Research article

Food safety and handling knowledge and practices among university students of Bangladesh: A cross-sectional study

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ABSTRACT

Keywords:
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Questionnaire

Our study aimed to examine the practices and knowledge of food handling and safety among 1534 university students in Bangladesh (mean age 22.09 ± 1.78), as well as the relationship between these factors and their academic and demographic backgrounds. Participants in this study were undergraduate and graduate students from four public universities in Bangladesh from different religions, income levels, years and majors of study, residential areas, living alone or not, and whose mothers are working or non-working. The questionnaire included 14 questions on food handling practices and 16 on knowledge. Questions were related to food preparation, hygiene, cross-contamination, and storage. The overall mean score for food handling practices was 34.9% (SD = 13.7), while that of knowledge was 41.8% (SD = 16.5). Female students, those from food-related majors, and those engaged in cooking activities scored significantly higher in the knowledge and practice sections (p < 0.05).

Students who lived with their families performed significantly better on the knowledge parts, while those who shared a home with roommates in mess performed significantly better on the practice part (p < 0.05). Students having housewife mothers, personal poisoning experience, and continuous involvement in food purchasing scored significantly higher (p < 0.05) in the practices section but not in the knowledge one. On the other hand, students living in urban areas scored significantly higher (p < 0.05) in the knowledge section but not in the practices one.

Our results highlight the importance of educational interventions and initiatives to enhance food safety awareness among Bangladeshi university students.

1. Introduction

The global public health concern is foodborne infections, even in nations with sophisticated food safety systems, such as ‘farm-to-fork’ in Europe and ‘farm-to-table’ in the USA (Morris, 2011; Lazou et al., 2012). Though it is difficult to measure the prevalence of foodborne diseases worldwide, it is thought that 1.6 million people each year pass away from acute gastroenteritis, primarily brought on by infected water and food. In the USA, each year, 1/3rd of people may get a foodborne illness. This percentage is increasing due to the globalized food trade, increasing tourism, mass production, and industrialized animal production, among others (Hassan and Dimassi, 2014).

Therefore, safe food purchase, cooking, preparation, and handling in households are key to reducing the prevalence of foodborne illnesses (Redmond and Griffith, 2003; Kennedy et al., 2005).

Mishandling of foods among young male adults (less than 30 years old) has been commonly reported (Li-Cohen and Bruhn, 2002; Medeiros et al., 2004; McArthur et al., 2007). Despite the fact that this age group is not considered ‘at-risk’ for foodborne illnesses, their poor hygienic practices have serious ramifications when they begin to provide care for other at-risk family members (children, the elderly, and pregnant women) (Abbot et al., 2009; Byrd-Bredbenner et al., 2008).

A plethora of

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studies on food safety knowledge and practices were conducted on youth, such as in Saudi Arabia (Sharif and Al-Malki, 2010), USA (Byrd-Bredbenner et al., 2007; Morrow and Rathburn, 2003), Turkey (Sanlier, 2009), Spain (Garayoa et al., 2005), Greece (Lazou et al., 2012), Lebanon (Hassan and Dimassi, 2014), Iran (Eslami et al., 2015), Canada (Majowicz et al., 2015), Bulgaria (stratev et al., 2017), Pakistan (Zeeshan et al., 2017), Ethiopia (Azanaw et al., 2019), Jordan (Osaily et al., 2011), Kuwait (Ashkanani et al., 2021), Oman (Al Makhroumi et al., 2022), Serbia (Vukasnovic et al., 2022), and Iraq (Muhayaddin et al., 2022).

Determing the actual level of food safety knowledge and practices is the starting point to improve this level among any group via educational programs. In other words, identifying the demographic factors of the handlers having the poorest knowledge of food safety is the foundation of any effective educational program. Numerous studies have documented the effect of different demographic characteristics, such as gender, income, education level, age, major of study, and residential location, on food handling knowledge and practices (Sanlier, 2009; Hassan and Dimassi, 2014; Ovca et al., 2014). However, these studies showed mixed results because of variations in population characteristics, design of studies, and questions of the survey.

Foodborne diseases or illnesses and other food safety hazards are prevalent in Bangladesh due to the high population density, poor water, sanitation, and hygiene (WASH) facilities, and unflapd infrastructure (Noor and Feroz, 2016). As a result, each year nearly 30 million individuals suffer from foodborne infections in Bangladesh (Khairuzzaman et al., 2014). In particular, diarrheal illnesses are the most prevalent foodborne illnesses, in addition to hepatitis and enteric fever as common cases (Food and Agricultural Organization of the United Nations, 2016; Suman et al., 2021). Al Mamun et al. (2013) investigated food safety knowledge and awareness among school-based street food vendors in Bangladesh, whereas Al Banna et al. (2021) evaluated factors influencing food safety knowledge and behaviors among meat processors. Additionally, knowledge and practices were assessed among fish farmers/restaurants, food handlers, chotpoti vendors, street food vendors, and chicken vendors in Bangladesh by Hashanuzzaman et al. (2020), Siddiky et al. (2022), and Hossen et al. (2020), respectively. Additionally, Tarannum (2021) investigated the practices, attitudes, and knowledge of food handlers in Bangladeshi households about food sanitation. As far as our search is concerned, there has not been any previous data on food safety knowledge and practices among students in Bangladeshi universities; therefore, our study assessed self-reported practices and knowledge related to food safety among four public universities in Bangladesh. Another important goal was to evaluate the impact of various demographic traits on food safety among four public universities in Bangladesh. Another important goal was to evaluate the impact of various demographic traits on food safety among four public universities in Bangladesh. Another important goal was to evaluate the impact of various demographic traits on food safety among four public universities in Bangladesh. Another important goal was to evaluate the impact of various demographic traits on food safety among four public universities in Bangladesh. Another important goal was to evaluate the impact of various demographic traits on food safety among four public universities in Bangladesh.

### 2. Materials and methods

#### 2.1. Study subjects

Between January and March 2022, a cross-sectional study at four public universities in Bangladesh was carried out. These universities were Patuakhali Science and Technology University (PSTU), Jashore University of Science and Technology (JUST), Hajee Mohammad Danesh Science and Technology University (HSTU), and Islamic University (IU). The selection of universities considered those offering bachelor’s degrees in both food-related (nutrition and food science, applied food technology and nutritional science, food processing and preservation technology) and non-food-related majors of study (arts, basic sciences, business studies, technology, and engineering). The inclusion criteria for the study include the following: Bangladeshi university students (both genders) registered at one of the selected universities from different majors of the study (food-related or non-food-related) and levels of the study (bachelor or master).

#### 2.2. Data collection

A total of 1650 participants were randomly selected using random number table from each major of the study, where 436 participants were from food-related majors of study, and the rest (1214 participants) were from non-food-related majors. The questionnaire was distributed to all the students who volunteered to take part in the study, giving written approval. Then, questionnaires were supplied to all the students, and those who volunteered to take part in the study gave their written approval. After filling out the questionnaire, an oral explanation of the study content, objectives, and the study protocol was given to the class teacher/instructor for initial approval. After getting the approval, the researchers met the students. They informed them about the importance, objectives and protocol of the study, and those who volunteered to take part in the study gave their written approval. Then, questionnaires were supplied to all the students.
| Demographic variable          | Food handling practices | Food safety knowledge |
|------------------------------|-------------------------|-----------------------|
|                              | Mean        | SD      | p-value   | Mean        | SD      | p-value   |
| Major of study               |             |         |           |             |         |           |
| Food related                 | 40.17       | 13.31   | <0.001    | 47.32       | 14.93   | <0.001    |
| Nonfood related              | 33.10       | 13.38   |           | 39.85       | 16.52   |           |
| Age (Years)                  |             |         |           |             |         |           |
| 18 to 20                     | 35.46       | 13.26   | 0.001     | 41.36       | 15.81   | 0.919     |
| 21 to 23                     | 35.77       | 13.72   |           | 41.87       | 16.27   |           |
| Above 23                     | 32.49       | 13.85   |           | 41.96       | 17.44   |           |
| Gender                       |             |         |           |             |         |           |
| Male                         | 33.94       | 13.71   | 0.007     | 40.70       | 17.47   | 0.005     |
| Female                       | 35.93       | 13.64   |           | 42.88       | 15.25   |           |
| Religion                     |             |         |           |             |         |           |
| Muslim                       | 34.89       | 13.62   | 0.983     | 41.87       | 16.58   | 0.741     |
| Hindu                        | 35.14       | 14.37   |           | 41.45       | 15.71   |           |
| Other<sup>a</sup>            | 34.07       | 12.08   |           | 38.46       | 16.11   |           |
| Year of study                |             |         |           |             |         |           |
| B.Sc. 1st year               | 34.85       | 13.23   | 0.003     | 40.39       | 16.11   | 0.062     |
| B.Sc. 2nd year               | 37.17       | 14.46   |           | 41.92       | 16.00   |           |
| B.Sc. 3rd year               | 33.64       | 13.79   |           | 41.81       | 16.40   |           |
| B.Sc. 4th year               | 34.49       | 14.07   |           | 42.08       | 16.30   |           |
| Masters<sup>a</sup>          | 32.06       | 11.74   |           | 46.80       | 18.63   |           |
| Residential status           |             |         |           |             |         |           |
| With Family                  | 37.99       | 14.33   | 0.003     | 42.87       | 16.29   | <0.001    |
| With Friends/Roommates in Hall | 34.41    | 13.65   |           | 40.77       | 15.98   |           |
| In mess with roommates       | 35.85       | 13.38   |           | 46.71       | 18.15   |           |
| Residential area             |             |         |           |             |         |           |
| Rural                        | 35.21       | 13.49   | 0.434     | 40.69       | 15.73   | 0.007     |
| Urban                        | 34.60       | 13.96   |           | 43.00       | 17.15   |           |
| Mother's education           |             |         |           |             |         |           |
| No formal education          | 34.19       | 12.29   | 0.747     | 39.55       | 16.99   | 0.113     |
| Primary                      | 34.60       | 14.59   |           | 39.71       | 15.58   |           |
| Secondary                    | 34.50       | 13.66   |           | 42.94       | 16.72   |           |
| Higher Secondary             | 35.50       | 13.60   |           | 42.02       | 16.62   |           |
| Bachelor and/or above        | 35.37       | 13.54   |           | 41.92       | 15.95   |           |
| Monthly income (BDT)         |             |         |           |             |         |           |
| Up to 15000                  | 34.78       | 13.56   | 0.509     | 40.32       | 15.13   | 0.062     |
| 16000 to 30000               | 34.55       | 13.57   |           | 41.65       | 16.49   |           |
| Above 30000                  | 35.68       | 14.10   |           | 43.45       | 17.49   |           |
| Mother employment status     |             |         |           |             |         |           |
| Employment/works             | 33.25       | 13.81   | 0.048     | 40.21       | 16.83   | 0.079     |
| Housewife                    | 35.26       | 13.67   |           | 42.09       | 16.35   |           |
| Cooking habit                |             |         |           |             |         |           |
| Yes, all time                | 32.82       | 14.49   | 0.007     | 40.03       | 15.64   | <0.001    |
| Yes, sometimes               | 35.80       | 13.63   |           | 41.86       | 15.92   |           |
| Yes, rarely                  | 35.36       | 13.56   |           | 43.80       | 16.63   |           |
| Never                        | 32.96       | 13.58   |           | 38.72       | 17.27   |           |
| Personal food poisoning experience | 35.76   | 13.85   | 0.002     | 42.02       | 15.92   | 0.189     |
| No                           | 33.42       | 13.34   |           | 41.34       | 17.36   |           |
| Involvement in food purchasing for personal or family use | 34.92 | 13.71 | 41.78 | 16.45 |

Note: a = Buddhist and Christians.
Table 3. Score distribution to food handling practices questions.

| Questions                                                                 | Multiple-choice responses | Correct responses (%) |
|---------------------------------------------------------------------------|---------------------------|-----------------------|
| **(1)** You cut meat on a chopping board and now you want to cut vegetables. Of the following, which one do you practice? | Use the board as it is.    | 4.0                   |
|                                                                           | You wipe the board off with a paper towel/cloth | 35.1                  |
|                                                                           | Use the other side of the chopping board to cut vegetables | 21.8                  |
|                                                                           | Use another chopping board to cut vegetables | 26.7                  |
|                                                                           | Don’t know                | 12.4                  |
| **(2)** When you cut raw meat and need to use the knife again, what do you do? | You reuse the knife as it is | 4.2                   |
|                                                                           | You rinse the knife with cold water | 38.8                  |
|                                                                           | You wipe the knife with a cloth/paper towel | 11.2                  |
|                                                                           | You wash the knife with soap and hot water | 45.8                  |
| **(3)** A refrigerator has three shelves, on which shelf do you place raw meat? | Top shelf                   | 20.3                  |
|                                                                           | Middle shelf               | 6.6                   |
|                                                                           | Bottom shelf               | 61.7                  |
|                                                                           | Does not matter            | 11.4                  |
| **(4)** Do you handle food if you have a wound on the back of your hand? | Yes, as long as the wound has a bandage on it | 25.6                  |
|                                                                           | Yes, as long as the wound is not infected | 17.7                  |
|                                                                           | Yes, as long as gloves are worn | 26.4                  |
|                                                                           | Not at all                | 30.3                  |
| **(5)** How do you check that food is sufficiently cooked? | By seeing the food color/By taking taste | 72.4                  |
|                                                                           | Density of Juice content/concentration of food | 18.5                  |
|                                                                           | By checking the central temp. of cooking pot | 2.5                   |
|                                                                           | Measuring the cooking time | 6.6                   |
| **(6)** How long do you heat Leftover foods? | Until they are boiling hot | 39.9                  |
|                                                                           | Heat it to the temperature you prefer | 32.4                  |
|                                                                           | Just until they are at least at room temperature or 250°C | 11.9                  |
|                                                                           | Reheating is not necessary | 3.3                   |
|                                                                           | Don’t know                | 12.5                  |
| **(7)** While washing your hands, how long do you rub them with soap? | 10 s                       | 25.0                  |
|                                                                           | 20 s                      | 50.8                  |
|                                                                           | 30 s                      | 11.4                  |
|                                                                           | 40 s                      | 4.0                   |
|                                                                           | Don’t know                | 8.8                   |
| **(8)** Do you take off the jewelry when preparing food? | Yes | 18.2                  |
|                                                                           | No                        | 27.6                  |
|                                                                           | Yes, sometimes            | 13.7                  |
|                                                                           | Not applicable            | 40.5                  |
| **(9)** Of the following, how do you thaw raw meat? | Thaw in refrigerator | 6.8                   |
|                                                                           | Thaw on chopping/cutting board (25-0°C/room temperature) | 13.6                  |
|                                                                           | Thaw in cold water in sealed package/pot | 41.2                  |
|                                                                           | Thaw in running water     | 31.7                  |
|                                                                           | Don’t know                | 6.7                   |
| **(10)** In case your electricity went off and the meat, chicken, and/or seafood in your freezer thawed and felt warm, what do you do? | Throw them away | 10.0                  |
|                                                                           | Cook them right away      | 28.7                  |
|                                                                           | See how they smell or look before deciding what to do | 44.7                  |
|                                                                           | Immediately re-freeze until future consumption | 16.6                  |

Table 3 (continued)

| Questions                                                                 | Multiple-choice responses | Correct responses (%) |
|---------------------------------------------------------------------------|---------------------------|-----------------------|
| **(11)** If your roommate or you are going to be several hours late for a hot meal, where do you leave the meal? | Store it in the refrigerator and reheat it when the person is ready to eat it | 31.7                  |
|                                                                           | Store it on the kitchen counter until the person is ready to eat it | 36.2                  |
|                                                                           | Store it in a warm oven until the person is ready to eat It. Not reheat again | 11.1                  |
|                                                                           | Store it in a cool oven until the person is ready to eat it | 18.2                  |
|                                                                           | Don’t know                | 2.8                   |
| **(12)** How do you wash your hands before starting preparing food or eating? | Cold Water only | 6.8                   |
|                                                                           | Wash hand With soap/hand wash and cold water | 83.7                  |
|                                                                           | Wipe with a towel or dish cloth | 6.1                   |
|                                                                           | I don’t clean them at all | 3.4                   |
| **(13)** You wash fruits and vegetables by using: | Water and soap | 6.8                   |
|                                                                           | Hot water                 | 11.0                  |
|                                                                           | We wash them under cold running water | 35.9                  |
|                                                                           | Using Normal water        | 46.3                  |
|                                                                           | Face®                     | 49.7                  |
|                                                                           | Clean cooking utensils/cooking pot | 33.6                  |
|                                                                           | Clean utensils            | 5.3                   |
|                                                                           | None of the above         | 11.4                  |

*d* indicates correct answer.

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in the selected classrooms so that they could be filled at the end of the sessions.

No other rewards were provided since the participation was completely voluntary and anonymous. Inappropriately filled or incomplete questionnaires were excluded from the study. Hence, out of 1650 filled questionnaires, only 1534 (92.96% response rate) were valid (396 from food-related majors and 1138 from non-food-related majors). Ethical approval was granted by the ethical committee of the department of Biochemistry and Food Analysis at Patuakhali Science and Technology University (PSTU) (approval number: BFA: 10/12/2021:04).

### 2.2. Questionnaire

To evaluate food handling and safety knowledge and practices among Bangladeshi university students, a questionnaire was developed by including questions collected from updated, valid, and reliable instruments produced by previous studies (Hassan et al., 2014; Hassan et al., 2018; Chuang et al., 2021; Lazou et al., 2012; Byrd-Bredbenner et al., 2007; Haapala and Probart, 2004; Ovca et al., 2014; Osaili et al., 2011). In addition, some questions related to geographical location, culture and eating habits in Bangladesh were modified. The questionnaire was piloted among 45 students to determine whether the wording was precise and appropriate and determine how long it would take to complete. Modifications were made based on the results of the pilot research.

The final questionnaire is divided into four sections: an introduction, demographic data, handling procedures for food safety, and food safety knowledge. The first part included a short introduction to the objectives of the study. The second part focused on demographic characteristics, including age, gender, religion, current educational status, residential status, monthly income (BDT), mother employment status, cooking habits, previous personal food poisoning experience, involvement in food purchasing, etc. The third part comprises the food safety practices section containing 14 questions that were
Table 4. Score distribution to food safety knowledge questions.

| Questions                                                                 | Incorrect responses | Correct responses (%) |
|---------------------------------------------------------------------------|---------------------|-----------------------|
| (15) Campylobacter bacteria are most likely associated with which food?    | Canned food         | 14.5                  |
|                                                                           | Raw or undercooked meat/fish | 44.0              |
|                                                                           | Fresh vegetables    | 4.5                   |
|                                                                           | Don’t know          | 37.0                  |
| (16) Which of the following is most likely to become contaminated with Listeria? | Canned food         | 13.1                  |
|                                                                           | Raw or undercooked meat/fish | 41.3              |
|                                                                           | Fresh vegetables    | 5.9                   |
|                                                                           | Don’t know          | 29.7                  |
| (17) The microorganisms that cause most of food-borne illnesses are:      | Bacteria            | 62.4                  |
|                                                                           | Fungi               | 14.0                  |
|                                                                           | Viruses             | 5.5                   |
|                                                                           | Parasites           | 5.5                   |
|                                                                           | Don’t know          | 12.6                  |
| (18) Which of these individuals are LEAST likely to get food poisoning?   | Old people          | 38.3                  |
|                                                                           | Pregnant women      | 25.6                  |
|                                                                           | Teenagers           | 11.7                  |
|                                                                           | Don’t know          | 24.4                  |
| (19) When is the best time to purchase frozen food when shopping?         | At the beginning of the shopping time | 9.4               |
|                                                                           | At the end of the shopping time | 63.0              |
|                                                                           | Whenever, does not matter | 7.7                |
|                                                                           | Don’t know          | 19.9                  |
| (20) All foods are considered safe when cooked to an internal temperature | 54 °C               | 7.6                   |
|                                                                           | 60 °C               | 11.2                  |
|                                                                           | 66 °C               | 6.0                   |
|                                                                           | 74 °C               | 11.1                  |
|                                                                           | Don’t know          | 64.1                  |
| (21) Which is the safest way to get fried egg?                            | Solid albumen and yolk | 43.2              |
|                                                                           | Semi-solid albumen and yolk | 18.6          |
|                                                                           | Solid albumen and semi-solid yolk | 19.2 |
|                                                                           | Solid albumen and liquid yolk | 7.8          |
|                                                                           | Don’t know          | 11.2                  |
| (22) How to prevent salmonella poisoning?                                | Fully heat food     | 51.7                  |
|                                                                           | Freeze food for more than 3 days | 10.3          |
|                                                                           | Those food will not safe for cooking | 7.4          |
|                                                                           | Don’t know          | 30.6                  |
| (23) People with which of the following symptoms should not cook for others? | Diarrhea, Fever, Sore throat or Flu | 58.3             |
|                                                                           | Skin allergies      | 16.0                  |
|                                                                           | Headache            | 2.4                   |
|                                                                           | All the Above       | 23.3                  |
| (24) What is the maximum refrigerators temperature should be to preserve the safety of foods? | -4 °C              | 35.7                  |
|                                                                           | 12 °C               | 4.6                   |
|                                                                           | 4 °C                | 31.9                  |
|                                                                           | Don’t know          | 27.8                  |
| (25) What is the recommended temperature for freezers?                   | -18 °C              | 45.7                  |
|                                                                           | 0 °C                | 13.3                  |
|                                                                           | 18 °C               | 4.6                   |
|                                                                           | Don’t know          | 36.4                  |
| (26) You can get food poisoning from eating which of the following?       | Fruits taken out of the refrigerator immediately | 3.3              |
|                                                                           | Raw or undercooked eggs | 12.5            |
|                                                                           | Raw or undercooked meat | 17.9            |
|                                                                           | Both B & C          | 59.5                  |
|                                                                           | Others              | 6.8                   |

Table 4 (continued)

| Questions                                                                 | Multiple-choice responses | Correct responses (%) |
|---------------------------------------------------------------------------|---------------------------|-----------------------|
| (27) Freezing Kills harmful germs in food                                  | Right                      | 24.8                  |
|                                                                           | Wrong                      | 41.7                  |
|                                                                           | Don’t know                 | 33.5                  |
| (28) Which is the most important for preventing food poisoning?            | Use detergent to disinfect kitchen countertop and stove weekly | 17.5                  |
|                                                                           | Avoid eating leftovers     | 19.2                  |
|                                                                           | Keep food refrigerated until it is time to serve them | 6.1                  |
|                                                                           | Washing hands properly before eating | 8.2          |
|                                                                           | Don’t know                 | 49.0                  |
| (29) Of the following, which do you think is the correct way to wash dishes? | Soak in water, after several hours, wash with the same water using detergent/Ash/Soap | 17.9                  |
|                                                                           | Wash immediately after meal using detergent/Ash/Soap and wipe off | 42.8                  |
|                                                                           | Wash immediately after meal using detergent/Ash/Soap and wipe off by towel | 27.1                  |
|                                                                           | Wash with automatic dish washer | 12.2          |
| (30) Which of the following scenario for cleaning kitchen counters and stoves are the best? | Brush with Soap/detergent and water, then use sanitizer | 61.1                  |
|                                                                           | Using Sanitizer, then water | 17.0                  |
|                                                                           | Brush with water, then sanitizer | 12.4          |
|                                                                           | Water, then drying         | 9.5                   |


d correct answer.

divided into 4 subsections: food microbiology and cross-contamination practices (4 items), food preparation and cooking practices (4 items), food storage and chilling practices (3 items), and cleaning and hygiene practices (3 items). Most of the questions were multiple-choice based. Part 4 was designed to assess the knowledge on food safety, which included 16 questions divided into four subsections: food microbiology and cross-contamination (4 items), food preparation and cooking knowledge (5 items), food storage and chilling (4 items), and cleaning and hygiene (3 items). Most of the questions in this section were multiple-choice based. The questionnaire took approximately 20 min to be filled.

2.3. Statistical analysis

Statistical software, SPSS version 28.0, was used to analyse the data acquired. Simple descriptive tests were used to observe the frequency, percentages, mean, standard deviation, and standard error. Each correct answer to each multiple-choice question was given a score of 1, while 0 for all wrong answers. Thus, food safety practices section score varies from 0 to 14 and the knowledge section from 0 to 16. Then, normality was checked for each variable with the dependent variable to observe the distribution of scores for each category. Due to skewed distribution, non-parametric tests (Wallis H test and Mann-Whitney U test) were performed to observe the differences of the mean sum of the correct responses of knowledge (16 questions) and practice (14 questions) sections within demographics. All tests were two-sided and done with 95% confidence intervals. Tests were considered significant when the p-value was found to be less than 0.05.

3. Results and discussion

A total of 1534 valid questionnaires filled by undergraduate and graduate students were analyzed, among which 49% were females, and 51% were males. In addition, 25.8% of students were from food-related
Food storage During your supermarket shopping, when do you

Food safety knowledge overall average 39 56 48

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performed signifi

roommates. Older students (above 23 years old) with food-related majors

signifi

part, female students and students living with their families scored

scores signifi

16.5). For the food handling

At home, how do you defrost frozen meat/chicken? You leave it in the fridge for few hours

AVERAGE 20 29 27

Cleaning and hygiene How do you wash your hands before cooking or eating? Soap and water

AVERAGE 67 61 68

Food handling practice overall average

Food handling practice question

Cross-contamination When you cut raw meat and need to use the knife again, what do you do? You wash the knife with soap and water

Food cooking For a burger to be safe to eat, it needs to be cooked until its internal temperature reaches:

Food safety knowledge question

Table 5. Comparison of food handling and safety practices and knowledge among Bangladesh, Lebanese and Greek university students.

| Food handling practice question | Best answer | Scores (%) | Bangladesh (our study) | Lebanon | Greece |
|-------------------------------|-------------|------------|------------------------|---------|--------|
| Cross-contamination           | In the fridge (not freezer) of your house, where is the raw meat stored? | Lowest shelf | 62 | 16 | 23 |
| Food storage                  | At home, how do you defrost frozen meat/chicken? | You leave it in the fridge for few hours | 7 | 28 | 25 |
|                                | If your roommate or family member is going to be several hours late for a hot meal, where do you leave the meat? | In the fridge | 32 | 29 | 28 |
| Cleaning and hygiene          | How do you wash your hands before cooking or eating? | Soap and water | 84 | 87 | 97 |
| Food storage                  | When preparing food, you wash your hands after touching which of these? | Your face | 50 | 34 | 39 |
| Food cooking                  | For a burger to be safe to eat, it needs to be cooked until its internal temperature reaches: | 74°C | 11 | 38 | 21 |
| Food safety knowledge question | How can a food be made safe if it has salmonella bacteria in it? | Cook it well | 52 | 68 | 53 |
| Food storage                  | During your supermarket shopping, when do you place refrigerated meat in your cart? | At the end of the shopping trip | 63 | 60 | 55 |
|                                | What is the recommended temperature for fridges? | 4°C | 32 | 53 | 44 |
|                                | Freezing kills harmful germs in food | FALSE | 42 | 64 | 78 |
|                                | AVERAGE | | 46 | 59 | 59 |
| Food safety knowledge overall average | | | 39 | 56 | 48 |

majors and 74.2% from non-food-related majors (basic sciences, arts, business, technology, and engineering). The mean student age was 22.09 (SD = 1.78). The majority of the undergraduate students were in 1st year (36%) while the postgraduate students formed 8% of the total population. About 9% of the participants lived with their parents. However, only 8% of the subjects answered that they cook all the time, and only 17% of the participants had a working mother (Table 1).

Table 2 displays the mean score for the practices and knowledge and the significant levels for each variable. The overall mean score for best practices in food handling was 34.9% (SD = 13.7). For the food handling part, female students and students living with their families scored significantly better than their male counterparts living with friends or roommates. Older students (above 23 years old) with food-related majors performed significantly better than younger students from non-food majors (p < 0.001 and p = 0.001, respectively). The participants with working mothers scored higher, with the significant different at (p = 0.048). Students with personal food poisoning experience and full involvement in food purchasing scored significantly higher (p = 0.002). On the other hand, the effects of religion, maternal education, and monthly income were not significant (p > 0.05), meaning that they have no influence on food safety knowledge or handling practices.

The overall mean score of food safety knowledge was 41.8% (SD = 16.5). Female students and those majoring in food-related fields of study scored significantly better than males and students from non-food majors (p = 0.005 and p < 0.001, respectively). In addition, subjects from urban areas and those who cook all the time had significantly higher score (p = 0.007 and p < 0.001, respectively). On the other hand, age, religion, year of study, maternal education and employment status, monthly income, personal food poisoning experience, and involvement in food purchasing were not significant (p > 0.05).

The responses reported in our study identified poor levels of food safety knowledge (41.8%) and implementation of food handling practices (34.9%). This poor food safety awareness was as well reported in the literature (Byrd-Bredbenner et al., 2007; Abbot et al., 2009; Garayoa et al., 2005; Osaili et al., 2011; Lazou et al., 2012; Unklesbay et al., 1998; Sharif and Al-Malki, 2010; Hassan and Dimassi, 2014). For instance, among university students in Greece, the United States, and Lebanon, the mean scores for food safety knowledge were 60, 60, and 54%, respectively, whereas the mean scores for food handling procedures were 44, 50, and 49%, respectively (Lazou et al., 2012; Hassan and Dimassi, 2014; Byrd-Bredbenner et al., 2007).

Students from food-related majors reported significantly (p < 0.001) higher scores on practices (40.2%) and knowledge (47.3%) scores (Table 2). This can be attributed to food safety, hygiene, and microbiology modules in the food-related major curricula. A similar conclusion was reported by Hassan and Dimassi (2014); Byrd-Bredbenner et al. (2007); Osaili et al. (2011); Garayoa et al. (2005); Unklesbay et al. (1998); Sharif and Al-Malki (2010).

Female students showed significantly higher scores than their male counterparts with regard to food handling practices (35.9%; p = 0.007) and food safety knowledge (42.9%; p = 0.005) (Table 2). This may be explained by the fact that women are typically in charge of maintaining the cleanliness and hygiene of the kitchen throughout East Asia, especially in Bangladesh. This goes in line with previous studies (Unklesbay et al., 2005; Osaili et al., 2011; Lazou et al., 2012; Garayoa et al., 2005; Byrd-Bredbenner et al., 2007).
In terms of practices and knowledge, students who lived with their families performed better than those who lived with friends or roommates (Table 2), and the difference was statistically significant ($p = 0.003$ and $p = 0.001$, respectively). Hassan and Dimassi reported the same observation (2014). This could be because when students live with their family, a more seasoned individual (the mother in the case of Bangladesh) will prepare the meals, leading to more standardized food handling and an opportunity for the student to learn more about food safety. Participants with working mothers scored less in both practice (33.3%) and knowledge (40.2%) questions, yet the difference was borderline significant ($p = 0.048$) for the practices only. The reason could be the fact that, in general, working mothers are usually educated, and therefore, they spend less time on food preparation compared to housewives, resulting in poorer food safety knowledge and food handling practices.

Concerning food handling practices, scores for each question are presented in Table 3. For instance, among the correct practices, only 26.7% of participants reported using another chopping board when switching from cutting meat to cutting vegetables, while 45.8% reported washing the knife with soap and hot water when switching from raw meat to another food. Additionally, while only 26.4% of subjects with a wound on their hand reported handling food after wearing gloves, almost half of the respondents (49.7%) said washing their hands after touching their faces. On the other hand, only 50.8% rub their hands with soap for about 20 s when they want to wash their hands, and only 18.2% take off half of the respondents (49.7%) said washing their hands after touching their faces. Surprisingly enough, while as low as 2.5% of participants reported checking the central temperature of the cooking pot to verify that food is sufficiently cooked, 6.8% of them thawed raw meat in the refrigerator, and 10% reported throwing meat away when it thaws and feels warm when the electricity goes off. This poor knowledge in food handling might be due to insufficient food safety and hygiene education on our tertiary education campuses.

In addition, Table 4 presents the results of food safety knowledge of the participants. The table reveals that about 44% and 41.3% of participants knew that Campylobacter is most likely associated with raw meat/fish and that raw meat/fish is most likely to become contaminated with Listeria. Only 11.7% of students knew that teenagers are the least prone to get food poisoned, and 11.1% knew that foods are safe if cooked to an internal temperature of 74 °C. On the other hand, 31.9% of the respondents knew that the maximum fridge temperature is 4 °C, and 41.7% knew that freezing does not kill harmful germs in food.

A comparison between our study with similar questions from a developed country, Greece (Lazou et al., 2012), and a developing country, Lebanon (Hassan and Dimassi, 2014), presented in Table 5, reveals that Bangladesh university students scored the least (20%) compared to the Greek (27%) and Lebanese (29%) students in the food storage practice, while they scored better (45%) than the Greek (37%) and Lebanese (39%) students in cross-contamination practice questions. For the cleaning and hygiene practice, Bangladesh students scored (67%) compared to 68% in Greece and 61% in Lebanon. As for the overall mean for the food handling common practice questions (7 questions), our score was 44%, which is similar to that of Lebanon (43%) and Greece (44%).

With regards to food safety knowledge, Bangladesh university students scored the least (32%), when compared to the Greek (37%) and Lebanese (53%) students. For cooking of food, Bangladesh students again scored the least (46%) compared to the Greek (59%) and Lebanese (59%) students. The overall mean scores also indicated that Bangladeshi students’ score was 39%, which was the lowest when compared to Lebanon (56%) and Greece (48%) with respect to food safety knowledge (Table 5).

4. Concluding remarks

The poor food safety awareness reported by Bangladeshi university students results in an increasing intake of risky foods and, therefore, a higher likelihood of foodborne diseases. This poor awareness of food safety will contribute, in the long run, to a higher likelihood of foodborne illnesses in household settings, as university students will be at some point, food handlers and caregivers for their families. Information collected from this study has identified the urgent need for food safety education among youth, in high schools and universities, on proper temperature control, prevention of cross-contamination, proper food preparation practices, cleaning, sanitation, and hygiene. Higher academic institutions can be the correct place to intervene and reach out to the uneducated and the younger generation. Although its limitations related to the design as sampling was based on four universities only in Bangladesh, in addition to the fact that we used the questionnaire of other similar studies without validating it, our study gave considerable insights to the status of food safety knowledge and practices in Bangladesh.

Declarations

Author contribution statement

Md. Nazrul Islam: Conceived and designed the experiments; Performed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Hussein F. Hassan: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data analysis tools or data; Wrote the paper.

Md. Bony Amin, Felix Kwashie Madilo: Analyzed and interpreted the data; analysis tools or data; Wrote the paper.

Md. Ashiqur Rahman, Md. Raisul Haque, Md. Aktarujjaman, Nawshin Farjana: Performed the experiments; Contributed reagents, materials, analysis tools or data or analysis tools or data.

Nitaal Roy: Conceived and designed the experiments; Performed the experiments; Contributed reagents, materials, analysis tools or data.

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Data availability statement

Data will be made available on request.

Declaration of interest’s statement

The authors declare no conflict of interest.

Additional information

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