

Improper food handling and its associated characteristic factors among domestic food handlers in rural areas of Anhui Province in China

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Abstract

Improper domestic food handling in rural areas of China is an important public health issue leading to foodborne illness. However, the underlying factors responsible for poor domestic food hygiene practices have not been comprehensively studied. Here, a cross-sectional study was conducted in Anhui Province, China between 2015 - 2016, using a questionnaire to collect data from 819 respondents, selected using multistage cluster random sampling techniques. Multivariate logistic regression analysis was then used to assess the demographic factors associated with improper food handling. Results showed that 525 (64.1%) of respondents used improper food handling techniques. The factors associated with improper food handling included gender, age, education, income, and occupation. Males (*vs.* females), adults aged ≥ 50 years (*vs.* those aged 18 - 30 years), individuals with primary school education or lower (*vs.* individuals with a bachelor's degree or higher), individuals with annual incomes of $< 4,387$ USD (*vs.* income $\geq 13,161$ USD), and workers (*vs.* other occupation groups) were more likely to report inappropriate food handling practices in rural areas. The results obtained from the present work may provide the basis for training in domestic food safety hygiene/handling practices in rural areas of China in order to reduce the incidence of foodborne illnesses.

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Introduction

Foodborne illnesses caused by the consumption of contaminated food are one of the world's most serious public health challenges and concerns. According to WHO (2015), contaminated food contributes to 600 million cases of foodborne illnesses and 420,000 deaths, annually. Of these, 30% of foodborne deaths occur in children under five years of age. In China, 4,291 food poisoning incidents were reported between 1999 - 2014, resulting in 159,614 individual cases and 2,837 deaths (Deng *et al.*, 2015); in 2017, there were 348 food poisoning outbreaks involving 7,389 cases and 140 deaths (Wang *et al.*, 2018a).

The prevalence of foodborne illnesses in rural areas of China is a serious threat to human health (Wang *et al.*, 2011), and the domestic home is the main source of contamination. From 2006 - 2010,

China's health authorities reported that 811 outbreaks of foodborne illness occurred in the home, resulting in 16,573 cases and 825 deaths (Pang *et al.*, 2011); between 2000 - 2015, 1,878 food poisoning incidents occurred in private homes, resulting in 34,010 cases and 2,314 deaths (Wang *et al.*, 2018b). *Salmonella*, *Bacillus cereus*, *Staphylococcus aureus*, rotavirus, and the hepatitis A virus are the main pathogens responsible for food poisoning outbreaks. Toxic mushrooms and histamine in spoiled fish (scombroid) are also responsible for some food poisoning incidents (Qing *et al.*, 2017; Wu *et al.*, 2018). Food poisoning outbreaks mainly occur due to the ingestion of toxic or contaminated food due to improper storage and cross-contamination (Gong *et al.*, 2011). Eating undercooked or raw food, such as undercooked kidney beans (Chang *et al.*, 2005) and raw aquatic products, can also cause food poisoning (Geng *et al.*, 2019). The consumption of previously cooked food

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stored without refrigeration or adequate reheating is a significant risk factor for foodborne illness (Tang, 2009). Similarly, outbreaks of food poisoning from the consumption of milk without appropriate heat treatments are frequently reported (Sha *et al.*, 2006). Raw milk contaminated by microorganisms and treated packaged milk that has not been refrigerated are also potential sources of food poisoning.

Individuals responsible for the preparation of domestic food play a key role in the potential spread of foodborne illness. Hence, the appropriate handling of food is essential for the maintenance of good food hygiene and family health. However, previous reviews suggest that many consumers may implement unsafe domestic food-handling practices (Redmond and Griffith, 2001). A study of meat handling in households of mainland China revealed inappropriate food handling practices among individuals preparing and storing the foods (Haruko and Kimie, 2014). Demographic factors may also contribute to unsafe food practices. For example, a study of consumer knowledge and food safety practices in the home showed that inappropriate behaviours relating to the purchase, preparation, and storage of foods were influenced by socio-demographic variables such as education level, marital status, and occupation (Elisa *et al.*, 2012). Another study suggested that age, gender, education level, and income range play a potential role in determining domestic food hygiene practice (Al-Sakkaf, 2015). However, an investigation of domestic consumer food safety knowledge and practices in Turkey did not find any relationship between demographic variables and food handling practices (Nurhan, 2007).

To date, the factors affecting domestic food handling practices in rural China have not been reported. Hence, the aim of the present work was to assess the potential associations between improper food handling and the demographic characteristics of rural domestic food handlers in the Anhui Province of China. Data were collected by questionnaire from 819 respondents between 2015 - 2016. Multivariate logistic regression analysis was then used to assess the underlying factors associated with improper food handling, and the results were discussed in detail.

Materials and methods

Study populations and sampling design

A cross-sectional study was performed from 2015 - 2016 in Anhui Province, China (latitude 29°41'

- 34°38'N; longitude 114°54' - 119°37'E) located in Eastern China. The province is ~450 km wide (east to west), 570 km long (north to south), and covers an area of 139,400 km². Respondents were recruited by multistage stratified cluster sampling, and the following were selected at random: (i) six cities (from the 17 in Anhui Province); (ii) one county from each of the six cities; (iii) two towns from each county; (iv) one administrative village from each town (12 in total); (v) individual households (details obtained from the 12 administrative villages); and (vi) individuals reporting primary responsibility for domestic food preparation. A total of 819 respondents elected to participate.

Data collection

Consumer trends in China

China has a diverse food culture and a wide variety of ingredients. Cooked foods such as stewed chicken feet, pickled duck, spiced beef, stewed pig feet, and cold dishes are common dishes on the Chinese table. Since the preparation of these foods is time-consuming, they are frequently purchased from delicatessens, supermarkets, and other food outlets. Precooked foods such as lamb are usually consumed after simple heating. Other cooked foods (*e.g.*, roast duck and beef in sauce) are typically eaten directly, which can pose a food safety risk if they are stored incorrectly. In China, the consumption of milk, once regarded as the "patent" of infants, is gradually becoming a population favourite. Consumer milk in China is sterilised by high temperature treatment such as pasteurisation, and usually sold in bags and cans. While most people choose to drink canned milk within shelf life, some elect to retain and consume the opened product beyond this period. The consumption of a variety of vegetables (*e.g.*, mushrooms, celery, potatoes, tomatoes, eggplants, cucumbers, and broccoli) with a dietary staple food (rice or noodles) has become the norm for the Chinese population. Kidney beans are one of the most common vegetables on the Chinese table. However, they require thorough heating to destroy the toxic lectin phytohemagglutinin before eating. Vegetables (*e.g.*, cucumbers and tomatoes) require thorough washing before cooking to remove any pesticide residues. Seafood is also a favourite of the Chinese, especially those living in Hainan, Fujian, Guangdong, and Zhejiang, where it is often eaten raw with a salt or sugar marinade.

Data questionnaire

Based on Chinese eating habits, a questionnaire was designed to collect the data. These were issued to respondents who were then required to sign an informed consent statement prior to participation in the survey. The questionnaire comprised six questions relating to demographic characteristics (gender, age, residence, education, total annual household income, and occupation). A further ten questions required yes/no responses to “frequent” food handling practices: (1) frequently thoroughly heat cooked foods purchased from outside the home before eating; (2) frequently thoroughly heat milk before drinking; (3) frequently store leftovers in the refrigerator; (4) frequently thoroughly heat leftovers stored in the refrigerator; (5) frequently thoroughly heat kidney beans; (6) frequently thoroughly wash raw vegetables purchased from outside the home; (7) frequently disinfect kitchen utensils by boiling; (8) frequently eat raw seafoods; (9) frequently store raw and cooked meats in the same container; and (10) frequently purchase of ingredients beyond their shelf life (*e.g.*, vegetables and fish). A frequent specific food handling behaviour was considered significant if it was $\geq 70\%$. Respondents were then contacted by data collection staff (seven researchers and three undergraduate students, who were given training in data collection methods and interviewing techniques) to explain the process, and answer any queries. The questionnaires were then completed by each respondent using yes/no answers. For questions (1) to (7), one point was given for each negative response, while zero points were assigned for each affirmative answer. For questions (8) to (10), one point was given for each affirmative answer, and zero points were given for each negative response. Hence, the total points ranged from 0 to 10, and these were then summed to obtain the individual total food handling scores. Respondents with scores of less than the mean value of their answers to the 10 questions of food handling were regarded as having “proper food handling”; those scoring greater than the mean value were regarded as having “improper food handling” (Tessema *et al.*, 2014).

Statistical analysis

Data were compiled using EpiData 3.1 software (EpiData, Odense, Denmark), and exported into IBM SPSS Statistics for Windows, Version 20.0 (IBM Corp., Armonk, NY, USA) for further analysis. Data were presented as frequencies and percentages,

and a descriptive analysis was performed for all variables. A chi-square test was used to compare the proportion of the population exposed to improper food handling behaviour based on the different demographic characteristics. Multivariable logistic regression analysis was carried out to analyse the associations between improper food handling and demographic characteristics. The variables having a significant association with improper handling were determined from the odds ratio (OR) with a 95% confidence interval (CI). A *p*-value of < 0.05 was considered significant; two-tailed tests were used.

Results

Demographic characteristics of respondents

A total of 819 respondents completed the questionnaire survey. Table 1 shows that there were more males than females (57.1% vs. 42.9%). The age distributions of respondents were 18 - 29 years = 40 - 49 years (34.1%) > 30 - 39 years (19.8%) > 50+ years (12.0%). The education status of most respondents was junior/senior high school (50.5%), followed by bachelor's degree or higher (26.4%), and up to primary school level (23.1%). Most respondents (33.0%) reported a total annual household income in the range of 7,311 - 13,161 USD; 24.1% had incomes of > 13,161 USD; 20.9% had incomes of < 4,387 USD; and 22.0% were in the range 4,387 - 7,311 USD. Occupations of the respondents were labourers (*e.g.*, factory workers; 26.4%) > medical staff (20.9%) > peasant farm workers (16.4%) > teachers (7.7%) > service personal (4.4%). A significant proportion of respondents (24.1%) reported that their occupations were other or unknown.

Proportion of improper food handling practices by respondents

The proportion of respondents reporting improper food handling behaviour is shown in Figure 1. The highest incidence of improper food hygiene behaviours (68.1 - 75.7%) included disinfection of kitchen utensils, thorough heating of milk before drinking, and thorough heating of cooked foods purchased from outside the home before eating. Nearly half of all respondents (46.2%) reported infrequently heating leftover foods stored in the refrigerator before consumption, while a lower proportion of respondents consumed raw seafoods (16.5%) or infrequently thoroughly heated kidney beans (14.3%).

Table 1. Demographic characteristics of respondents.

Characteristic	Number (<i>n</i>)	Percentage (%)
Gender		
Male	468	57.1
Female	351	42.9
Age (year)		
18 - 29	279	34.1
30 - 39	162	19.8
40 - 49	279	34.1
≥ 50	99	12.0
Education		
Primary school or lower	189	23.1
Junior and senior high school	414	50.5
Bachelor's degree or higher	216	26.4
Total annual household income (USD)		
< 4,387	171	20.9
4,387 - 7,311	180	22.0
7,311 - 13,161	270	33.0
≥ 13,161	198	24.1
Occupation		
Peasant	135	16.5
Teacher	63	7.7
Service personal	36	4.4
Medical staff	171	20.9
Worker	216	26.4
Other or unknown	198	24.1

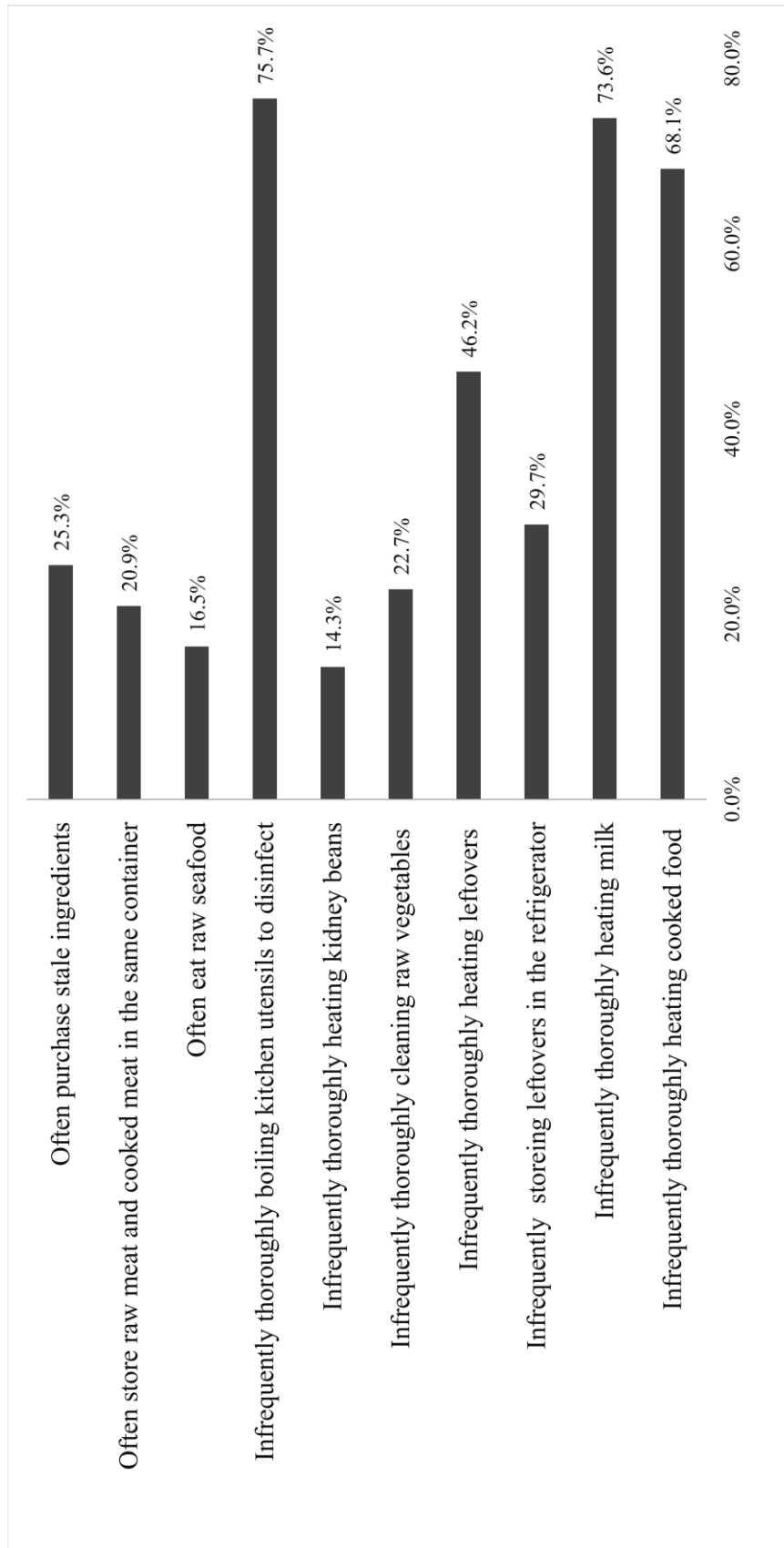


Figure 1. Distribution of improper food handling behaviours among respondents.

Distribution of food handling practices for each category of respondents

Table 2 shows that the proportion of respondents answering no to the question “frequently thoroughly heat cooked foods purchased from outside before eating” was significantly ($p < 0.05$) higher in males (73.1%), ≥ 50 years of age (90.9%), primary school education or lower (80.1%), income range 4,387 - 7,311 USD (75.0%), and the worker (83.3%) groups, when compared with other groups in the same categories. The proportion of respondents answering no to “frequently thoroughly heat the milk before drinking” was significantly ($p < 0.05$) higher in the ≥ 50 years of age (90.9%), $< 4,387$ USD income (89.5%), and worker (91.7%) groups. The proportion of respondents responding no to “frequently store leftovers in the refrigerator” was significantly ($p < 0.05$) higher in age 50 years or more (45.5%), educated to junior and senior high school level (34.8%), income under 4,387 USD (52.6%), and the worker (54.2%) groups. For the question “frequently thoroughly heat leftovers stored in the refrigerator”, the proportion of respondents answering no was significantly ($p < 0.05$) higher in the groups as follows: females (71.8%), ≥ 50 years (63.6%), primary school education or lower (61.9%), income of $\geq 13,161$ USD (54.5%), service personnel (100.0%). For the question “often thoroughly heat kidney beans”, the proportion of respondents answering no was significantly ($p < 0.05$) higher in the groups as follows: males (17.3%), primary school or lower (23.8%), income within 4,387 - 7,311 USD (20.0%), service personal (25.0%), when compared with other groups in the same categories.

Table 3 shows that the proportion of respondents answering no to the question “frequently thoroughly clean raw vegetables” was significantly ($p < 0.05$) higher for ≥ 50 years old (42.4%), junior and senior high school educated (27.5%), income $< 4,387$ USD (40.4%), and teacher (28.6%), when compared with other groups in the same categories. The proportion of respondents answering no to the question “often thoroughly boil kitchen utensils to disinfect” was significantly ($p < 0.05$) higher in males (79.3%), those aged 40 - 49 years (84.2%), primary school or lower educated (89.9%), income range 7,311 - 13,161 USD (84.2%), and the medical staff (88.3%) groups. For the “frequently eat raw seafood” question, respondents answering yes was significantly ($p < 0.05$) higher in the female (21.2%), bachelor’s degree or higher educated (41.7%),

income range 7,311 - 13,161 USD (23.3%), and the worker (25.0%) groups. The proportion of respondents answering affirmatively to “frequently store raw meat and cooked meat in the same container” was significantly ($p < 0.05$) higher in the ≥ 50 years (36.4%), primary school or lower educated (28.6%), income range 7,311 - 13,161 USD (33.3%), and the service personal (50.0%) groups. The proportion of respondents answering yes to “often purchase stale raw vegetables, meats, and other ingredients”, was significantly ($p < 0.05$) higher in males (30.8%), the age 30 - 39 years (39.8%), primary school or lower educated (95.2%), income range 4,387 - 13,161 USD (30.0%), and the service personnel (50.0%) groups.

Improper food handling level of respondents

Table 4 shows the distribution of food handling behaviours for each category/group of respondents. The differences between each group were all statistically significant ($p < 0.01$). From a total of 819 respondents, 525 (64.1%) could be regarded as having improper food handling behaviours. Conversely, 294 (35.9%) had proper food handling skills. The proportion of respondents regarded as having improper food handling behaviours was highest in males (69.0%), and the age ≥ 50 years (82.8%), primary school or lower educated (50.5%), income $< 4,387$ USD (74.3%), and the worker (81.5%) groups.

Demographic characteristics associated with improper food handling

Multivariable logistic regression was used to determine the categories/groups associated with improper food handling. Gender (male = 1, female = 2), age (18 - 29 years = 1; 30 - 39 years = 2; 40 - 50 years = 3; ≥ 50 = 4), education (primary school or lower = 1; junior and senior high school = 2; bachelor’s degree or higher = 3), income ($< 4,387$ USD = 1; 4,387 - 7,311 USD = 2; 7,311 - 13,161 USD = 3; $\geq 13,161$ USD = 4), and occupation (peasant = 1; teacher = 2; service personal = 3; medical staff = 4; worker = 5; other or unknown = 6) were the independent variables, while food handling behaviours (proper food handling = 0, improper food handling = 1) were taken as the dependent variables. Table 5 shows that males (*vs.* females), age ≥ 50 years (*vs.* 18 - 29 years), primary school or lower educated (*vs.* bachelor’s degree or higher), incomes of $< 4,387$ USD and 7,311 - 13,161 USD (*vs.* income $\geq 13,161$

Table 2. The proportions of respondents answering “no” or “yes” to food handling questions (%).

Food handling (no/yes)	Gender		Age (year)				Education			Income (USD)					Occupation				
	Male	Female	18 - 29	30 - 39	40 - 49	≥ 50	Primary school or lower	Junior and senior high school	Bachelor's degree or higher	< 4,387	4,387 - 7,311	7,311 - 13,161	≥ 13,161	Peasant	Teacher	Service personal	Medical staff	Worker	Other or unknown
Frequently thoroughly heat cooked foods purchased from outside the home before eating																			
no	73.1	61.5 ^a	67.7	61.1	64.5	90.9 ^a	81.0	60.9	70.8 ^a	73.7	75.0	66.7	59.1 ^b	53.3	57.1	75.0	68.4	83.3	63.6 ^a
Frequently thoroughly heat the milk before drinking																			
no	75.0	71.8 ^c	74.2	72.2	67.7	90.9 ^a	71.4	73.9	75.0 ^c	89.5	85.0	73.3	50.0 ^a	66.7	57.1	25.0	84.2	91.7	63.6 ^a
Frequently store leftovers in the refrigerator																			
no	28.8	30.8 ^c	9.7	27.8	45.2	45.5 ^a	23.8	34.8	25.0 ^b	52.6	25.0	23.3	22.7 ^a	20.0	14.3	0.0	21.0	54.2	27.3 ^a
Frequently thoroughly heat leftovers stored in the refrigerator																			
no	40.4	71.8 ^a	45.2	33.3	48.4	63.6 ^a	61.9	39.1	45.8 ^a	42.1	35.0	50.0	54.5 ^b	46.7	14.3	100.0	41.2	45.8	50.0 ^a
Frequently thoroughly heat kidney beans																			
no	17.3	10.3 ^b	16.1	16.7	12.9	9.1 ^c	23.8	13.0	8.3 ^a	0.0	20.0	16.7	18.2 ^a	13.3	0.0	25.0	15.8	16.7	13.6 ^b

^a $p < 0.001$; ^b $p < 0.05$; and ^c $p > 0.05$.

Table 3. The proportions of respondents answering “no” or “yes” to food handling questions (%).

	Gender		Age (years)					Education					Income (USD)					Occupation				
	Male	Female	18 - 29	30 - 39	40 - 49	≥ 50	Primary school or lower	Junior and senior high school	Bachelor's degree or higher	< 4,387	4,387 - 7,311	7,311 - 13,161	≥ 13,161	Peasant	Teacher	Service personal	Medical staff	Worker	Other or unknown			
Food handling (no/yes)																						
Frequently thoroughly wash raw vegetables purchased from outside the home																						
no	22.4	23.1 ^c	12.9	38.9	16.1	42.4 ^a	23.8	27.5	12.5 ^a	40.4	20.0	13.3	22.7 ^a	26.7	28.6	25.0	21.1	19.4	22.7 ^c			
Frequently disinfect kitchen utensils by boiling																						
no	79.3	70.9 ^b	72.8	73.5	84.2	63.6 ^a	89.9	69.1	75.9 ^a	72.8	73.5	84.2	63.6 ^a	75.6	71.4	50.0	88.3	85.6	60.1 ^a			
Frequently eat raw seafoods																						
yes	10.3	21.2 ^a	16.1	16.7	19.4	9.1 ^c	23.8	0.0	41.7 ^a	5.3	20.0	23.3	13.6 ^a	20.0	0.0	0.0	21.1	25.0	9.1 ^a			
Frequently store raw meat and cooked meats in the same container																						
yes	23.1	17.9 ^c	25.8	22.2	9.7	36.4 ^a	28.6	23.9	8.3 ^a	21.1	5.0	33.3	18.2 ^a	20.0	14.3	50.0	15.8	29.2	13.6 ^a			
Frequently purchase stale ingredients																						
yes	30.8	17.9 ^a	35.5	38.9	12.9	9.1 ^a	95.2	0.0	12.5 ^a	10.5	30.0	30.0	27.3 ^a	33.3	28.6	50.0	31.6	20.8	13.6 ^a			

^a $p < 0.001$; ^b $p < 0.05$; and ^c $p > 0.05$.

Table 4. Distribution of food handling behaviours for each category/group of respondents.

Characteristic	Food handling (n, %)		p-value
	Proper	Improper	
Gender			
Male	145 (31.0)	323 (69.0)	0.001
Female	149 (42.5)	202 (57.5)	
Age (year)			
18 - 29	90 (32.3)	279 (67.7)	< 0.001
30 - 39	56 (34.6)	106 (65.4)	
40 - 49	131 (47.0)	148 (53.0)	
≥ 50	17 (17.2)	82 (82.8)	
Education			
Primary school or lower	11 (5.8)	178 (94.2)	< 0.001
Junior and senior high school	200 (48.3)	214 (51.7)	
Bachelor's degree or higher	83 (38.4)	133 (61.6)	
Total annual household income (USD)			
< 4,387	44 (25.7)	127 (74.3)	< 0.001
4,387 - 7,311	72 (40.0)	108 (60.0)	
7,311 - 13,161	83 (30.7)	187 (69.3)	
≥ 13,161	95 (48.0)	103 (52.0)	
Occupation			
Peasant	63 (46.7)	72 (53.3)	< 0.001
Teacher	45 (71.4)	18 (28.6)	
Service personal	9 (25.0)	27 (75.0)	
Medical staff	56 (32.7)	115 (67.3)	
Worker	40 (18.5)	176 (81.5)	
Other or unknown	81 (40.9)	117 (59.1)	

Table 5. Multivariable logistic regression analysis of factors associated with food handling.

Characteristic factor	B	P	Exp (B) (95% CI)
Gender			
Male	0.383	0.042	1.467 (1.015 - 2.121)
Female	Ref	Ref	Ref
Age (year)			
18 - 29	Ref	Ref	Ref
30 - 39	-0.041	0.876	0.960 (0.570 - 1.615)
40 - 49	-0.184	0.394	0.832 (0.545 - 1.270)
≥ 50	0.984	0.004	2.676 (1.359 - 5.272)
Education			
Primary school or lower	2.420	< 0.001	11.241 (5.452 - 23.176)
Junior and senior high school	-1.181	< 0.001	0.307 (0.201-0.470)
Bachelor's degree or higher	Ref	Ref	Ref
Total annual household income (USD)			
< 4,387	1.015	< 0.001	2.759 (1.586 - 4.801)
4,387 - 7,311	0.143	0.602	1.154 (0.674 - 1.974)
7,311 - 13,161	1.141	< 0.001	3.129 (1.909 - 5.133)
≥ 13,161	Ref	Ref	Ref
Occupation			
Peasant	Ref	Ref	Ref
Teacher	-1.424	0.001	0.241 (0.107 - 0.544)
Service personal	0.871	0.084	2.389 (0.889 - 6.425)
Medical staff	-0.042	0.886	0.959 (0.539 - 1.706)
Worker	1.371	< 0.001	3.939 (2.157 - 7.192)
Other or unknown	0.514	0.064	1.672 (0.971 - 2.878)

USD), and workers (*vs.* peasants) were positively correlated with improper handling. Junior and senior high school educated (*vs.* bachelor's degree or higher) and teachers (*vs.* peasants) were negatively associated with improper food handling.

Discussion

Appropriate domestic food hygiene practices can prevent the transmission of foodborne illnesses. Although several studies have evaluated food handling practices, the results differed considerably due to variations in the study designs, populations, and the survey questions employed. For example, a study of food safety knowledge, attitudes and practices, and personal hygiene during a religious mass gathering (Baghdad, Iraq), showed that 42.7% of the voluntary workers preparing food demonstrated unsatisfactory attitudes and practices towards food handling (Lami *et al.*, 2019). In a further study of food handling practices in public food establishments (Northwest Ethiopia), the proportion of good food handling practices among food handlers was 40.1% (Chekol *et al.*, 2019). In addition, an investigation of the factors associated with food safety practices in Gondar City (Ethiopia) food and drink establishments revealed that 188 (49.0%) out of 384 food handlers had good food handling practices (Azanaw *et al.*, 2019). The results from the present work demonstrated that 35.9% of domestic food handlers demonstrated proper food handling, while the majority (64.1%) had improper food handling, which differed from the previous studies (Lami *et al.*, 2019; Chekol *et al.*, 2019; Azanaw *et al.*, 2019). Here, the practices of infrequent boiling of kitchen utensils for disinfection (75.7%; 89.9% for primary school or lower educated), infrequently heating milk before drinking (73.6%; 90.9% for those aged ≥ 50 years and 91.7% for workers), and infrequently thoroughly heating of cooked foods purchased outside of the home before eating (68.1%; 90.9% for those aged ≥ 50 years) were most common among the domestic food handlers. It was also interesting to note that the behaviours of "infrequently thoroughly heating leftovers stored in the refrigerator" and "frequently purchasing stale ingredients" was common among domestic food handlers identified as service personnel (100.0%) and primary school or lower educated (95.2%) respectively.

Previous studies have shown that food handling practices may vary within different population categories. For instance, a study of food safety perceptions and practices in older adults indicated that adults > 60 years generally have better food safety practices, especially women and educated adults (Odeyemi *et al.*, 2019). Another investigation indicated that men, individuals with high household incomes, elderly individuals, and rural residents were more likely to display inappropriate food handling practices while elsewhere, these behaviours were reported more often for middle aged and younger adults (18 - 19 years), and those with higher education (Altekruse *et al.*, 1996; Patil *et al.*, 2005; Nesbitt *et al.*, 2009). In the present work, males, domestic food handlers aged ≥ 50 years, primary school or lower educated, respondents with total annual incomes of $< 4,387$ USD, and those employed as workers had a higher proportion of improper food handling when compared with other groups in their category. Groups corresponding to males aged ≥ 50 years, primary school or lower educated, incomes of $< 4,387$ USD and 7,311 - 13,161 USD, and workers were all positively associated with improper food handling. The probabilities of improper food handling amongst the various categories/groups were as follows: > 1.4 times in males than in females; > 2.6 times in domestic food handlers aged 50 years or more (*vs.* those aged 18 - 29 years); > 11.2 times in domestic food handlers with primary school or lower education (*vs.* bachelor's degree or higher); > 3.1 in domestic food handlers with incomes of 7,311 - 13,161 USD; > 2.7 times in domestic food handlers with incomes of $< 4,387$ USD (*vs.* income $\geq 13,161$ USD); and > 3.9 times in workers (*vs.* other occupations).

Inadequate food hygiene knowledge (Patil *et al.*, 2005) and a low-risk perception of foodborne diseases in the home (Anderson *et al.*, 2011; Al-Sakkaf, 2015) are likely causes of improper food handling behaviours. Hence it is imperative that domestic food handlers living in rural areas of China undergo training in domestic food hygiene to improve their perception of the risks associated with foodborne illnesses. The results obtained from the present work indicated that the disinfection of kitchen utensils, appropriate heating of foods such as milk and precooked items purchased outside the home and leftovers stored in the refrigerator, and food quality/shelf life may provide the basis for future instruction.

Study limitations

Studies of this nature may have some limitations, and the following should be considered: (i) cross-sectional studies are observational “snap shots” in time, and cannot be used to determine time-dependent causality, hence the relationships between demographic factors and food handling in the home are only indicative; (ii) the size of the geographical area selected was small, and may not reflect the practices of all domestic consumers in greater China; and (iii) the self-reporting of food handling behaviours by respondents may be biased by desired behaviours.

Conclusion

Results obtained in the present work indicated that improper food handling behaviours were common in families from rural areas of Anhui Province in China. These practices included inadequate disinfection of kitchen utensils, consumption of milk, precooked foods, and leftovers without thorough heating, improper storage of leftover foods, and the purchase of ingredients beyond their recommended shelf life. In addition, raw and cooked meats were frequently stored in the same container, and vegetables purchased from outside the family home were usually inadequately washed.

Based on these observations, the following recommendations could be proposed: bowls, chopsticks, plates, spoons, basins, and other items used in domestic food preparation should be washed and disinfected in boiling water for 5 - 10 min daily. Foods such as milk and cooked foods purchased from outside the home (including refrigerated items) and leftover foods stored with residual temperatures of 10 - 60°C for > 2 h should be heated to a centre temperature of 70°C before consumption. Leftover foods should be allowed to cool before refrigerating at an appropriate temperature. Containers used for cooked and raw foods should be identified (labelled), reserved, and separately stored to avoid cross-contamination. Fresh ingredients such as fruits and vegetables should be thoroughly washed/soaked in water for 30 min to remove pesticide residues.

The demographic factors of the respondents associated with improper domestic food handling included gender, age, education, income, and occupation. Males, aged ≥ 50 years, received primary school or lower education, families with incomes < 4,387 USD, and those who reported their occupation

as a worker had a greater risk of improper food handling. Hence a structured and targeted system of domestic food hygiene training, including the risk perception of foodborne illnesses, should be implemented regularly in rural communities. To realise this task nationally, further studies including research into the causal relationship between demographic factors and the practices of domestic food handlers will be required.

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