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Food safety knowledge among adult consumers in Bangladesh: a COVID-19 comparative study

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Abstract

Purpose – Since the COVID-19 pandemic had a significant impact on all facets of civilisation around the world, including food safety, this study aimed to determine and compare the pre-COVID and post-COVID food safety knowledge of Bangladeshi consumers and their association with sociodemographic variables.

Design/methodology/approach – The current study performed a cross-sectional survey of 503 consumers who prepared food at least 2–4 times per week through a validated questionnaire, selected through convenience sampling from two metropolitan cities and two rural districts in Bangladesh. The non-parametric Wilcoxon signed-rank test, Mann–Whitney *U* tests, Kruskal–Wallis H and binary logistic regression were used for statistical analysis.

Findings – Although an increased percentage of consumers showed a better level of overall food safety knowledge in the post-pandemic (38.2%) than the pre-pandemic (28.8%), there is a low level of awareness of the appropriate duration of handwashing, foodborne pathogens, consuming raw milk or eggs, safe storage and temperature control of food. University graduates, families with few children and urban consumers had a good understanding of food safety both pre- and post-pandemic.

Originality/value – This study compares consumers' pre- and post-COVID-19 food safety knowledge previously unknown in Bangladesh. The findings have significantly contributed to existing food safety knowledge in Bangladesh to adopt policies and structure training programmes for consumers in the country.

Keywords Food safety knowledge, Foodborne disease, Food handler, Household, COVID-19, Bangladesh

Paper type Research paper

Abbreviations

FBD	Foodborne disease
FSK	Food safety knowledge

1. Introduction

Food safety is a shared responsibility of all stakeholders and a paramount concern for government, food producers, traders and consumers (WHO, 2016; Garcia *et al.*, 2020; Ishra *et al.*, 2022). The World Health Organisation (WHO) has reported that globally, around 600 m people fall ill, and 420,000 deaths occur annually due to consuming food contaminated by microorganisms or chemicals (WHO, 2015). Further documents suggest that contaminated food is the source of the spreading of 200 different disease types. Certain foodborne diseases

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(FBDs) can lead to severe health consequences, including hypertension, diabetes and renal and central nervous system dysfunctions. The fatal outcome usually occurs in pregnant women, children and older adults (Al Banna *et al*., 2022).

Food contamination occurs at any level, from the farm to food processing, transportation, storage and food preparation (WHO, 2016). These contaminants reach the food system via improper food handling, cross-contamination, inadequate personal hygiene, contaminated food supplies, poor storage conditions or inadequate cooking methods (WHO, 2015; Osaili *et al*., 2022). Studies have shown that the FBD outbreak was because of the deficiency of proper food safety knowledge (FSK) in household food preparation (Ruby *et al*., 2019; Al-Sakkaf, 2015; Wu *et al*., 2018). The linkage between FBDs and food consumed within households has been observed in a considerable number of cases, although the possibility of undetected or misdiagnosed instances exists (Keegan *et al*., 2009; Redmond and Griffith, 2003; Vrbova *et al*., 2012). Misinterpretation of FBD is one reason why consumers at home do not seek medical treatment (Lim *et al*., 2016). Previous studies have reported that over 35% of FBDs occur at home while handling food (ECDC and European Centre for Disease Prevention and Control, 2021; Draeger *et al.*, 2018; Finger *et al*., 2019; Langiano *et al*., 2012). The hands of consumers spread harmful microorganisms through cross-contamination, making them a significant cause of food contamination (Campos *et al*., 2009; Kunadu *et al*., 2016). Proper hygiene practices among consumers can reduce cross-contamination and help protect them from diseases (Jevšnik *et al*., 2008).

The prevalence of FBDs obtained from household kitchens considerably differs between countries (Al-Shabib *et al*., 2016). Previous studies revealed that 20–50% of FBDs occurred in Australia and New Zealand due to homemade food (Redmond and Griffith, 2009). In mainland China, households had the highest number of outbreaks (58.5%) and deaths (89.5%), with 7,073 FBD outbreaks resulting in 37,454 illnesses and 143 fatalities in 2020 (Li *et al*., 2021). In the European Union, 36.4% of FBD outbreaks occurred because of the food prepared in homes (European Food Safety Authority and European Centre for Disease Prevention and Control, 2017). The Centres for Disease Control and Prevention (CDC) has reported a rise in FBD outbreaks due to home-prepared food in the last few years (CDC, 2023).

The impact of FBD remains severe on a global scale in developing countries such as Bangladesh. The total population of Bangladesh is over 165.1 m, average life expectancy is 72.4 years (BBS, 2022), the total fertility rate (TFR) among women aged 15–49 is 2.3 (BDHS, 2022), and the median age of the country is 25.7 years (Worldometer, 2024). Bangladeshi people are particularly vulnerable due to factors like dense population, inadequate infrastructure and insufficient access to clean water, sanitation and hygiene services (Ishra *et al*., 2022). The incidence of FBD infections reaches 30 m annually in Bangladesh (Ishra *et al*., 2023). The Institute of Epidemiology, Disease Control and Research (IEDCR) noted that in 2015, there were 0.28 m individuals in Bangladesh who experienced acute gastroenteritis, a common symptom of food poisoning. According to estimates from the Institute of Epidemiology (2015), 30,000 and 500 people, respectively, contract enteric fever and hepatitis each year. The consequences of FBDs can lead to financial costs for both the individual and the nation, in addition to physical and mental impairment or even death (Fung *et al*., 2018).

Consumers represent the final stage in the food supply chain where direct interaction with food occurs; research has demonstrated that consumer awareness of food safety plays a substantial role in mitigating FBD outbreaks during food handling in household kitchens (Mullan *et al*., 2015; Odeyemi *et al*., 2019). Numerous researchers have found that consumers' age, gender, level of education and cooking experience influence their FSK (Burke and Dworkin, 2015; Farahat *et al*., 2015; Sanlier and Karakus, 2010; Shori, 2017; Ruby *et al*., 2019). Experts have successfully designed food safety education programmes that are effective for developing food safety proficiency among different country consumers (Meysenburg *et al*., 2014; Tabrizi *et al*., 2017).

The COVID-19 pandemic has had a notable effect on food safety recently (Trmčić *et al*., 2021). The pandemic has altered the global food system (Swinnen and Vos, 2021; Bakalis *et al*., 2020), consumer food safety awareness, hygiene behaviour (Faour-Klingbeil *et al*., 2021; Mucinhato *et al*., 2022; Erol *et al*., 2023), food preparation and eating habits (Gerritsen *et al*., 2021; Soon *et al*., 2021; Osaili *et al*., 2022; Güney and Sangün, 2021). The transmission routes of this virus are through person-to-person contact and respiratory droplets via sneezing, coughing or talking (Wang *et al*., 2020). No evidence suggests that COVID-19 is an FBD; however, the entire phenomenon encircling food products may act as a route of virus transfer (WHO, 2020). For example, if an infected person comes into contact with food, food packages, machinery or utensils, the food can become the vehicle of disease transmission (Osaili *et al*., 2021). Experts recommend preventive measures, including handwashing and maintaining good personal hygiene to reduce SARS-cov-2 virus transmission and cross-contamination among food handlers during the COVID-19 pandemic (Olaimat *et al*., 2020). When individuals are most vulnerable during a pandemic, their pandemic-related cognitive perceptions affect the extent to which they are conscious of food safety (Yang, 2021; Mucinhato *et al*., 2022). Hence, this study presumes that consumer FSK may have been influenced due to this COVID-19 pandemic.

Globally, there has been significant development in food safety concepts and legislation, which educate food processors and consumers regarding the imperative of safe food handling and strategies to mitigate the risk of FBDs (Jaffee *et al*., 2018). Food legislation is a comprehensive compilation of legal texts consisting of laws, regulations and standards. It provides a framework for food control within a country and varies across nations (Motarjemi, 2013). Further, the food safety management system (FSMS) framework entails resource deployment and strategy adoption to effectively and safely produce, process and distribute food for consumers (Rincon-Ballesteros *et al*., 2021). In Bangladesh, limitations inherent in legal and regulatory systems result in inadequate enforcement of food safety regulations. The overlapping regulatory mandates across multiple ministries and agencies, compounded by the complexity of numerous and diverse food-related laws and regulations, hinder effective enforcement and inter-ministerial coordination (Suman *et al*., 2021). Under the Food Safety Act of 2013 (FSA, 2013), the primary body responsible for enforcing the FSMS in Bangladesh is the Bangladesh Food Safety Authority (BFSA). After being established in 2015, its primary function is to support and coordinate the organisations responsible for food safety. By the Act, the mandate of BFSA includes a robust food safety network establishment, reaching the field level to coordinate all participating authorities within the food safety management system. This network's responsibilities encompass the development and implementation of good agricultural practices (GAPs), good hygiene practices (GHPs), good manufacturing practices (GMPs), good aquaculture practices (GAqPs), hazard analysis frameworks and comprehensive food safety auditing systems (Suman *et al*., 2021).

A significant range of agricultural goods is produced in Bangladesh, including rice, wheat, corn, legumes, fruits and vegetables and various animal products (e.g. meat, fish, seafood and dairy) (ITA, 2022). Bangladesh exports over 700 diverse items, such as cereal grains, frozen fish, processed meats, tea, vegetables, tobacco, fruits, spices and dried food products and imports food grains, soybeans, pulses, fresh fruits, tree nuts, dairy products and processed foods. Food processing constitutes approximately 13% of the total manufacturing output (BIDA, 2024). The food industry in Bangladesh is subject to rigorous enforcement of regulations, utilising mobile courts to uphold quality and control prices. BFSA appoints food safety inspectors to conduct routine investigations, searches, exams, sample collection, documentation and search and seizure (Suman *et al*., 2021). The BFSA has identified ten public food testing labs under various departments and public institutions, such as the Bangladesh Standards and Testing Institution (BSTI) and the National Food Safety Laboratory (NFSL). However, only a few of these labs have obtained accreditations for multiple testing parameters. The authority has several challenges and weaknesses in its functions, including

setting up international standards such as Codex Alimentarius and hazard analysis critical control point (HACCP). Furthermore, FSMS implementation enhances consumer education and awareness (Suman *et al*., 2021). Therefore, understanding consumer food safety knowledge is crucial before implementing food safety programmes in Bangladesh, particularly in this post-COVID era.

In Bangladesh, several studies have been undertaken to examine the FSK level among street vendors, restaurant staff and factory food handlers (Al Banna *et al*., 2022; Al Mamun *et al*., 2013; Nizame *et al*., 2019; Siddiky *et al*., 2022; Jubayer *et al*., 2020; Hashanuzzaman *et al*., 2020). Despite the significance of household food handling in preventing food contamination, there is a lack of research on consumer food safety knowledge before (pre) the COVID-19 pandemic. However, limited studies have highlighted consumers' household food handling knowledge levels after (post) the pandemic started. The WHO declared the COVID-19 pandemic a worldwide emergency in January 2020 (WHO, 2020). This study refers to the post-pandemic period after the emergence of the COVID-19 pandemic in January 2020. Therefore, the objectives of this research are

(1) To examine and compare adult consumers' pre-pandemic and post-pandemic FSK who handled food in the household environment.

(2) To evaluate the association between consumers' sociodemographic profiles and their FSK level.

(3) To investigate the elements that regulate FSK.

Measuring and comparing the pre-pandemic and post-pandemic FSK will help understand the difference in consumer food safety behaviour and any positive and negative behavioural patterns, which will help implement food safety strategies according to their knowledge level. Executing food safety interventions in low-socioeconomic and high-risk target groups will aid in the reduction of FBD by informing the public about the precautions they can take to protect themselves and their families from FBDs.

2. Methods

2.1 Study design and sampling

To compare the responses between urban and rural areas, the present research acquired data from four locations in Bangladesh between November 2021 and March 2022. The research sites included two metropolitan cities (Dhaka and Chittagong) and two rural districts (Faridpur and Cox's Bazar). Dhaka, the capital of Bangladesh, is a bustling metropolis home to an industry-based economy and a population of approximately 14.7 m. Faridpur is a district in the Dhaka division with a population of about 2.1 m and an agriculture-based economy (BBS, 2022). The coastal region of Bangladesh is home to Chittagong and Cox's Bazar. With a population of about 9.1 m, the second-largest city is Chittagong, and its local economy mostly depends on industry, agriculture and fishing. The district of the Chittagong division, Cox's Bazar, has 2.8 m people and a predominantly agricultural economy (BBS, 2022).

This study conducted a cross-sectional descriptive survey targeting consumers aged 18 years or above who prepared food at least 2–4 times per week and were willing to participate in the study. People who were not physically and mentally sound and not willing to participate were excluded from the survey. This study determined a sample size of 385, considering 50% population prevalence (as the original population prevalence or any estimated prevalence of knowledge, attitude or practices relating to food hygiene was unknown), utilising a 5% margin of error and a 95% confidence interval (Glen, 2021). It is generally accepted that a large sample size increases the study's accuracy, given its inferential objectives. Consequently, the study obtained more data, and the total sample was 503. This sample size was determined after considering the possibility of refusals, losses and missing data and the need for adjustments for confounding factors, as suggested by Martínez-Mesa *et al*. (2014).

2.2 Data collection

The data collection procedure commenced following approval from the relevant university human research ethics committee. According to university regulations, all research assistants received thorough training before starting the data collection, and the data were translated into Bengali from English. This study used the convenience sampling method because it is a simple, least time-consuming and least expensive strategy, considering the time and resources of this particular study (Bornstein *et al*., 2013). The research assistants randomly visited the selected public locations from the study sites, including local markets, supermarkets, traditional bazaars, schools, colleges and parks. The research assistants contacted people in front of stores or schools to select the participants. Following the disclosure of the study's objectives, ensuring confidentiality, and obtaining informed consent, the interviewer verbally presented the questions and available choices to participants, assisting in the electronic completion of the questionnaire using Google Forms. Each survey took between 15 and 20 min to finish.

2.3 Concept and survey instruments

The knowledge, attitudepractice (KAP) theory, which highlights the significance of knowledge and attitude in supporting practices, has been selected as a theoretical framework for this study (Mihalache *et al*., 2021; Zanin *et al*., 2017). The KAP model remains a widely adopted methodology for food safety research (da Cunha *et al*., 2022; Soon *et al*., 2021; Ruby *et al*., 2019). KAP is a crucial cognitive measure in public health when it involves health promotion. It contains a variety of perspectives regarding the causes of diseases, factors that contribute to making them worse, how to recognise symptoms, what therapies exist and the outcomes of the condition (Ferdous *et al*., 2020). A person's belief system may be influenced by numerous sources, including official government information, Internet platforms (such as social media), prior individual experiences, medical sources and even stereotyped concerns about the illness. Depending on how accurate these beliefs are, people's views and behaviours around the prevention and treatment of the disease may change. Any misunderstood or incorrect belief or ignorance about an illness may frequently affect an individual's health (Chen *et al*., 2020). Accordingly, this paper presents an exploration of knowledge constructs about food safety among adult consumers in Bangladesh, aiming to mitigate false beliefs and knowledge insufficiency.

This study employed a questionnaire with validated scales that were used in previous studies (Gong *et al*., 2016; Moreb *et al*., 2017; Soon *et al*., 2021; Odeyemi *et al*., 2019; Ruby *et al*., 2019; Tabrizi *et al*., 2017). The survey instruments are divided into two sections: sociodemographic characteristics and questions on consumers' knowledge of food safety.

The demographic information comprised age, gender, education, family income, occupation, place of residence, total number of individuals and the number of children in the household. The participants were asked questions on their knowledge of personal hygiene, cross-contamination, safe storage, foodborne diseases and temperature control using a set of 21 items in the FSK area. Each question had three alternative answers: "Yes", "No" and "Don't know". A correct response received one point, whereas an incorrect or "don't know" response received zero points. "Don't know" was added to the multiple-choice answers to reduce the likelihood that participants would select the correct response accidently or randomisation bias (Meher *et al*., 2022; Saeed *et al*., 2021; Ruby *et al*., 2019; Osaili *et al*., 2013). Respondents without a strong opinion or those unsure about the answer would nevertheless be required to select a response (non-attitude reporting). To reduce non-attitude reporting, a "Don't know" option is predicated on two assumptions (Krosnick *et al*., 2002). First, there are only two categories of respondents: those who have opinions on any given topic and are conscious of having them and those who have no ideas on any given topic but have a reasonable level of self-awareness. Second, it is assumed that responders will act rationally. Because of this, respondents who fall under the first category are expected to provide their thoughts, whether or

not they include a "Don't know". When presented with a choice, it is assumed that the second type will select "Don't know". Therefore, if a "Don't know" response is absent, this could potentially portray an opinion as overly biased (Krosnick *et al.*, 2002; Velez and Ashworth, 2007).

Both pre- and post-pandemic food safety knowledge data were collected using the same questionnaire and response scale. Each respondent could get a maximum of 3–8 points for each subsection of the knowledge section and 21 points for the entire knowledge section for both pre- and post-pandemic responses. If participants correctly responded to more than half of the questions in each area (such as personal hygiene, cross-contamination and safe storage), they were considered to have good knowledge. Participants who received 5–11 out of a possible 21 points for overall FSK were deemed to have poor knowledge, and those with 12–21 points were considered to have good knowledge (Gong *et al.*, 2016).

2.4 Validity and reliability

A bilingual translator translated the survey materials into Bengali while another research team member reviewed the translations. Before launching the final survey, researchers conducted a pilot study to test the validity of the instruments among a small group of consumers ($n = 30$). The final results did not include the pilot study. Cronbach's alpha tests were used to determine each scale's internal consistency. The Cronbach's alpha for pre-pandemic and post-pandemic constructs of FSK were 0.838 and 0.904, respectively, showing satisfactory reliability (Taber, 2018).

2.5 Data analysis

The data were analysed using SPSS software (Mac OS version 29). The pre- and post-pandemic responses in the study were determined by frequency analysis. The Shapiro–Wilk test results showed that the data were not normally distributed. The non-parametric Wilcoxon signed-rank test was used to assess pre- and post-pandemic levels of knowledge on food safety. Several Mann–Whitney *U* tests and Kruskal–Wallis *H* tests were carried out to contrast consumer pre- and post-pandemic food safety scores with demographic factors. The effects of pre- and post-pandemic FSK and sociodemographic variables such as gender, age and income on the probability of respondents considering a good level of knowledge were evaluated through binary logistic regression.

3. Result

3.1 Demographic characteristics

Table 1 outlines the demographic characteristics of 503 adult Bangladeshi consumers. Among them, 90.3% were female, 39% were 30–39 years old and 51.5% had primary or secondary education. The results also showed that 63% of respondents had 2–3 children in the family, and almost half of the participants were from rural (49.7%) and half from urban (50.3%) areas.

3.2 Food safety knowledge (FSK)

Table 2 summarises the participant responses to pre- and post-pandemic knowledge questions. Correspondingly, 77.9, 99.2 and 83.5% of respondents correctly knew that "wash the knife that has been used to cut raw meat with soap and water before using it again", "abdominal pain, diarrhoea, vomiting, nausea is foodborne illnesses symptoms" and "inadequate cooking of raw food can cause the outbreak of foodborne illness" during the pre-pandemic period. About 99% of participants knew that handwashing minimises the risk of food contamination before and after cooking a meal. However, only 30.6% confirmed the correct duration of handwashing, 10.9% reported that Hepatitis A virus, *Salmonella* and *Staphylococcus* are foodborne pathogens, and only 30.6% of them knew leftover food smelling good is not safe to eat in the

Table 1. Sociodemographic characteristics of the consumer

Demographic characteristics	*N* (503) *n*	Percentage (%)
Age (years)		
18–29	134	26.6
30–39	196	39
40–49	136	27
50 and above	37	7.4
Gender		
Female	454	90.3
Male	49	9.7
Education		
Primary/secondary	259	51.5
University (Bachelor/Masters/above)	244	48.5
Number of persons in family		
Up to 5	268	53.3
6 and more	235	46.7
Number of children in family		
0–1	130	25.8
2–3	317	63
4 and more	56	11.1
Residency place		
Urban	253	50.3
Rural	250	49.7

Source(s): Authors' own work

post-pandemic. The analysis also revealed that more than 60% of consumers did not know about refrigerator and freezer operating temperatures in the pre- and post-pandemic period.

The Wilcoxon signed-rank test showed that the pandemic caused a significant increase in consumer personal hygiene ($Z = -16.7$, $p < 0.001$) and overall FSK ($Z = -5.47$, $p < 0.001$) (Table 3).

As the data were not normally distributed, non-parametric tests Kruskal–Wallis H and Mann–Whitney U were conducted to investigate the relationship between consumer sociodemographic factors and their FSK level (Table 4). The analysis found that those aged 50 years and more, male gender, university graduates, urban residents, up to five people and 2–3 children in the family had the highest knowledge score in the pre- and post-pandemic period compared to their counterparts.

Binary logistic regressions were utilised to ascertain the influence of sociodemographic variables (e.g. gender, age and education) on pre- and post-pandemic FSK, as shown in Table 5. All predictors in the model were tested using the Omnibus tests of model coefficients, pre-pandemic [$\chi^2(8) = 187.53$, $p < 0.001$] and post-pandemic [$\chi^2(8) = 161.76$, $p < 0.001$] cases. Further, the Hosmer and Lemeshow test was done to confirm the pre-pandemic [($\chi 2 = 11.71, 8$) $p = 0.16$] and the post-pandemic [($\chi 2 = 13.52, 7$) $p = 0.06$] model. Because the Hosmer and Lemeshow test's p value was higher than 0.05, it was assumed that this model was a reliable indicator of consumers' degree of understanding regarding food safety (Pallant, 2005). The pre-pandemic logistic model explained 44.5% (Nagelkerke R^2) of the variance and correctly classified 77.1% of cases, and the post-pandemic model explained 37.4% (Nagelkerke R^2) of the variance and correctly classified 74.8% of cases. After adjusting the sociodemographic variables, the pre-pandemic binary logistic regression analysis showed that consumers aged 50 years and above ($B = 1.25$, $p < 0.01$) and university graduates ($B = 1.85$,

Table 2. Responses of food safety knowledge of adult consumers in Bangladesh

Questions	Pre-pandemic (%)			Post-pandemic (%)		
	Yes	No	Do not know	Yes	No	Do not know
Personal hygiene						
Handwashing before and after cooking reduces the risk of food contamination	44.3	43.5	12.1	99.0	0.6	0.4
20 s duration is enough for handwashing	6.2	46.1	47.7	30.6	23.1	46.3
It is necessary to wash hands after touching your body parts	8.9	39.0	52.1	27.6	20.5	51.9
Cross-contamination						
Uncovered abrasion or cuts can cause cross contamination of food	42.3	12.7	44.9	44.5	10.7	44.7
It is necessary to wash the knife that has been used to cut raw meat with soap and water before using it again	77.9	10.5	11.5	85.9	2.6	11.5
Storing raw and cooked food together can cause food contamination	47.5	4.2	48.3	47.9	3.8	48.3
Safe storage						
Leftover food smelling good is not safe to eat	30.4	45.3	24.3	30.6	45.1	24.3
It is ideal not to keep leftover food in the fridge for more than 2 days	48.1	27.0	24.9	49.1	26.2	24.7
Storing leftover food on the table or kitchen shelf is not good	44.7	29.0	26.2	44.9	28.8	26.2
Foodborne disease						
Abdominal pain, diarrhoea, vomiting and nausea are foodborne illnesses symptoms	99.2	0.2	0.6	99.2	0.2	0.6
Headache is a symptom of foodborne illnesses	13.3	25.8	60.8	13.5	25.8	60.6
Children, pregnant women and older people are more at risk of foodborne illnesses	53.7	6.6	39.8	53.3	6.6	40.2
Abortion in pregnant women be induced by foodborne disease	7.4	11.7	80.9	7.4	11.5	81.1
Poached egg, raw milk and soft cheese are not good for pregnancy	19.7	47.3	33.0	19.3	47.7	33.0
Microorganisms can be found on skin, nose and mouth of healthy handlers	39.0	11.5	49.5	39.0	11.3	49.7
Hepatitis A virus, *E. coli*, *Salmonella* and *Staphylococcus* are food borne pathogen	11.1	4.4	84.5	10.9	4.8	84.3
Inadequate cooking of raw food (meat, chicken and vegetable) can cause outbreak of foodborne illness	83.5	1.2	15.3	83.7	1.0	15.3
Temperature control						
−18 degree C or below is the optimal temperature for freezing food	22.1	4.2	73.8	22.3	3.8	74.0
1–5 degree C is the refrigerator operating temperature	36.6	1.8	61.6	36.6	1.4	62.0
Bacteria that cause food poisoning multiply rapidly at a temperature of 37 °C	11.5	5.2	83.3	12.3	5.0	82.7
Bacterial growth does not accelerate at a temperature of 75 °C	11.9	6.2	81.9	11.1	7.4	81.5

Source(s): Authors' own work

$p < 0.001$) had comparatively good FSK scores than the others. On the other hand, consumers with an increasing number of children in the family ($B = -0.706$, $p < 0.01$) and rural regions ($B = -1.40$, $p < 0.01$) had significantly poor FSK scores. The post-pandemic regression analysis also observed that university graduates ($B = 1.53$, $p < 0.01$) were the strongest predictor, with 4.6 times more likely to have good FSK, and the increased number of children

Table 3. Wilcoxon signed rank test showing the comparison of pre-and post-pandemic food safety knowledge

FSK	Pre-pandemic Mean ± SD	Percentage[a]	Post-pandemic Mean ± SD	Percentage[a]	Z	*p*
Personal hygiene	0.59 ± 0.772	10.1	1.57 ± 0.829	36.4	−16.7	<0.001***
Cross contamination	1.67 ± 1.160	46.9	1.78 ± 1.333	48.5	−1.81	0.07
Safe storage	1.23 ± 1.287	38.6	1.24 ± 1.283	39.2	−0.19	0.84
Foodborne disease	3.26 ± 1.830	35	3.26 ± 1.766	35.6	−0.06	0.94
Temperature control	0.82 ± 1.268	24.9	0.82 ± 1.260	25	−0.36	0.71
Overall knowledge	7.59 ± 4.129	28.8	8.68 ± 4.975	38.2	−5.47	<0.001***

Note(s): $p < 0.001$***, a = Shows "Good" level of knowledge and FSK – Food safety knowledge
Source(s): Authors' own work

Table 4. Association between sociodemographic factors and consumers pre- and post-pandemic food safety knowledge scores

Sociodemographic factors	Pre-pandemic U/H	Mean rank	Post-pandemic U/H	Mean rank
Age in years[b]	χ^2 (3) = 25.96	$p < 0.001$	χ^2 (3) = 28.27	$p < 0.001$
18–29		250.16		247.55
30–39		251.31		259.68
40–49		225.01		216.76
50 and above		361.50		356.95
Gender[a]	$Z = -3.79$	$p < 0.001$	$Z = -2.80$	$p < 0.01$
Male		326.52		306.95
Female		243.96		246.07
Education[a]	$Z = -15.25$	$p < 0.001$	$Z = -12.99$	$p < 0.001$
Primary/secondary		156.53		170.71
University (Bachelor/Masters/above)		353.34		338.29
Number of persons in family[a]	χ^2 (2) = −9.89	$p < 0.001$	$Z = -8.95$	$p < 0.001$
Up to 5		311.76		306.01
6 and more		183.85		190.40
Number of children in family[b]	χ^2 (2) = 75.09	$p < 0.001$	χ^2 (2) = 71.02	$p < 0.001$
0–1		267.89		296.39
2–3		273.35		259.74
4 and more		94.22		105.13
Residency place[a]	$Z = -15.39$	$p < 0.001$	$Z = -12.76$	$p < 0.001$
Urban		350.72		333.75
Rural		152.10		169.27

Note(s): $p < 0.001$, $p < 0.01$; a = Mann–Whitney *U* test and b = Kruskal–Wallis *H* test
Source(s): Authors' own work

($B = -0.775, p < 0.001$) and rural regions ($B = -0.779, p < 0.05$) had a negative association to the good FSK score.

4. Discussion

Examining the impact of a condition or illness on people's behaviour necessitates knowledge (Marathe *et al*., 2016). Consumers need to prioritise developing food safety knowledge (FSK) and recognise the significance of educational programmes in this area. So far, no studies have been conducted on FSK comparing the pre- and post-COVID situation in low- and middle-income countries such as Bangladesh. This study surveyed a target population through a systematic, standardised questionnaire to measure and analyse consumer understanding (knowledge) to compare pre- and post-COVID food safety knowledge.

Table 5. Binary logistic regression analysis showing sociodemographic factors and pre- and post-pandemic food safety knowledge level

Variables	Pre-pandemic B	Pre-pandemic Or (95% C.I.)	Post-pandemic B	Post-pandemic Or (95% C.I.)
Age (years)				
18–29	Ref		Ref	
30–39	0.485	1.625 (0.85, 3.08)	−0.232	0.793 (0.45, 1.38)
40–49	0.681	1.975 (0.95, 4.07)	−0.467	0.627 (0.33, 1.16)
50 and above	1.251	*3.949*** (1.38, 8.82)	0.765	2.15 (0.85, 5.39)
Gender				
Male	Ref		Ref	
Female	−0.375	0.687 (0.35, 1.35)	0.116	1.123 (0.58, 2.16)
Education				
Primary/secondary	Ref		Ref	
University (Bachelor/Masters/above)	1.859	*6.417**** (2.79, 14.74)	1.531	*4.622*** (2.24, 9.52)
Number of persons in family	0.054	1.055 (0.58, 1.90)	−1.65	0.848 (0.50, 1.41)
Number of children in family	−0.706	*0.494*** (0.30, 0.81)	−0.775	*0.461**** (0.30, 0.70)
Residency place				
Urban	Ref		Ref	
Rural	−1.404	*0.246*** (0.10, 0.59)	−0.779	*0.461** (0.21, 0.98)

Note(s): ***$p < 0.001$, **$p < 0.01$ and *$p < 0.05$; Regression model was adjusted for age, gender, education, number of persons, number of children, residency place; Ref: Reference group
Source(s): Authors' own work

The result of this study found that 99.0% of consumers had a higher understanding of handwashing during the post-pandemic, complying with studies conducted in other countries, such as Brazil (93.4%) and Jordan (77.5%) (Almanasrah *et al*., 2022; Mucinhato *et al*., 2022). However, only 30.6% of consumers reported knowing the correct handwashing technique (e.g. handwashing with warm water and soap for at least 20 s), and the result was lower than the previous studies (Almanasrah *et al*., 2022; Osaili *et al*., 2022; Saeed *et al*., 2021). About 99.2% of the consumers in this study comprehended the general symptoms of FBDs, such as abdominal pain, diarrhoea and vomiting, yet above 10% knew about FBD pathogens (e.g. Hepatitis A virus, *E. coli*, *Salmonella* and *Staphylococcus*) in the pre- and post-pandemic. This percentage was lower than a previous study result that found 45% of street-food consumers were aware of FBD pathogens in Bangladesh (Al Banna *et al*., 2022), and this difference may be due to the sample size and study populations. Further, both pre- and post-pandemic results indicated that the majority (>80%) of the respondents were not aware of the consequences of consuming high-risk foods such as poached eggs and raw milk during pregnancy, and only 7.4% (pre- and post-pandemic) knew FBD induced abortion. This finding suggests a lack of awareness for high-risk groups (e.g. pregnant) that contrasts with the previous studies (Al Banna *et al*., 2022; Ma *et al*., 2019). Literature suggests that due to long-time food habits and various misconceptions, many rural individuals in Bangladesh consume raw milk, which has significant health consequences (Reza *et al*., 2021). Unexpectedly, very few proportions of consumers exactly reported the operating temperatures of the freezer (22%) and refrigerator (36%) in pre- and post-pandemic responses in this study, which was consistent with the studies conducted in Malaysia (Ruby *et al*., 2019) and the UAE (Saeed *et al*., 2021).

Overall, the findings of this study indicated that consumer food safety knowledge (FSK) measures, such as personal hygiene knowledge, have significantly improved after the onset of the pandemic. However, other FSK measures such as cross-contamination, safe storage, foodborne diseases and temperature control knowledge have not increased notably after the pandemic outbreak. Despite the above results, this research found a significant rise in overall

food safety knowledge (FSK) levels during the post-pandemic (38.2%), mainly attributed to personal hygiene knowledge. This study utilised KAP theory and reported the knowledge construct in this paper, understanding food safety awareness and comparing the pre-and post-pandemic paradigms. KAP theory is a widely used method to study how individuals act when affected by a disease or condition (Marathe *et al*., 2016). The COVID-19 pandemic has posed an immense threat to the health and well-being of individuals. During this pandemic crisis, individuals felt a threat to their existence, and they became more alert to the potential harm and employed preventive strategies. Experts advised various methods to prevent the transmission of COVID-19 infection. One of the personal hygiene measures, such as handwashing, has been widely encouraged during the pandemic to reduce this virus transmission. Many international and national health organisations announced the COVID-19 infection prevention measures on their websites. The pandemic fear led consumers to obtain this knowledge from various sources, such as word of mouth, mass media, and the internet (Mucinhato *et al*., 2022). Thus, the psychological impact of the pandemic affects individuals' knowledge of hygiene and their exposure to information contributes to increased overall food safety knowledge after the outbreak of the pandemic. On the other hand, cross-contamination, safe storage or foodborne disease knowledge remains the same as pre-pandemic, which may be due to less dissemination of this knowledge compared to the personal hygiene measures during the pandemic or they might be more alert for transmitting COVID infection rather than FBDs. Therefore, this study has depicted that a higher portion of consumers (>60%) had overall poor food safety knowledge in the pre- and post-pandemic periods, which should be improved to minimise foodborne disease (FBD) incidence during this post-COVID era. Additionally, the protection motivation theory (PMT) by Rogers (1975) is applicable to explain this result. According to the PMT, when individuals perceive a threat, they engage in threat-appraisal processes to assess the severity and vulnerability of the threat and employ coping-appraisal processes to protect themselves and respond to perceived health risks. Future research can use the PMT constructs (e.g. severity, vulnerability, efficacy and protection motivation) to understand consumer food safety behaviour in Bangladesh.

Additionally, consumers aged 50 years and over, university graduates, males, families with 2–3 children, up to five family members and urban residents scored good levels of FSK in pre- and post-pandemic times. Aged 50 years and above showed significantly higher knowledge in the pre-pandemic after adjusting the sociodemographic variables. The reasons may be elderly consumers' long-time experience and superior insights into food safety issues (Worsley *et al*., 2013). However, post-pandemic FSK did not exhibit any notable disparity in age. A possible explanation for this finding might be that young adults tend to use Internet services more (Osaili *et al*., 2021), which might have enabled them to access food safety information made public by the government and the media during this pandemic. In addition, their active involvement in food preparation at home due to the pandemic lockdown also might have influenced the above finding.

Aligning with previous research (Moreb *et al*., 2017; Tomaszewska *et al*., 2018), after adjusting for different covariates, consumers with university graduation showed significantly higher FSK scores in the pre- and post-pandemic. Generally educated consumers are more sceptical of food hygiene and are more worried about the possibility of FBDs at home (Parra *et al*., 2014). This group of consumers may understand the risks of FBD due to their prior knowledge from direct or indirect input through their education. In contrast to the earlier research (da Cunha *et al*., 2022; Shori, 2017; Ruby *et al*., 2019), gender showed no significant difference in this study. There were fewer men than women participants in this study. For a comprehensive knowledge of this gender issue, additional research using a sizable sample of male gender would be required.

The adjusted model also found that urban residents and consumers with few children in the family possess better knowledge than others (pre- and post-pandemic), which aligns with the study by Islam *et al*. (2023). In Bangladesh, consumers with few children (less than 4) usually reside in urban places (Haq and Ahmed, 2018). Urban individuals generally possess higher

levels of education (university bachelor's and above) than rural residents. During the COVID-19 pandemic, when health uncertainty existed, educated individuals adopted new behaviours, such as digital activities and e-learning, to overcome these uncertainties. Higher cognition in individuals living in urban places enables them to recognise and relate health emergencies and misinformation from various sources, including mass media, the Internet or their past knowledge. In contrast, rural residents often have little access to quality education; therefore, their weak cognitive abilities and financial circumstances may prevent them from having the luxury of understanding all the necessary food safety precautions.

5. Conclusion

The current study revealed that Bangladeshi consumers' overall food safety knowledge (FSK) has improved during the post-COVID-19; there is still an insufficiency in consumer understanding of the appropriate duration of handwashing, foodborne pathogens, consuming raw milk or eggs, safe storage and temperature control of food. This study's results have significant implications for policymakers and provide a strong foundation for local authorities to increase FSK among consumers, particularly in the above measures. This research has revealed that proper dissemination and effective food safety campaigns can improve the consumer knowledge level, evident through their handwashing improvement knowledge during the post-pandemic time. The data from this study showed that stronger reinforcement is needed for instructional programmes on household food safety in low- and middle-income countries (LMICs). The local government agencies and educational institutions could utilise this data to identify food safety issues and potential target audiences (e.g. rural consumers) for FBD prevention. Further, the government and policymakers should implement food safety strategies, including the Hazard Analysis Critical Control Point (HACCP) concepts and the "Five Keys to Safer Food" – to educate consumers to improve food safety in this community. To ensure that knowledge is implemented into practice, educational programmes should be repeated at predetermined intervals in the LMIC, such as in Bangladesh. Educational messages should also be spread through official and informal education and the media to reach mass people. It would be more beneficial for future research to investigate the perceived barriers of consumers to obtaining information about food safety.

6. Strengths and limitations

There are several limitations associated with the study. To the best of our knowledge, this is the first study that compared consumer food safety knowledge (FSK) before and after the outbreak of the COVID-19 pandemic in Bangladesh. Since no prior study measured consumer FSK before the COVID-19 pandemic in Bangladesh, it contributes knowledge to the growing body of literature on consumer awareness of food safety issues. Another significant strength is that the diversified sample clearly illustrates the urban and rural settings of the country regarding food safety issues. Limitations included the inability to generalise consumers in Bangladesh due to the convenience sample approach. Besides, a chance of recall bias is possible in the case of pre-pandemic answers, as the data were collected after the onset of the pandemic. To reduce the recall bias, research questions were selected carefully, validated data collection instruments were used, and participants were allowed sufficient time for adequate recall of long-term memory by the well-trained surveyors (Grimes and Schulz, 2002).

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Further reading

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