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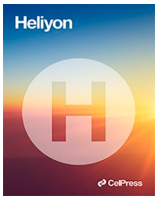

Foodborne pathogens awareness and food safety knowledge of street-vended food consumers: A case of university students in Ghana

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ABSTRACT

Food pathogens, such as bacteria, viruses, and parasites are agents present in food or water that can cause foodborne illness. Some of these pathogens have been identified in Ghanaian foods and were responsible for the major foodborne disease outbreaks in Ghana. Thus, the current study assessed the awareness of foodborne pathogens and food safety knowledge of students in Ghana. The study employed non-probability techniques, as well as purposive and convenient techniques, to recruit institutions and students for the study. Out of 803 students, the majority (52.3%) were male, between the ages of 20 and 25 (52.8%), attended Ho Technical University (49.8%), and offered non-science-related courses (45.1%). The majority of the respondents were aware of foodborne pathogens, particularly *Staphylococcus aureus* (53.4%) and *Salmonella typhimurium* (53.5%). The mean overall score of foodborne pathogen awareness was 14.36 ± 4.57; the passing rate was 73.6%; tribe, institution, field of study, and level of study all had a significant ($p < 0.05$) effect on awareness of foodborne pathogens. The mean overall score of food safety knowledge was 12.43 ± 3.27; the passing rate was 77.3%; age, tribe, institution, field of study, and level of study all had a significant ($p < 0.05$) effect on food safety knowledge. Hence, food safety courses should be extended to all levels of education to increase awareness.

1. Introduction

Nowadays, food safety issues have become a major concern for many people all over the world due to the emergence of microbial foodborne pathogens [1]. Globally, approximately 600 million people are infected with foodborne pathogens after consuming pathogen-contaminated food, with approximately 420,000 deaths per day [2,3]. According to Atabila et al. [4], having access to safe

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and nutritious food is the most essential factor for sustaining life and promoting better health. They added that unsafe foods containing microbial pathogens and chemical substances contribute to worldwide morbidity and mortality. The pathogens can easily contaminate processed or be left out in the open foods, beverages, or drinking water [5]. Food pathogens can be bacteria, viruses, or even parasites that are found in food, drinks, or water and can cause infections, poisoning, or infections spread by toxins. They are grouped based on the types of foods they infect [5]. They may include *Campylobacter* (found in raw or undercooked foods), *Salmonella* species (found in meat, poultry, or eggs), *Shigella*, *Escherichia coli* (found in meat and under-pasteurized milk), *Clostridium botulinum* (improperly canned foods), *Clostridium perfringens*, *Yersinia, Vibrio cholera, V. vulnificus, V. parahaemolyticus, Staphylococcus aureus, Bacillus* species and *Listeria monocytogenes* (found in undercooked meats, vegetables, unpasteurized milk, and soft cheese) which are linked to foodborne diseases [6].

In Ghana [36], identified *Enterobacter, Citrobacter, Klebsiella, Shigella,* and *Escherichia coli* as the predominant bacterial pathogens that were associated with Ghanaian foods including salads, *fufu*, *omo tuo*, *kenkey*, red pepper, and tomato stew [7]. discovered mesophilic bacteria and *Enterobacteriaceae* above acceptable levels in ready-to-eat street-vended foods in Ghana [8]. also identified *Enterobacter, Citrobacter*, *Klebsiella*, and *E. coli* as the most prevalent food-borne pathogens in Ghanaian street-vended food. Recent reports from the [37] indicated that approximately fifty-three (53) individuals were taken to various health facilities in Accra after consuming contaminated food from Mawako restaurants. Analysis of samples (juice drinks and swaps from the environment at the East Legon branch) revealed high levels of microbial pathogens, which could be the source of the reported foodborne disease outbreak. Hence, the branches in Abelemkpe, Spintex, La, and East Lagon were closed. Again [38], reported that between 2013 and 2021, a total of 1914 Ghanaians suffered from various forms of food poisoning. The report added that about 60 of the cases from 36 facilities resulted from disease outbreaks with 36 patients losing their lives. These reports, however, are insufficient to determine whether or not the players in the food processing industries and the food value chain are aware of and concerned about these pathogens. However, a literature search has revealed that no such study has been conducted in Ghana. Hence, the call for this study.

Several studies on food safety and pathogens awareness have been conducted in various educational institutions all over the world [9–11]. According to Ref. [12], the majority of the college students at King Saud University in Saudi Arabia who prepare their own food lack knowledge of food safety, thereby compromising food safety standards including poor food handling and holding temperature practices. Additionally, several institutional catering facilities such as schools, hospitals, and prisons were linked to foodborne disease outbreaks with schools being the most prevalent [13]. Gong et al. [14] reported that school food establishments constitute about 77% of foodborne disease outbreaks in Ghana. For instance, according to Ref. [15] over twenty students from Awudome SHS in the Volta region were hospitalized due to food poisoning. Again, at the University of Cape Coast, a food vending facility was closed down after a student died of food poisoning [15]. [15] also concluded his findings that the outbreak of cholera among the University of Cape Coast students was as a result of a lack of food safety awareness and poor hygiene behavior among students.

Besides, a number of studies have been conducted to investigate food safety and foodborne pathogens knowledge among students [12,16]. Unfortunately, these studies were carried out outside of Ghana. Despite numerous reports of food poisoning among Ghanaian students, including a number of deaths, no single study on foodborne pathogen awareness among Ghanaian university students has been conducted. Nivethitha et al. [16] suggested that schools should incorporate lessons on food safety and foodborne pathogen awareness into their curricula because of the prevalence of reported cases of food poisoning there. It also needs to be stressed that foodborne infections might be difficult to overcome without proper food safety education. In addition [15], stated that an investigation into the underlying causes of outbreaks of foodborne diseases in educational institutions ought to be conducted among the students. Therefore, the present study investigated students' knowledge of food safety and awareness of foodborne pathogens at the three public universities in Ghana's Volta Region.

2. Materials and method

2.1. Sample selection and ethical approval

The data were collected between August 2021 and February 2022. The three universities including Ho Technical University (HTU), University of Allied and Health Sciences (UHAS), and Evangelical Presbyterian University College (EPU) in the Volta Region of Ghana were purposively recruited for the study. The inclusion criteria included all university students (male and female), who were both residents and non-residents of the three universities in the region. However, tertiary students who are not university students were excluded from the study. Thereafter, a non-probability convenient sampling technique was used to recruit about 803 (81%) out of 991 (188 excluded due to incomplete questionnaire responses) students from the three universities for the study. The study protocol was ethically approved (HTU2022/DRI/05/202) by the University's Research Ethics Committee before the commencement of data collection. The respondents' approval to be included in the study was sought by using a written consent form. After that, they were assured that the information they provided would be kept confidential and anonymous [17].

2.2. Questionnaire design and validation

A questionnaire was developed, modified, and validated by food safety experts at HTU's Food Science and Technology Department in order to collect accurate and valid data for this study. The questionnaire was validated by the food safety experts at HTU and then piloted among thirty (30) students at Ho Nursing Training College which was not among the targeted institutions for the study. The concerns (too many questions to answer; some options are confusing; and not familiar with the names of the organisms) raised were used to modify the questionnaire before adoption for final data collection. In all, there were 46 items (questions) excluding the

Table 1
Socio-demographic characteristics.

Issue	Variable	N	%
Sex	Male	420	52.3
	Female	383	47.7
Age (Years)	Less than 20	122	15.2
	20–25	424	52.8
	26–30	243	30.3
	Above 30	14	1.7
Tribe	Ewe	324	40.3
	Akan	200	24.9
	Ga	202	25.2
	Fante	77	9.6
Institution	HTU	400	49.8
	UHAS	302	37.6
	EPU	101	12.6
Field of study	Food Science related	239	29.8
	Medical Science related	202	25.2
	Non-Science Related	362	45.1
Level	Certificate course	8	1.0
	HND	333	41.5
	Bachelor of Science	370	46.1
	B-Tech	92	11.5
Residential status	On-campus resident (University hall)	307	38.2
	Off-campus resident (Private hostel)	308	38.4
	Off-campus resident (from the house)	188	23.4
Total		**803**	**100.0**

HTU=Ho Technical University; UHAS=University of Health and Allied Sciences; EPU = Evangelical Presbyterian University.

demographic characteristics. The entire questionnaire was then grouped into four (4) sections. In particular, section "A" (demographic characteristics) which includes age, gender, tribe, institution, the field of study, levels of study, and residential status. Section "B" dealt with "Frequency of patronizing ready-to-eat foods and reasons for doing so, "; section "C" consisted of "Food safety awareness of student consumers of vended foods" and contained 21 questions; and section "D" was entitled "Awareness of foodborne microbial pathogens" and contained 25 questions, such as identification of foodborne pathogens, media through which pathogens were heard, causes of foodborne illness, important food safety concerns nowadays, ways of avoiding foodborne pathogens, symptoms of foodborne illnesses, and vehicles of foodborne pathogens. The scoring method described by Ref. [18] was used to evaluate the participants' understanding of foodborne pathogen awareness and food safety. Finally, the questionnaire took not more than 25 min to complete.

2.3. Statistical analysis

All the data were analyzed using SPSS version 28.0 (IBM, NY, USA). Simple descriptive tests were used to calculate the frequency, percentages, mean, standard deviation, and standard error. Each correct answer was given a score of one, while every wrong answer was given a score of zero. The food safety awareness of student consumers of vending foods segment comprised 21 questions with more than or equal to 50% correct answers ($10.5 \approx 11$) considered aware/pass. Similarly, there were 25 questions on knowledge of foodborne microbial pathogens, with more than or equal to half of the correct answers ($12.5 \approx 13$) considered aware/pass. For multiple response analysis, the 'yes' option in the knowledge source section was coded as 1, while the remaining options were coded as 0. In addition, cross-tabulation was used to determine the pass rate for each category, and *p*-values were calculated using the Chi-square test. A "test of normality" was then used to conduct further analysis of the data. Since the data had a skewed distribution, non-parametric tests were used to observe any variations between categories (Kruskal-Wallis H test and Mann-Whitney *U* test). The Mann-Whitney *U* test is utilized to compare the differences between two independent groups. The Kruskal-Wallis H-test is used to compare differences between more than two independent groups. All tests were two-sided and had 95% confidence intervals. The test was considered significant when the p-value was less than 0.05.

3. Results and discussion

3.1. Demographic characteristics

Table 1 shows the demographic characteristics of the students who took part in the study. Out of 52.3% of the participants were male and 52.8% were between the ages of 20 and 25 (Table 1). Ho Technical University (HTU) had the most recruits (49.8%), with the majority of them offering non-science courses (45.1%), pursuing a Bachelor of Science degree (46.1%), and living in private hostels (38.4%).

Table 2
Frequency of awareness of foodborne pathogens.

Issue observed	Do not know	No	Yes
Are you aware that certain foodborne bacteria can cause diseases that may lead to death?	111 (13.8)	346 (43.1)	**346 (43.1)**
Have you ever heard about *Escherichia coli*	106 (13.2)	347 (43.2)	**350 (43.6)**
Have you ever heard about *Salmonella typhimurium*	90 (11.2)	283 (35.4)	**430 (53.5)**
Have you ever heard about *Campylobacter jejuni*	92 (11.5)	319 (39.7)	**392 (48.8)**
Have you ever heard about *Listeria monocytogenes*	124 (15.4)	289 (36.0)	**390 (48.6)**
Have you ever heard about *Staphylococcus aureus*	103 (12.8)	271 (33.8)	**429 (53.4)**
The presence of allergens is an important food safety concern nowadays	94 (11.7)	253 (31.5)	**456 (56.8)**
Foodborne bacteria is an important food safety concern nowadays	86 (10.7)	248 (30.9)	**469 (58.4)**
The sale of expired foods is an important food safety concern nowadays	76 (9.5)	181 (22.6)	**546 (68.0)**
The unknown food source is an important food safety concern nowadays	66 (8.2)	190 (23.7)	**547 (68.1)**
Too much junk foods are an important food safety concern nowadays	92 (11.5)	220 (27.4)	**491 (61.1)**
Washing vegetables in the salt solution is a way of destroying pathogens	73 (9.1)	199 (24.8)	**531 (66.1)**
Washing vegetables in vinegar solution is a way of destroying pathogens	116 (14.4)	197 (24.6)	**490 (61.0)**
Washing hands frequently with soap and water is a way of destroying pathogens	87 (10.8)	223 (27.8)	**493 (61.4)**
Heating food thoroughly at a high temperature is a way of destroying pathogens	94 (11.7)	201 (25.0)	**508 (63.3)**
Putting food in the fridge is a way of destroying pathogens	110 (13.7)	**242 (30.1)**	451 (56.2)
Pathogens get into food by food handlers	91 (11.3)	225 (28.1)	**487 (60.6)**
Pathogens get into food via raw materials and ingredients	61 (7.6)	146 (18.2)	**596 (74.2)**
Pathogens get into food via cooking water	77 (9.6)	208 (25.9)	**518 (64.5)**
Pathogens get into food via cooking utensils	67 (8.3)	222 (27.6)	**514 (64.1)**
Diarrhea is a symptom of foodborne illness	101 (12.6)	209 (26.0)	**493 (61.4)**
Nausea is a symptom of foodborne illness	67 (8.3)	207 (25.8)	**529 (65.9)**
Headache is a symptom of foodborne illness	82 (10.2)	205 (25.5)	**516 (64.3)**
Dizziness is a symptom of foodborne illness	74 (9.2)	270 (33.6)	**459 (57.2)**
Fatigue is a symptom of foodborne illness	85 (10.6)	279 (34.7)	**439 (54.7)**
Pathogens get into food via cooking utensils	67 (8.3)	222 (27.6)	**514 (64.1)**

Note: Bold indicates the correct answer.

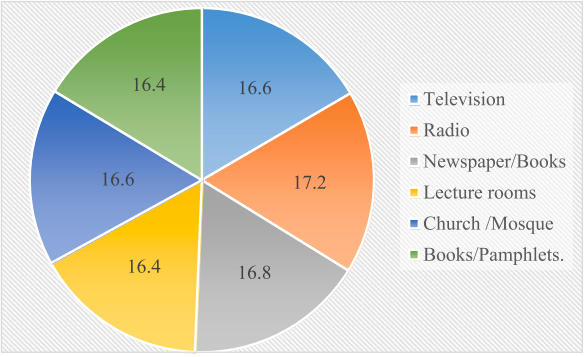

Fig. 1. Media through which foodborne pathogens information was received.

3.2. Awareness of foodborne pathogens

To appropriately assess students' awareness of foodborne pathogens on their campuses, around twenty-five (25) questions were asked, and the results are shown in Table 2. Surprisingly, when asked if they were aware that certain pathogenic germs contaminate food and can cause diseases that can lead to death, less than half of the students in the majority said both 'yes' and 'no.' The table, on the other hand, shows that the majority of respondents were aware of *Escherichia coli, Salmonella Typhimurium, Campylobacter jejuni, Listeria monocytogenes*, and *Staphylococcus aureus*. They did, however, demonstrate that they were more knowledgeable of *Staphylococcus aureus* (53.4%) and *Salmonella typhimurium* (53.5%) than the other pathogens. Yoonis [19] found that students in Bangladesh were well aware of foodborne pathogens (57%). Sharif and Al-Malki [20] found that students in Saudi Arabia had a high level of awareness about foodborne pathogens (75%). In Jordan, around 54% of students were aware of foodborne pathogens and diseases associated with them [21]. [22], on the other hand, observed that the overall awareness of the students selected for the study was relatively low. They also stated that the majority of respondents (65%) were unaware of foodborne pathogens. Furthermore, they stated that approximately 35% of the students were able to identify all five (5) major foodborne pathogens that were shown to them. According to Henke et al. [22,23], except for Salmonella, which was well-known among the respondents, they had very little awareness of foodborne pathogens. Moreover, the majority of respondents reported that "expired foods" (88%), "unknown sources of food" (68.1%), and "too much junk food" (61.1%) were some of the top food safety problems that could contribute to foodborne disease outbreaks (Table 2). They have also demonstrated an awareness of how readily foodborne diseases can be prevented. The

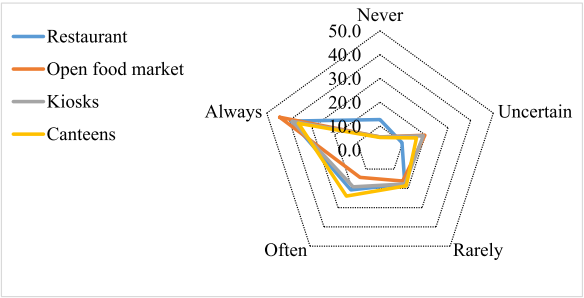

Fig. 2. Outlets students get worried when purchasing foods.

Table 3
Association between sample characteristics and awareness of foodborne pathogens.

Variables	Categories	Pass rate (%)	χ^2	*p*-value	Mean ± SD	*p*-value
Age (Years)	Less than 20	82.0	6.64	0.084	14.97 ± 3.38	0.558
	20–25	73.3			14.29 ± 4.72	
	26–30	69.5			14.16 ± 4.92	
	Above 30	78.6			14.43 ± 2.38	
Sex[a]	Male	73.1	0.12	0.735	14.35 ± 4.55	0.558
	Female	74.2			14.37 ± 4.60	
Tribe	Ewe	66.0	16.17	0.001	13.61 ± 5.21	0.011
	Akan	79.5			15.16 ± 4.15	
	Ga	78.7			14.75 ± 3.80	
	Fante	76.6			14.40 ± 4.22	
Institution	HTU	64.0	59.72	0.000	13.59 ± 5.49	0.000
	UHAS	89.1			15.64 ± 2.54	
	EPU	65.3			13.57 ± 4.50	
Field of study	Food Science related	72.0	40.94	0.000	14.66 ± 4.55	0.000
	Medical Science related	90.1			15.57 ± 2.50	
	Non-Science Related	65.5			13.48 ± 5.26	
Level of study	Certificate course	50.0	64.44	0.000	15.25 ± 4.43	0.000
	HND	59.8			13.22 ± 5.69	
	Bachelor of Science	85.9			15.39 ± 3.00	
	B-Tech	76.1			14.25 ± 4.38	
Residential status	On-campus resident (University hall)	75.6	2.54	0.280	14.62 ± 3.92	0.061
	Off-campus resident (Private hostel)	70.5			13.92 ± 4.80	
	Off-campus resident (from house)	75.5			14.66 ± 5.12	
Total		73.6			14.36 ± 4.57	

Note: a = Mann-Whitney *U* Test, rest of them Kruskal-Wallis H test.
FSR = Food Science Related; MSR = Medical Science Related; NSR = Non-Science Related, SD= Standard deviation.

majority indicated that vegetables should be cleaned in a salt solution (66.1%) or vinegar solution (61.0%) to prevent or destroy foodborne pathogens, along with frequent handwashing with soap and warm water (61.4%), and thorough cooking at a high temperature (63.3%). Surprisingly, only about 30% of students knew that refrigerators do not kill microorganisms that cause foodborne illness. This is a worrying assertion because the majority of students, particularly female students, have refrigerators to preserve cooked food because they have little time to prepare fresh meals because they are always at school.

However, in terms of the sources of foodborne pathogens in food, the respondents have shown an average level of awareness. The majority of them stated that they were aware that pathogenic organisms get into food via food handlers (60.6%), raw materials and ingredients (74.2%), cooking water (64.5%), and utensils (64.0%). In addition, they were aware that symptoms such as diarrhea, nausea, exhaustion, and dizziness could develop after consuming foods infected with pathogenic bacteria, as reported by the majority of participants (more than 50% in each case). These results were in line with the reports by Ref. [19] which illustrated that more than 52% of Somali students have more knowledge of the symptoms of food poisoning than their counterparts in Bangladesh. In Malaysia, about 80% of university students were very much aware of the symptoms of food poisoning [24]. This report was strengthened by other studies [25].

Moreover, when respondents were asked to identify the medium/media via which they primarily obtain knowledge about foodborne pathogens, nearly all of them indicated television, radio, newspapers, lecture halls, churches, or books (Fig. 1). Again, the majority of students were "always" concerned about foodborne pathogens when shopping at open food markets, restaurants, kiosks, and canteens (Fig. 2). This was in contradiction to Ref. [19] which demonstrated that 55% of the respondents relied on the internet rather than health professionals, newspapers, or family members when seeking information on foodborne pathogens and related problems.

Table 4
Frequency of food safety knowledge.

Issue observed	Do not know	No	Yes
Food poisoning is caused by pathogenic microbes	163 (20.3)	250 (31.1)	**390 (48.6)**
Some toxins produced by microbesare poisonous	158 (19.7)	221 (27.5)	**424 (52.8)**
Drinking raw (unprocessed) milk poses a high risk of food poisoning	86 (10.7)	196 (24.4)	**521 (64.9)**
Consuming undercooked meat poses a high risk of food poisoning.	111 (13.8)	261 (32.5)	**431 (53.7)**
Consuming unwashed fruits and vegetables poses risks of food poisoning.	70 (8.7)	178 (22.2)	**555 (69.1)**
I use always use detergents for hand washing.	110 (13.7)	298 (37.1)	**395 (49.2)**
I always wash my hands before handling food	70 (8.7)	232 (28.9)	**501 (62.4)**
I always keep my fingernails short, unpolished, and clean	84 (10.5)	245 (30.5)	**474 (59.0)**
I use adequate clothing only when cooking food.	87 (10.8)	182 (22.7)	**534 (66.5)**
I use appropriate utensils to minimize bare-hand contact with food.	89 (11.1)	185 (23.0)	**529 (65.9)**
I use clean water during food preparation.	101 (12.6)	237 (29.5)	**465 (57.9)**
I use the same knife and cutting board for both raw and ready-to-eat foods.	101 (12.6)	**274 (34.1)**	428 (53.3)
Preparation of food in advance can cause foodborne illness	130 (16.2)	275 (34.2)	**398 (49.6)**
Microorganisms can cause foodborne illness	73 (9.1)	187 (23.3)	**543 (67.6)**
Toxic chemical contamination can lead to long-term diseases.	61 (7.6)	132 (16.4)	**610 (76.0)**
Expired foods can cause foodborne illness.	46 (5.7)	135 (16.8)	**622 (77.5)**
Food allergen is a serious food safety issue nowadays.	78 (9.7)	191 (23.8)	**534 (66.5)**
Fatty foods can cause foodborne illness.	76 (9.5)	178 (22.2)	**549 (68.4)**
Insecticides can cause food poisoning.	134 (16.7)	131 (16.3)	**538 (67.0)**

Note: Bold indicates the correct answer.

3.3. Association of awareness of foodborne pathogens per demographic characteristics

The passing rate, mean score, and level of significance for each variable on awareness of foodborne pathogens were presented in Table 3. The results of the association between respondents' foodborne pathogen awareness and demographic characteristics were analyzed using the non-parametric tests Chi-square ($\chi 2$), Manne-Whitney U, Kruskal-Wallis H. The overall passing rate for foodborne pathogen awareness was 73.6% with an overall mean score of 14.36 ± 4.57. In Table 3, the demographic factors of Tribe, Institution, Field of Study, and Level of Study were strongly associated with awareness of foodborne pathogens ($p < 0.05$). While on the contrary, age, sex, and residential status were not significantly associated with awareness of foodborne pathogens. Students from the Akan tribe had a higher passing percentage (79.5%), a mean score of 15.16 ± 4.15, and are noticeably more knowledgeable than their counterparts. Students in the medical sciences had the highest pass rate (90.1%) and mean values (15.57 ± 2.50) compared to those in the food science (72.0%) and students not majoring in sciences (65.5%). This might be because medical students learn more about diseases and pathogens in their academic courses, and it might also be that they are more aware of their own health [15]. reported that health science students were more informed about foodborne pathogens than their counterparts in other study areas which are strongly consistent with our study. Students at the Bachelor of Science level had the highest passing rate (85.9%), the highest mean value (15.39 ± 3.00), and were much more aware than study participants at other levels. A Similar study [15] also reported that field of studies, place of studies, and level of education were factors that determine the awareness of foodborne pathogens. Additionally [26], stated that age, sex, and field of study were significantly different and were determinants of food safety and hygiene awareness, and concluded that health science students were more aware of food safety issues than their counterparts in the other fields.

Besides, in terms of foodborne microbial pathogens awareness (Table 3), age, sex, and residential status could not play any significant roles in the student's awareness of foodborne microbial pathogens ($p > 0.05$) [19,27]. also registered no significant difference between age, gender, awareness of foodborne pathogens, and natural food toxins ($p > 0.05$) [21]. stated that educational levels, high school type, and, college of the study were the main factors that contributed to the respondent's awareness of salmonellosis caused by *Salmonella* species and shigellosis caused by *Shigella* species. They concluded that students with higher educations have better opportunities of being aware of foodborne diseases. These results clearly established the fact that education is the key to improving the knowledge of food safety and creating awareness of foodborne microbial pathogens.

3.4. Food safety knowledge

Additionally, aside the foodborne pathogen awareness, the researchers also wanted to know if the students in the three Universities have some knowledge of food safety using about twenty-one (21) food safety issues. The results of this segment were presented in Table 4. The table shows that in almost all of the food safety issues observed, the majority of the students demonstrated that they were aware of and had adequate knowledge of food safety issues. This was because the majority (more than 50%) of them responded positively to almost all of the positive statements presented to them regarding food safety (Table 4). Correspondingly [9], reported sufficient knowledge, greater than 70% of respondents (students) in Maine, Chelsea. Yusof et al. [28], and Kortei et al. [27] have also published adequate knowledge among students in Taiwan, Malaysia, and Ghana, respectively.

However, it was so intriguing to observe that less than 50% of the respondents, though the majority, were aware that food poisoning is caused by pathogenic microbes, and the preparation of food in advance could cause foodborne illness. They have also not agreed that using the same cutting board and knife for both raw and ready-to-eat food was not the best food safety practice (34.1%) despite their knowledge of foodborne pathogens (Table 2).

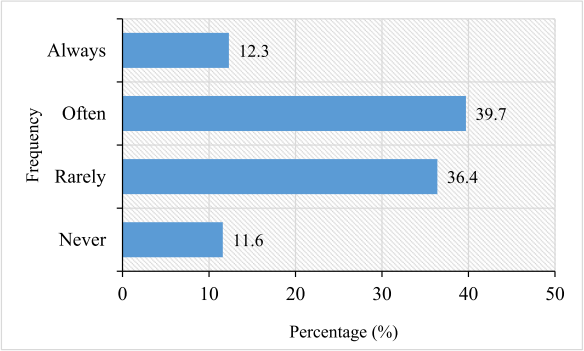

Fig. 3. Frequency of eating street-vended food.

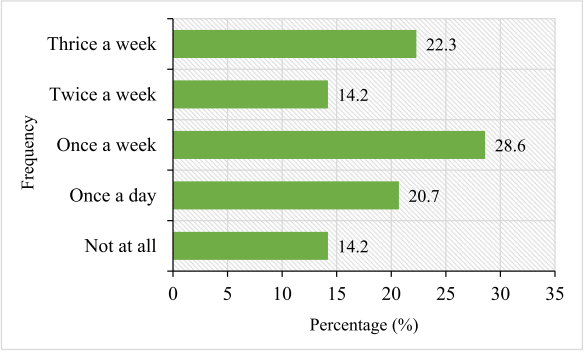

Fig. 4. Frequency of food preparation by the students.

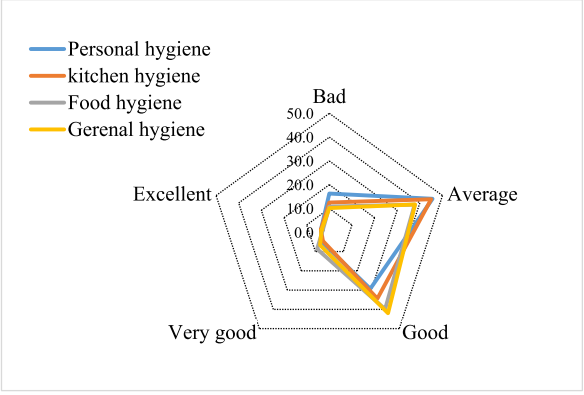

Fig. 5. The hygiene level of the street food vendors.

Again, when the investigators wanted to know how regularly the respondents patronize street-vended foods, Fig. 3 reveals that the majority of the respondents often eat or purchase ready-to-foods (39.7%). Fig. 4 also publishes that the majority (28.6%) of the students could only prepare food once a week. This actually confirmed how regularly they consumed street-vended foods. Assessing the hygiene level of the vendors most of the respondents have also indicated that the personal, kitchen, food, and general hygiene levels of the vendors were between "good" and "average" (Fig. 5).

3.5. Association between food safety knowledge per demographic characteristics

Table 5 shows the results of the Chi-square (2), Manne-Whitney U, and Kruskal-Wallis H tests used to examine the relationship between students' demographic characteristics and passing rates, as well as the mean score of the food safety knowledge section. The table shows that students in Ghana's three Public Universities (Volta region) have a high overall passing rate of 73.6% (mean value

Table 5
Association between sample characteristics and food safety knowledge.

Variables	Categories	Pass rate (%)	χ^2	*p*-value	Mean ± SD	*p*-value
Age (Years)	Less than 20	91.0	18.27	0.000	13.33 ± 2.73	0.002
	20–25	75.2			12.41 ± 3.33	
	26–30	73.3			11.95 ± 3.37	
	Above 30	92.9			13.29 ± 2.05	
Sex[a]	Male	75.0	2.74	0.098	12.36 ± 3.31	0.528
	Female	79.9			12.50 ± 3.22	
Tribe	Ewe	72.5	15.24	0.002	12.18 ± 3.64	0.015
	Akan	87.0			13.07 ± 2.81	
	Ga	75.7			12.20 ± 3.15	
	Fante	76.6			12.38 ± 2.79	
Institution	HTU	69.5	33.97	0.000	12.12 ± 3.92	0.090
	UHAS	88.1			12.92 ± 2.16	
	EPU	76.2			12.15 ± 2.99	
Field of study	Food Science related	77.8	21.74	0.000	12.97 ± 3.30	0.000
	Medical Science related	88.1			12.93 ± 2.25	
	Non-Science Related	71.0			11.78 ± 3.60	
Level of study	Certificate course	87.5	29.32	0.000	13.38 ± 2.62	0.595
	HND	68.2			12.02 ± 4.10	
	Bachelor of Science	85.1			12.73 ± 2.30	
	B-Tech	78.3			12.60 ± 3.09	
Residential status	On-campus resident (University hall)	79.8	1.84	0.399	12.58 ± 2.93	0.800
	Off-campus resident (Private hostel)	75.3			12.26 ± 3.51	
	Off-campus resident (from house)	76.6			12.44 ± 3.38	
Total		77.3			12.43 ± 3.27	

Note: a = Mann-Whitney *U* Test, rest of them Kruskal-Wallis H test.
FSR = Food Science Related; MSR = Medical Science Related; NSR = Non-Science Related.

12.43 ± 3.27). These findings were in sharp contrast with several similar studies. For instance Refs. [29,30], reported a low level of food safety knowledge (53%) among students in Lebanese and Hispania Universities [31]; recorded poor knowledge (32%) of food safety and handling practices among Greek University students, while the same level of knowledge of food safety was found among American students [32], and among Jordan University students the level of knowledge was 52% [33].

According to the findings, knowledge of food safety was highly correlated with demographic factors such as age, tribe, and field of study ($p < 0.05$). Participants under the age of 20 had significantly the highest passing rate (91.0%) and mean value (13.33 ± 2.73) compared to participants in other age groups. Students from the Akan tribe had a higher passing rate (87%) and mean value (13.07 ± 2.81) than students from any other tribe. The pass rate (88.1%) and the mean value (12.93 ± 2.25) for students majoring in medical-related fields were much higher than those of any other academic discipline. This might be due to the fact that their courses might contain models related to food safety and microbiology. A Similar study by Ref. [29] was found and they reported that students found in health science-related courses had significantly highest food safety knowledge (58%) and food handling practices (49%) as compared to their counterparts. Students studying at UHAS (88.1%) and completing a certificate course (87.5%) had the best passing rates. Conversely, both the sex and residential status of the respondents could not have any positive influences on the food safety knowledge of the students ($p > 0.05$). These findings correspond vividly with the reports of [29,34]. While [14] reported significant differences among ages, gender, and education [35], have published significant differences ($p < 0.05$) among all the demographic characteristics [26]. also stated that age, sex, and field of study were significantly different and were determinants of food safety and hygiene awareness, and concluded that health science students were more aware of food safety issues than their counterparts in the other fields.

4. Conclusion

This study examined the foodborne pathogen awareness and food safety knowledge of students at the three universities in Ghana's Volta Region. The study assessed the average foodborne pathogen awareness and food safety knowledge of students from the three universities. Food science-related courses, advanced degrees, and enrollment at the University of Health Allied Science increased students' awareness of foodborne pathogens and food safety issues. Male and female students at UHAS had a greater understanding of food safety and awareness of foodborne diseases than their counterparts at sister universities. In addition, the institution and field of study had a substantial impact on students' understanding of foodborne pathogens, with UHAS (a science-based university) and Medical Science-related courses having the greatest passing rates. This is clear evidence that studying science is an important component in influencing students' knowledge of food safety and raising awareness of foodborne microbial diseases. As a result, the inclusion of food safety as a subject (course) of study in Ghana's school curricula at all levels of education is critical to preventing or reducing foodborne disease outbreak cases. A similar study on foodborne pathogens knowledge involving street food sellers, however, should be conducted to determine their level of awareness. Due to insufficient financial resources, this study was unable to cover all the tertiary education institutions (Colleges of Education, Nursing Training Colleges, and Community Health Training Institutions) in the region.

Author contribution statement

Felix Kwashie Madilo: Conceived and designed the experiments; Performed the experiments; Wrote the paper.
Md. Nazrul Islam, Md. Bony Amin, Nitai Roy: Analyzed and interpreted the data; Wrote the paper.
Ekua Quansah, Priscilla Ama Darku: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data.
Emmanuel Letsyo, Comfort Mawuse Klutse: Conceived and designed the experiments; Performed the experiments.

Data availability statement

Data included in article/supp. material/referenced in article.

Funded information

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Declaration of competing interest

The authors declare no competing interests.

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