarly, 50% to 87% reported foodborne diseases outbreaks had been associated with the home (Redmond & Griffith, 2003). Unsafe food preparation and consuming raw animal originated foodstuff like milk and eggs are also resulting in the foodborne illnesses at home (Klontz et al., 1995).

Food safety required proper handling, cooking and storing the foods from production to consumption. In this chain of supply of food, home is vital to reduce foodborne illness risk to a significant level. Earlier studies conducted worldwide with different masses in different societies assessed the knowledge, behaviour, attitude toward the food safety for last decades (Woodburn and Raab, 1997; Bruhn and Schutz, 1999; Burke et al., 2016; Patil et al., 2005; Sanlier, 2009; McIntyre et al., 2013; Sani and Siow, 2014; Leal et al. 2017; Jevsnik et al., 2008; Omemu and Aderoju, 2008; Kunadu et al. 2016). Exclusively, they determined the food safety knowledge and practices of focus groups of different ages, students, and residents representing various societies. They emphasized food safety practices and knowledge which contributes to food safety and lowers the hazards associated with food. Considering earlier work on food safety practices, a research gap was observed on the estimating the food safety index and analysing its determinants to help food policymakers to focus directly on the factors affecting the food safety significantly. Therefore, the primary purpose of this study was to assess the food safety practices adopted on regular bases by food preparers and handlers of rural families, and their knowledge of some essential elements regarding food (foodborne illness, cross-contamination, danger zone, etc.). Moreover, these food safety practices were incorporated in estimating the food safety index with the assumption of positively contributing to the provision of safe food at home of the rural area in Punjab. The specific objectives of this study are presented below:

Objectives of the study

1. Exploring the adopted food safety practices at the household level of the rural area
2. Exploring the basic knowledge of household food preparers
3. Exploring eating behavior of family members
4. Estimating the food safety index at the household level based on adopted practices
5. Analyzing the determinants of food safety level and developing some policy recommendations

Materials and Methods

Study area

The study area was Punjab province of Pakistan. It is the second largest province after Baluchistan with an area of 205344 km^2. Figure 1 shows the Punjab province. The plain area is predominated in Punjab with some hilly areas in the North-West and the extreme South-West. It consists of 36 districts with more than 100 million population according to the latest census (2017) which is comprised 52.94% of the total country population. The general literacy rate is 59.6%. It is an agricultural province and contributes to food grain production of the country by 68% (Government of Punjab, 2017). The total number of households in Punjab (Rural and Urban) is 17.11 million out of which 10.71 million still living in rural areas (PBS, 2017).

For this study, the multi-stage sampling technique was adopted. At the first stage the districts were selected based on two criteria; 1) the largest number of households, 2) having rural population. Based on these criteria, the Lahore district was excluded due to absence of rural population. Data about the number of households were taken from Pakistan Bureau of Statistics, Government of Pakistan. Therefore, the five districts with the largest number of households were selected; Faisalabad (1.23 million), Rawalpindi (0.89 million), Multan (0.76 million), Gujranwala (0.75 million), and Rahim Yar Khan (0.70 million).

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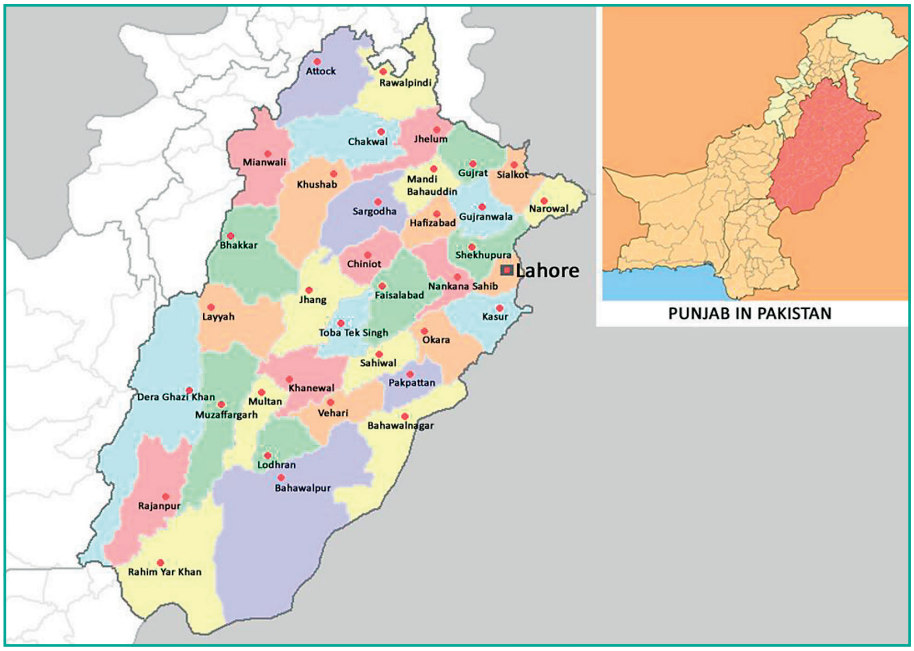

FIGURE 1: *Map of the Study area with Districts Location (wikia.org, 2019).*

After the selection of the districts, their sub-divisions of districts, administratively called the Tehsils were selected based on the largest number of households living in rural area. Thus, the Faisalabad Sadar Tehsil (0.21 million) from Faisalabad district; the Rawalpindi Tehsil (0.18 million) from Rawalpindi district; the Multan Sadar Tehsil (0.19 million) from Multan district; the Gujranwala Sadar Tehsil (0.09 million) from Gujranwala district; and the Rahim Yar Khan Tehsil (0.14 million) from Rahim Yar Khan district were chosen.

The sampling procedure continued by selecting one Union Council (Administratively a smaller place of residency) from each pre-selected Tehsil, and four villages from each Union Council. Then ten households from each village were randomly selected (a total of 200 households), and this made the sample size of this study.

TABLE 1: Description of explanatory variables.

Variables	Definition
Age of the household head (male)	Number of years
Age of woman responsible for food handling and cooking	Number of years
Education level of the household head (male)	Actual schooling years attended
Education level of the woman as the second head of the family	Actual schooling years attended
Household members	Number of family members
Market distance from home	Km
Off-Farm source Income of male head	1 = Yes and 0 = No
Operated Land	Acres
Having university graduated family member	1 = Yes and 0 = No
Knowledge of foodborne illness	1 = Known and 0 = unknown
Knowledge of danger zone	1 = Known and 0 = unknown
Knowledge of cross-contamination	1 = Known and 0 = unknown
Quality of drinking water	Very good = 5; Good = 4; Normal = 3; Bad = 2; Very Bad = 1
Drainage system in village or town	Very good = 5; Good = 4; Normal = 3; Bad = 2; Very Bad = 1
Development level in village or town	Very good = 5; Good = 4; Normal = 3; Bad = 2; Very Bad = 1
Average medical expenditures per month	Monthly medical expenditure (Rs)
House condition	3 = Good (Cemented) 2 = Moderate (Cemented and Mud), 1 = Bad (Mud)

Questionnaire design

The basic questionnaire consisted of many statements indicating the possible practices contributing toward food safety at home. The questionnaire had different parts of gathering information of socio-economic characteristics, the basic knowledge on the consequences of unsafe food consumption like foodborne illnesses, etc. Moreover, some statements about eating behavior were also asked.

Preliminary study and alteration of the questionnaire

The pilot/preliminary study was conducted with 30 households in rural areas. The purpose of pilot study was to confirm the validity of survey tool. The results of the pilot study were further used to judge lack of some practices adopted by food preparers at home in rural areas of Punjab. Therefore, the necessary food safety practices were added in the final survey tool. In the end, the final questionnaire contained 44 statements regarding food safety. The five keys of WHO on food safety, socioeconomic characteristics, and cultural and traditional values of the locality were extensively utilized to select these statements (2006).

Data collection and scoring of food safety practices

The questionnaires were administered by face to face interviews with the heads of the households, main food preparers, and handlers of foodstuff. The main problem faced during the interview was the traditional and cultural barriers in the rural community to interact with the food preparers because in the rural area of Punjab food is commonly handled and prepared by women after food raw material and stuff entered in the boundary of home. Because most of the women were shy to interact with the researchers, the interviews were conducted in the presence of their husbands or sons.

The data were collected and entered into the statistical software packages to analyze and extract the suitable results. Proper codes for the socioeconomic characteristics were prepared to enter data. The statements regarding food safety were scored based on the adapted practice's contribution toward food safety level at home. In this way, the answer is given by the head and food preparers was scored „1“ if it was considered to have the positive influence on food safety otherwise “0”. For example, the practices of hand washing before handling the raw food material was scored as one if applied, and 0 if ignored.

Adoption index calculation for each food safety practices

The adoption level of each food safety practices was assessed, and the

average level of the households in five keys (clean, separate, well-cooked, keep at the safe temperature, and safe water and raw material) were analyzed. The adoption index for each 44 food safety practices was calculated as described by Yila and Resurreccion (2012).

Adoption Index of Practices (i) = f/n

Where;
f = Number of the adapters of a practice
n = Sample size

Estimation of food safety index

The total 44 food safety statements were distributed into five dimensions of food safety categories described by WHO. A total 18 food safety statements fell in the "clean" category, while 7 statements in the "separate" category, 4 statements in the "well-cooked" category, 5 statements in the "keep at safe temperature" category, and 10 statements in the "safe water and raw material" category (Table 2). This means that the clean dimension of food safety takes a maximum value of 18 (the highest attention of keeping the food environment and personal body clean) and minimum value 0 (denotes the ignorance of food handlers and preparers to keep the environment and personal body clean). The other dimensions of the 44 food safety statements were also interpreted in the same method. Under each dimension, these maximum and minimum values were used to make the food safety dimensions standardized which helped to make food safety index values simple to interpret. For standardization, the following formula described by Freudenberg (2003) was used when maximum value

TABLE 2: Food safety statements classified under the five keys.

Food Safety Measurement Statements	Adopter's. no.	Adopter (%)	Non adopter (%)	Adoption index
Keep clean				**0.61**
Do you have good sanitary condition of your kitchen?	158	79.0	21.0	0.79
Do you have kitchen made of cement?	143	71.5	28.5	0.72
Do you have closed kitchen?	109	54.5	45.5	0.55
Do you have good water system in kitchen?	103	51.5	48.5	0.52
Is kitchen washed and cleaned on daily basis?	187	93.5	6.5	0.94
Do you have kitchen far away from toilet?	156	78.0	22.0	0.78
Do food preparers properly wash hands with anti-germ soap before kneading flour?	67	33.5	66.5	0.34
Do your all family members wash hands with soap after using bathrooms?	135	67.5	32.5	0.68
Do family members wash hands with only water before eating meals?	168	84.0	16.0	0.84
Do family members wash hands using soap before eating meals?	141	70.5	29.5	0.71
Do family members dry hands after washing with disposable tissues?	113	56.5	43.5	0.57
Do food preparers frequently take care about washing/cleaning utensils before using?	146	73.0	27.0	0.73
Do food preparers wash the knife before using?	111	55.5	44.5	0.56
Do food preparers wash their hands before cutting vegetables?	107	53.5	46.5	0.54
Do food preparers wash their hands using soap before handling raw food material?	77	38.5	61.5	0.39
Do food preparers use boards for cutting vegetables/food material?	45	22.5	77.5	0.23
Do food preparers use separate knives for vegetables and meat?	109	54.5	45.5	0.55
Do food preparers clean the meat properly before storing in fridge?	126	63.0	37.0	0.63
Separate				**0.65**
Eating and cooking place is separated?	105	52.5	47.5	0.53
Do food handlers keep dry fruits or food items (spices) in closed box?	142	71.0	29.0	0.71
Do food handlers take care about not keeping food items near cleaning material?	162	81.0	19.0	0.81
Store food in containers with lid while putting in freezer or refrigerator	117	58.5	41.5	0.59
Do food handlers take care about keeping raw materials below cooked food in freezer/refrigerator	49	24.5	75.5	0.25
Do family members take care about keeping medicine and food items separate.	153	76.5	23.5	0.77
Is food items covered properly?	184	92.0	8.0	0.92
Well-cooked				**0.64**
Meat, chicken and fish etc. cooked thoroughly with no visible blood?	200	100	0.0	1.00
Reheat the cooked item properly?	150	75.0	25.0	0.75
Do you have microwave oven at home?	19	9.5	90.5	0.10
Do you boil the milk before storing into fridge?	144	72.0	28.0	0.72
Keep at safe temperature				**0.51**
Do food handlers take care about overstock in freezer/refrigerator?	20	10.0	90.0	0.10
Do food handlers take care about not putting hot food in fridge?	130	65.0	35.0	0.65
Do food handlers frequently store vegetables and fruits in fridge?	148	74.0	26.0	0.74
Food handlers store potatoes and onion in dark room but on floor?	149	74.5	25.5	0.75
Do any of your family members take care about temperature of freezer/refrigerator?	67	33.5	66.5	0.34
Safe water and raw material				**0.55**
Are your flour and food items safe from the mice, lizard and cockroach etc.?	144	72.0	28.0	0.72
Do food handlers dry rice in sun and store it properly?	123	61.5	38.5	0.62
Do you have proper storage for wheat at home to use over the year?	165	82.5	17.5	0.83
Do food handlers keep onion and potatoes together?	97	48.5	51.5	0.49
Do you have good source of drinking water (Mineral or filter plant)	77	38.5	61.5	0.39
If you store canned or packed items and once you opened them; do you consume them before spoiling?	119	59.5	40.5	0.60
Do your family members take care about expiry date of packed/canned food items?	68	34.0	66.0	0.34
Do ladies work or cook the food when they have flue, diarrhoea?	22	11.0	89.0	0.11
Do food handlers use the same water for cleaning and cooking food which is used for drinking purpose?	150	75.0	25.0	0.75
Do food handlers use separate water for food preparing and other purpose such as washing clothes and cleaning the house?	142	71.0	29.0	0.71

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considered toward more food safety. Therefore, in the current study, every dimension of food safety needs the high value to maintain good food safety level at home because every statement required no ignorance for enjoying safe food at home.

$$\left(\frac{X-minimum\ Value}{Maximum\ Value-Minimum\ Value}\right)$$

Here; X = Actual value of an indicator

After standardization, the factor analysis procedure, a positive and data reduction technique for estimating factor loadings (Gomez- Limon and Fernandez, 2010; Fodor, 2002) was applied. The primary purpose of estimating the factor loadings was to calculate the weights for the aggregations of dimensions based on their variance explained in a component.

For assessing the sampling adequacy and relevancy of explanatory variables in factor analysis, the Kaiser-Meyer-Olkin (KMO) test and Bartlett's Test of Sphericity were applied. The value of KMO test varies between 0 and 1. As this value decreases the feasibility of factor analysis also decreases (Hair et al., 1998; Tabachnick and Fidell, 2007; Williams, 2010). The KMO test values are evaluated as 0.90 or greater (very good), 0.80 (good), 0.70 (moderate), 0.60 (low), 0.50 (very bad), and less than 0.50 (not acceptable). For retaining the factors, the "Eigenvalues" and the "Scree tests" were used. In practice, the factors having an eigenvalue greater than1 are selected. The second method is the "Scree plot" which graphically illustrates the Eigenvalues and examines the natural bend in data. The number of data points above the bend or break point is considered as the retained factors (Costello and Osborne, 2005). The mathematical model of factor analysis was explained in following form (Ness, 2002).

$$X_1 = b_{11} f_1 + b_{12} f_2 + \ldots\ldots\ldots\ldots + b_{1k} f_k + u_1$$
$$X_2 = b_{21} f_1 + b_{22} f_2 + \ldots\ldots\ldots\ldots + b_{2k} f_k + u_2$$
$$\vdots$$
$$X_p = b_{p1} f_1 + b_{p2} f_2 + \ldots\ldots\ldots\ldots + b_{pk} f_k + u_p$$

Here
f_k = factor weight in the measurement of p^{th} variable of K^{th} factor
b_{pk} = Correlation between the p^{th} variable and K^{th} factor (factor loading)
u_p = Unexplained variation by Factor

Weights estimation; Once the factor loadings were estimated which show the variance explained by each dimension of a component retained, the next step was using factor loadings to get the weights for each dimension. Due to lack of prior criteria about each food safety dimension, the highest factor loading was used to group the five dimension of food safety into an intermediate food safety index like Nicoletti et al. (2000). Hereafter the following formula was used to estimate the weight.

$$w_{Fi} = \frac{(factor\ loading_{Fi})^2}{eignvalue_i}$$

Here, w_{Fi} is the weight for each food safety dimension (Clean, Separate, Well-Cooked, Keep at the safe temperature, and Safe water and raw material). F is food safety dimension, and I is component retained. Every dimension was weighted and summed up to estimate the Intermediated Food Safety Indices IFSI (equal to the number of the component retained).

$$IFSI_{ik} = \sum_{F=1}^{F=n} w_{Fi} I_{Fk}$$

Where $IFSI_{ik}$ is the intermediate food safety index for component i, the household k. The w_{Fi} represents the weights of dimension F in i component estimated in the previous equation, and I_{Fk} represents the standardized values of dimension F for household k.

Finally, each intermediate food safety Index was aggregated by using the following formula to find Food Safety Index (FSI) for K^{th} household.

$$FSI_k = \sum_{i=1}^{n} \alpha_i IFSI_{ik}$$

Where α_i the weights was applied to intermediate food safety indices, which is estimated as

$$\alpha_i = \frac{eignvalue_i}{\sum_{i=1}^{n} eignvalue_i}$$

Categorizing the households based on food safety index (FSI)

The main aim of categorizing the households without subjective interference was to find the homogeneous group of sampled households based on FSI. Therefore, these three groups were used to determine the factors affecting the food safety in rural areas. For this, cluster analysis was performed to cluster the households into three groups named as low, moderate, and high food safety households. The cluster analysis gathered the households into three Food Safety Groups, and within each cluster, the households were alike to each against those of another cluster (Hair et al., 2009). Haq et al., (2016) and Shahbaz et al., (2017) also applied cluster analysis in their research for fulfilling the purpose of finding groups of homogeneous objects.

Determinants of food safety of households

The resulted groups of the cluster analysis were used to explore the determinants of the food safety of households. Since households regarding food safety were divided into three ordered and independent groups such as low, moderate, and high, the ordered logistic model was applicable. The dependent variable for the ordered logit model was coded as 0 = Low food safety Households, 1 = Moderate Food Safety Households and 2 = High Food Safety Households. The specific form of the ordered logistic model was expressed as

$$y^* = ß'x_i + \epsilon,\ \epsilon \sim N(0,1)$$
$$y = 0 \quad \text{if } y^* \le 0$$
$$y = 1 \quad \text{if } 0 < y^* \le \mu_1$$
$$y = 2 \quad \text{if } \mu_1 < y^* \le \mu_2$$

Where, y^* is the dependent variable, ß' is the vector of coefficients. x_i shows the vector of explanatory variables and ϵ explains the vector of normally distributed error terms

[0,1]. Y is the observed dependent variable as the probability of high food safety. μ explains the cut off points which indicates the level of inclination of a household to have higher food safety level.

Because of the cutoff points are normally distributed (Chen et al. 2002); the central limit theorem, the households with similar socioeconomic characteristics and knowledge are expressed to have similar cutoff points. Greene, (1993), McLean-Meyinsse (1997) Abdel-Aty, (2001) and Chen et al. (2002) expressed the probability of the respondents when the ϵ is normally distributed across the observation that is given in the following equation.

prob (y = 0) = ϕ (ß'x)
prob (y = 1) = ϕ (μ_1–ß'x) – ϕ (–ß'x)
prob (y = 2) = ϕ (μ_2–ß'x) – ϕ (μ_1–ß'x)

Where,
ϕ explains the cumulative probability distribution function of the standard normal distribution. The probability of y_i falls into the j^{th} category is specified as

Prob (y_i = j) = ϕ (μ_j–ß'x_1) – ϕ (μ_{j+1} – ß'x_1)
j = 0, 1, 2, 3… J

μ_{j+1} and μ_j and are lower and upper threshold values for category j, respectively. Therefore, log-likelihood function is presented in below equation which is the sum of log probabilities of each individual respondent.

$$L = \sum_{j=1}^{j} \sum_{y_1=j} \log(\Phi(\mu_j - \beta' x_i) - \Phi(\mu_1 - \beta' x_i)$$

By the end, the marginal effects of each explanatory variables were estimated which represented how much each independent variable increase (decrease) the likelihood of a respondent in each of three categories of the dependent variable. Therefore, the marginal effect can be calculated by using the following equation.

$$\frac{\partial P(y_i = j)}{\partial x_k} = \left[\Phi\left[\mu_{j-1} - \sum_{k-1}^{k} \beta_k x_k\right] - \Phi\left[\mu_j - \sum_{k-1}^{k} \beta_k x_k\right]\right]\beta_k$$

$\partial P/\partial x_k$ is partial derivative of probability with respect to the independent variable x_k. The positive value of marginal effect of x_k describes that probability of a household selecting the specific category increases with x_k and vice versa. The sum of the marginal effects should be zero by canceling the one another out across the response categories (Boz and Akbay, 2005).

Definition of independent variables and descriptive statistics; The independent variables used in this study were first checked for multicollinearity, and the variables having VIF less than 4 denoted no multicollinearity, were included in the ordered logistic model. The multicollinearity was assessed by VIF value. The ages of the household head and the women responsible for handling food preparation were asked in the continuous form. The education level of the respondents was asked in actual schooling years attended. Family size was determined by the actual number of the individuals in a family. The distance between market and home was queried in Km. Regarding off-farm occupation, if a family head had off-farm occupation it was coded 1, and 0 otherwise. Similarly, if a family having university graduated member it was scored 1, and 0 otherwise. A respondent familiar with foodborne, cross-contamination, and danger zone then scored as 1, otherwise 0. The quality of drinking water, development level of the area, and drainage system quality were assessed by a five-point Likert scale (1=very bad, 2=bad, 3=normal, 4=good and 5=very good) and respondents were asked to score their perceptions on each of these three items. The medical expenditures were inquired by requesting the amount of money a household spent for medical treatments and health care in a month. The house conditions were coded into three categories as good (made of cement) = 3, moderate (made of a mix of mud and cement) = 2, and poor (made of mud) = 1. Broader descriptions and definitions of the explanatory variables are presented in Table 1.

Results and Discussion

Five keys of food safety and their explanation

The World Health Organization (WHO) developed the Ten Golden Rules for safe food preparation in 1990, and since then it consulted with food experts and reduced these rules to the simplest and applicable Five Keys in 2001. These Five Keys to safer food were presented in figure 2 as i) Clean; ii) Separate; iii) Well-Cooked; iv) Keep at a safe temperature and v) safe water and raw material.

Keep clean; Pollutants present everywhere in soil, air, and water. If something looks clean, it does not mean that it is actually clean. Invisible dangerous microorganisms can easily transfer to food through hands, utensils, and cutting boards, and cause foodborne diseases. Keeping hands, clothes, kitchen, and any place at home clean lowers the risk of food born illness.

Separate; Separate describes the situation of keeping raw material separate from cooked food. Meat should be kept away from the vegetables, if not it can be a serious source of cross-contamination. Separate equipment should be used for preparing and cooking meat, vegetables, and other raw materials. Further, the cooked food and raw material while storing in freezer/refrigerator should be kept separate with proper cover or lid.

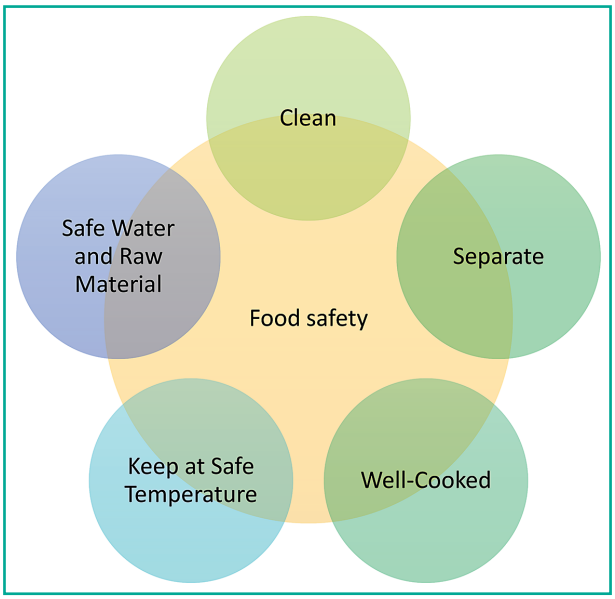

FIGURE 2: *Five keys of food safety developed by WHO 2001.*

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Well-cooked; The term well-cooked explains the condition of no visible blood in meat, chicken, and fish while it is cooked. The cooked and stored food in the freezer should be adequately reheated before reuse. The proper judgment of leftover foodstuff before reuse should be confirmed by its smell and color.

Keep at safe temperature; The keeping food and raw material at safe temperature and place also has a big concern to safer and eat healthy food. It describes the storage in freezer/refrigerator at the proper temperature, avoiding over storage, taking care of adequate storage for the grain food (wheat, rice), and vegetables like onion and potatoes at appropriate place and temperature.

Safe water and raw material; As water is the fundamental element of the food at every stage from production to consumption, it should be of good quality. Further fresh and safe selection of raw material and proper washing can reduce the risk of food contamination. Water quality for drinking, washing raw material, and ice-making should not be compromised. These five keys of food safety were described based on the information provided in the Five Keys of Food Safety Manual developed by the Department of Food Safety, Zoonoses, and Foodborne Diseases, World Health Organization.

Adoption level of food safety practices by the rural households

Table 2 presents the possible statements that were considered to be adapted and practiced by the food handlers and food preparers at home. Each statement was scored based on its contribution toward the food safety. This adoption of the food safety practice includes personal hygienic and handling practices of food in rural areas of Punjab. Good personal hygienic and food handling practices can decrease the transfer of dangerous pathogens from food handler to end consumer (Evans et al., 1998).

The adoption index scores of all statements were also calculated. The average adoption level of the "clean" dimension which had 18 different statements explaining the kitchen sanitary, hand and utensils cleaning level was 61%. Studies such as Scott (1992) and Jevsnik et al., (2008) considered the home-kitchen as one of the high riskiest factors that increase the risk of occurrence of foodborne illnesses. In the present study, the household's food preparers were taking care of the kitchen sanitary condition. They were mostly cleaning their kitchen on a daily basis, but the absence of proper water system in kitchen and having a kitchen with no walls were the only problems observed. The lowest adoption level was in using cutting-boards to cut vegetables and raw material (23 %) because mostly cutting of food raw material was performed by hands. Lim et al. (2016) also found that cutting-boards are not commonly used. Additionally, the human body may be the source of the cross-contamination by transferring pathogenic germs during handling and preparing the food (Scott, 1992). Therefore, washing the hands with anti-germ soap before kneading the flour (34%) and handling the raw material (39%) measured in low levels because people mostly reported that they washed their hands without using any soap. It describes the ignorance of the food preparers to maintain the personal hygiene. Altekruse et al., (1996) and Lim et al., (2016) also described that the unsafe hand washing practices (using only water) might increase the chance of food poisoning risk as compared to the safe hand washing with soap and water. Using proper and thoroughly cleaned utensils with high hygienic standards hinders cross-contamination. The microbiological examination of utensils surface and knives have identified the presence of numerous bacteria/pathogens like Coliforms, Shigella and Salmonella (Barro et al., 2006). Mensah et al., (2002) also reported the presence of the pathogens, flies' fecal matter, and dust particles at a single knife when it is repeatedly used for cutting and chopping the raw foodstuff. In the current study, 54.5% of the respondents reported that they took care of the washing knife properly before using it for second cutting, and 73% described that they care about the proper washing of the utensils.

The adoption index for the "separate" dimension had the highest score (65%) among all dimensions. The freezer or refrigerator are used to store raw and cooked food items, but the practice of storing uncovered food in the fridge is also observed. This increases the risk of cross-contamination because air is a major source of contamination in which many types of invisible bacteria or pathogens live. Under this situation covering the ready to eat, cooked food, and even the raw material properly reduces the chance of cross-contamination. Ray (2016) reported that storing cooked food items properly avoids the food from cross contamination. In the current study, the food handler was not so conscious about the place of raw and cooked food and using the lid box to store cooked food in refrigerator/freezer. Sly (2015) emphasized the placing of raw and cooked food on right shelf in freezer/refrigerator is more critical than storing food with lid box.

The food preparers were found to be more conscious in cooking food well since their adoption index score on "well-cooked" dimension was 64%. It was observed that most of the families had no microwave ovens because it is a technology which is utilized by only wealthy families in rural areas. Most of the families were using fuel and crops' leftovers as an energy source for cooking.

The dimension "keeping at safe temperature" had the lowest score (51%) among rural households because of the ignorance of maintaining the temperature, and carelessness about overstocking in freezer/refrigerator. About 66% of the households were careless about maintaining the temperature of the fridge, and 90% of them overstocked food items in freezer and refrigerator. The 35% of the households still put the cooked hot food in refrigerator/freezer before it becomes fully cold. Goulart, (2010) emphasizes the two hours rule which means that the food should be put in fridge/refrigerating after two hours of cooking.

The last dimension of food safety was "safe water and raw material" which is described by some practices to ensure the safe water and safe raw material. Further, it explained the food preparers' practice of cooking food while they are experiencing flu or diarrhea. Ohiokpehai (2003) also demonstrated that the sick food handler might create the medium for the pathogens to contaminate the food items when they handle the raw foodstuff. The food preparers in this study were in general careless regarding flue and diarrhea. It was observed that only a small percentage of them (11%) took adequate measurements while preparing food during their flu or diarrhea period. Fein et al. (1995) reported that commonly consumers ignore the transmission of diarrheal diseases during the handling and cooking the food.

Only 34% were conscious about the expiry date of canned food items like fruit juice and similar beverages before using them. Water is an essential part of cooking food, but it is an easy source of transmitting the pathogens such as E. coli, Salmonella spp. and Campylobacter spp. (Mankee et al., 2003). Only 39% reported that they had a proper

TABLE 3: Knowledge of household food preparers.

Knowledge of food preparers	Yes		No	
	No.	%	No.	%
Do you know what is foodborne illness?	99.00	49.50	101.00	50.50
Do you know the danger zone (4 to 60 °C) in which food born bacteria can grow?	98.00	49.00	102.00	51.00
Do you know; how long can raw meat be kept in refrigerator 2–4 days?	87.00	43.50	113.00	56.50
Do you know what cross contamination is?	133.00	67.00	67.00	33.00
Do you know the proper shelf on which raw material should be kept in refrigerator? (bottom shelf)	128.00	64.00	72.00	36.00
Do you think it is better to use separate cutting equipment for meat, raw material, and vegetables? (knife, board etc.)	93.00	46.50	107.00	53.50

source of drinking water (mineral or filter plant) and the remaining part had no access of good source of drinking water as they fetch their drinking water from the bank of canal daily. A common unconscious practice was that most of the respondents kept potatoes and onions together.

Knowledge of household food preparers

The knowledge of household food preparers was asked in several questions the results of which are shown in Table 3. It can be seen from the table that less than 50% knew what food born illnesses are, while 50.50% did not. This means that the rate of the household not knowing about food born illnesses is quite high. Fifty-one percent had knowledge of the danger zone of the temperature range between 4–60 °C having a high risk of microorganism growth. Those who correctly reported the period of keeping raw meat in the refrigerator to keep it useable were 43.50%. Sixty-seven percent of the food preparers described correctly what cross contamination is. Another 67% were familiar with the proper shelf to keep the raw material in the refrigerator. Although 46.50% thought that it is better to use separate cutting equipment for meat, raw material, and vegetables; 53.50% reported that there is no need of using separate equipment if properly washed.

Behavior of household members

The common behaviors of families regarding their eating conditions were presented in Table 4. The first behavior was buying onion and potatoes on weekly or monthly basis. The findings showed that 81% purchased potatoes and onion on weekly or monthly base while only 19% purchased them on time of use. The second behavior was regularly cutting the nails to reduce the risk of food contamination for which a large majority (73.50%) gave positive responses. Covering hairs while cooking was considered as the third behavior and it was obeyed by 90%. The fourth behavior was using spoon for eating which was applied by 74% of the family members. Eating leftover food was the fifth behavior for which 91.50% reported positive answers indicating that most of the respondents in the locality used leftover food, particularly on next day. Finally, almost 96% preferred fresh food for breakfast, lunch, and dinner at home.

Food safety index at household level

The factor analysis (FA) feasibility assessed by the KMO test. It is a sampling adequacy criterion which explains the relevance of the explanatory variables with the subject of factor analysis. A KMO value 0.80 for current study indicates that the results are quite feasible. Earlier studies of Kaiser, 1974; Hutcheson and Sofroniu, 1999; Hair et al. (2010) and Pallant (2001) described that the KMO value should be higher than 0.60. Based on five key food dimensions (Clean, Separate, Well-cooked, Keep at safe temperature, and Safe water and raw material), only one component was extracted at the end of the factor analysis process and it was named as food safety component. The total loading of the five key dimensions was 2.636 and it explained 53% of the variation (Table 5). The higher factor loading of each dimension explains stronger association with the underlined factor or component (Rahn, 2008). The first dimension which had the strongest association with the underlying factor was "Separate" with a factor loading of 0.809. Field (2000) and Pallant (2001) suggested that a dimension having a loading value less than 0.40 should be suppressed in outcomes. No dimension in this component had loading less than 0.40. The third column showed the weights to aggregate these five dimensions of food safety into a food safety index.

TABLE 5: Factor loading and weights for food safety dimension.

Five keys of food safety	Factor loadings	Weights of dimensions
Separate	0.809	0.25
Keep clean	0.754	0.22
Safe water and raw material	0.738	0.21
Keep at safe temperature	0.680	0.18
Well-cooked	0.637	0.15
Explained variation by component	2.636	1.00

TABLE 4: Behavior of household members.

	Yes		No	
	No.	%	No.	%
Do you buy onion and potatoes on weekly or monthly basis?	162.00	81.00	38.00	19.00
Do your family members regularly cut their nails?	147.00	73.50	53.00	26.50
Do food preparers cover their hair during preparing and handling food?	180.00	90.00	20.00	10.00
Do your family members use spoon for eating?	148.00	74.00	52.00	26.00
Do you eat leftover meal for the next day?	183.00	91.50	17.00	8.50
Do your family members prefer fresh cooked food for breakfast, lunch, and dinner?	191.00	95.50	9.00	4.50

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Classification of households

The resulted food safety index was analyzed by cluster (K-mean) analysis to determine the three groups of the households with low, moderate and high food safety level. The three food safety levels with the numbers of the households were presented in Table 6. The low-level food safety group contains 49 households with 24.50% of total sample size. A total of 73 households had moderate food safety level consists of 36.50% the sample size. The high food safety level included 78 households which comprised 39% of the total sample size.

Based on food safety index, the average of the three levels of food safety and their ranges were presented in Figure 3. The ranges of food safety were 0–0.47 for the low level, 0.48-0.65 for moderate level, and 0.66–1.00 for the high level. The average index values were, 0.39, 0.57, and 0.74, respectively. The overall food safety index was calculated as 0.59 which fell in the range of moderate level.

Analyzing the determinants of food safety level

Total 17 independent variables were regressed with the food safety levels (Low, Moderate and High) as the dependent variable. These independent variables explained 64 percent variation independent variable. The model was statistical significant ($p<0.001$) which explained the proper factorability of correlation matrix (Akbulut et al., 2008). All independent variables had the expected signs. Of the 17 variables 12 were statistically significantly at 0.05 level in Table 7. The first significant variable was age of female responsible for the handling foodstuff and cooking which had a negative effect on the probability of a household of having good food safety level. The young female is more likely to safely handle, manage and keeping the foodstuff before and after the food ready to eat. The younger females had a higher tendency toward their home sanitary conditions and care about their family members as compared with older females. In terms of education, family male heads and women as second heads (who is equally participating in the decision regarding family members) with higher education levels increase the likelihood of having better food safety level. Off-farm source income of male head also significantly affected the likelihood of the family to have safe food and low risk of foodborne illness. Off-farm income may increase the overall income of the family which makes it possible to purchase equipment such as refrigerator, microwave oven, water filters, and anti-germ detergent, etc. All of these items make significant contributions to food safety at home. More operational land under cultivating crops (grain, vegetables) for home consumption affects the probability of household to

TABLE 6: Classification of households by cluster analysis.

Food safety level	Frequency	Percent	Valid percent	Cumulative percent
Low	49	24.50	24.50	24.50
Moderate	73	36.50	36.50	61.00
High	78	39.00	39.00	100.00
Total	200	100	100	

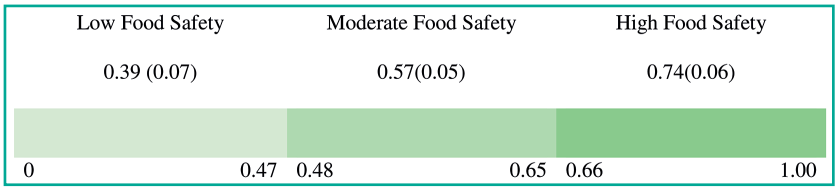

FIGURE 3: *Food Safety Levels.*

TABLE 7: Determinants of food safety among rural households.

Variables	Coefficient	Std. err.	Marginal effects Prob. (low food safety)	Prob. (moderate food safety)	Prob. (high food safety)
Age of the Head (male)	0.01	0.02	–0.00014	–0.00089	0.00103
Age of woman responsible for food handling and cooking	–0.06**	0.03	0.00096	0.00595	–0.00691
Education	0.14*	0.05	–0.00227	–0.01412	0.01638
Education of the woman as second head of Family	0.18*	0.05	–0.00298	–0.01853	0.02151
Household members Nos.	–0.05	0.04	0.00076	0.00475	–0.00551
Market distance from Home	–0.04	0.03	0.00066	0.00414	–0.00480
Off-Farm source Income of male head	1.07**	0.46	–0.01759	–0.10955	0.12714
Operated Land (Acres)	0.07***	0.04	–0.00107	–0.00668	0.00775
having university graduated family member	0.23	0.55	–0.00380	–0.02370	0.02750
Knowledge of Foodborne illness	2.02*	0.52	–0.03326	–0.20720	0.24046
Knowledge of danger zone	0.99**	0.48	–0.01627	–0.10135	0.11762
Knowledge of cross-contamination	1.53*	0.49	–0.02509	–0.15627	0.18136
Quality of drinking water	0.95*	0.18	–0.01566	–0.09755	0.11321
Drainage system in village or town	0.41**	0.19	–0.00673	–0.04192	0.04865
Development level in village or town	0.21	0.19	–0.00014	–0.00089	0.00103
Average Medical Expenditures per month in Last year	–0.001*	0.0002	0.00096	0.00595	–0.00691
House condition	1.08*	0.26	–0.00227	–0.01412	0.01638
/cut1	4.45	1.61			
/cut2	10.36	1.84			

(*) Shows coefficient with $p<0.01$, (**) Coefficient with $p<0.05$, (***) Coefficient with $p<0.10$ N = 200; Log Likelihood –78.076; LR x^2 (17) = 275.72; $p> x^2 = 0.000$; Pseudo $R^2 = 0.64$

enjoy high food safety level. Knowledge of main handler and food preparers about foodborne illness, danger zone (4°C to 60°C) and cross-contamination contribute positively and significantly in the probability of food safety at home level. The availability of good source of water (filter or mineral water source) significantly increases the chance of the household to enjoy safe food. Similarly, the good drainage system in village or town affect significantly and positively the probability of high food safety at home. Per month medical expenditure negatively and significantly affects the food safety. It may be due to households with high food safety experienced lower probability of illness which reduce the medical expenditure per month. The mud-made houses reduce the probability of high food safety level, whereas concrete and mixed houses contribute positively in the level of food safety.

Conclusion

This study provides some key insights into food safety practices applied by rural households in Punjab Pakistan. There are many food safety practices in the region which have been developed by the knowledge, information, experiences, local culture, and traditions of the region. These practices were organized considering the "five food safety keys" of the WHO, and 44 food safety items were identified. The adoption of these practices was considered as a positive contribution toward home level food safety. This criterion of positive contribution enabled 1) to calculate the adoption index of each individual food safety practice, 2) to estimate food safety index, and 3) to explore the determinants influencing home level food safety.

The average adoption indices for each individual dimension of the "five food safety keys" were 0.65 for the "Separate" dimension, 0.61 for "Clean" dimension, 0.64 for "Well-cooked" dimension, 0.51 for "Keep at safe temperature" dimension, and 0.55 for "Safe water and raw material" dimension. These numbers indicate that the "Separate" dimension was given a higher priority among the households of the Punjab region. The common problems lowered food safety level was identified as i) overstocking of food items in fridge/refrigerator; ii) carelessness about the adequate temperature of fridge/refrigerator; iii) ignorance of hand washing with anti-germ soap before kneading flour; iv) not using of cutting board; v) carelessness about hand washing before handling raw material; vi) the unavailability of safe drinking water at home; vii) handling and cooking food during the period of flue and diarrhea, and viii) keeping onion and potatoes together.

More than 43 percent of sampled households had knowledge of foodborne illness, danger zone (4 to 60-degree centigrade), cross-contamination, and benefits of using separate cutting tools for raw materials and vegetables. This finding implies that more than half of the respondents lacked information about these issues which are critical for food safety. Since the practice of purchasing potatoes and onion in bulk amounts was a typical and traditional behavior in the study area, it looks quite challenging to change this behavior in a short period of time. The situations with regular nail cutting and covering hair during food preparation were more optimistic as 73.50% of the respondents took care of nail cutting on time, and 90% covered their hair while food preparing. Although the percentage is lower than the other figures (26%), more than one-fourth of the respondents still do not use a spoon for eating. They also emphasized that eating with the hand is a quite safe practice if hands are appropriately washed before the meal.

The overall food safety index yielded a moderate (0.59) food safety level. The households were classified as high food safety level (39%), moderate food safety level (36.50%), and low food safety level (24.50%). Although there is no earlier study using the same methods to compare these figures, it is assumed that many local measurements must be taken to higher the overall food safety index, as well as to reduce the percentages of households belonging in the moderate, and particularly in the lower food safety category.

The significant factors influencing home food safety were age of main food prepares; education level of the household head; education level of the woman handling and cooking food; off-farm occupation of the household head; operational land; knowledge of foodborne illness; knowledge of cross-contamination; knowledge of danger zone; quality of water; development level; drainage system; medical expenditures; and house conditions. These factors must be taken into consideration when developing food safety programs for the locality. Most of these factors are closely related to the economic development level of the country. For example, education level of the individuals, amount of operational land, provision of quality water, general development level, drainage system, and house conditions are related to economic development and indirectly affect food safety. However, the factors such as knowledge of foodborne illnesses, cross-contamination, and danger zone are directly affecting food safety and any nationwide or local program focusing on these issues will probably make significant contributions.

Policy recommendations

The study generated valuable results based on which the following policy recommendations were proposed.

Food safety education programs should be conducted at school, college and university level because the continuity of such programs at each institution will help the future generations to nourish with safe food and grow up healthy.

Local government employees such as health workers and local dispensaries in villages should arrange food safety education seminars in the local language to educate adults who are mainly responsible for food handling and cooking.

Local grocery shops and markets should hang colorful and attractive posters to deliver food safety messages.

The Punjab food authorities should conduct regular visits to rural areas and inspect local meat shops for their hygienic condition.

As the development and better drainage systems have a significant effect on food safety, the local government should take care about rebuilding roads, maintaining the drainage systems, providing the dustbins at accessible points, and also should take care about proper dispose of the garbage.

Conflict of interest

The authors declare no conflict of interest.

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