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Impact of FOODAlyzer© application on knowledge, attitude, and perception towards selecting commercial eateries to prevent foodborne disease

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ABSTRACT

Foodborne disease related to commercial eateries remains a major concern in food safety control programs worldwide. This study aimed to assess the impact of the FOODAlyzer© as a web-based food safety education system on the knowledge, attitude, and perception of selecting commercial eateries among students of non-health-related courses in higher educational institutions in Peninsular Malaysia. The interventional study design was used as follows: the intervention group (n = 59) was compared with the control group (n = 59) in the pre-test (before the intervention), post-test (immediately after the intervention), and follow-up post-test (two weeks later). Baseline data showed that both the intervention and control groups had no significant difference in knowledge score, attitude, and perception. The intervention group achieved a higher knowledge score ($p = 0.022$) and attitude score ($p < 0.0001$), indicating a significant impact of food safety education in the FOODAlyzer© compared with the control group. The test of within-subjects showed a significant increase in respondents' scores on knowledge, attitude, and perception. By contrast, the test of between-subjects found that the intervention group achieved a higher knowledge score ($p = 0.022$) and attitude score ($p < 0.0001$), which indicates a significant impact of food safety education compared with the control group. The findings suggest that knowledge and attitude in selecting commercial eateries based on food safety criteria among the students remained lacking. This paper presents the impact of food safety education to empower consumers towards the selection of commercial eateries and thus reduce the risk of foodborne illness.

1. Introduction

The lack of food safety awareness among consumers (Bolek, 2020; New et al., 2017) regarding the selection criteria of commercial eateries could put them at risk of developing foodborne diseases. The term "foodborne disease" is defined as any illness that results from consuming food contaminated with pathogenic bacteria, viruses, parasites, or chemical substances (Adley & Ryan, 2016; World Health Organization, 2022). Nevertheless, consumers frequently use the terms "foodborne disease" and "food poisoning" interchangeably (Gibert, 2016; U.S.

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Department of Agriculture, 2019) without distinguishing the causes. Foodborne diseases remain a global public health concern that affects disability-adjusted life years (DALYs), which results in the loss of 33 million healthy life years, 420,000 deaths, and nearly one in 10 people worldwide falling ill each year (Havelaar et al., 2015). In addition, this number may be much greater given that the exact incidence of foodborne diseases is often unknown due to undetected and unreported cases (Codex Alimentarius, 2018; Soon et al., 2011).

Despite stringent decrees on food establishment regulations to be complied by food business operators, foodborne diseases have been continuously linked to commercial eateries (Angulo et al., 2006; Arshad & Zahoor, 2018, 2018; Gormley et al., 2012) where positive pathogenic bacteria were found in the microbiology investigation of samples from consumers who suffered from foodborne illness after eating at restaurants that matched with the food sample obtained from the restaurants (Karthik et al., 2014; Navaneethan & Effarizah, 2021; Packer et al., 2020). Data analysis from the reported foodborne outbreaks showed that most outbreaks were highly attributed to food premises that do not comply with food safety requirements compared with fully compliant premises (Fleetwood et al., 2019). However, Consumers have a feeling of trust and confidence that the handling of food cooked in restaurants is similar at home. They have difficulty selecting restaurants based on food safety criteria (de Andrade et al., 2019), and a majority of consumers stated that restaurants were doing a good job, were capable, and committed to food safety (Knight et al., 2007).

Previous studies found that young consumers had poor food safety practices (Moy et al., 2018), inadequate knowledge of the causes of foodborne disease, and were not concerned about ensuring proper food safety; they were more likely to assume that food business operators were more responsible for food safety than themselves (Tomaszewska et al., 2018). Students in higher education institutions were among the potential consumers as the majority of them began to live far from home when they started their campus life and may often buy food from campus cafés or other eateries (Mohd Fadzly, 2018) with an insufficient level of knowledge about food safety (Dehghan et al., 2017; Luo et al., 2019; Osaili et al., 2021). Taste, value, convenience, and cost were the main determinants influencing campus food-purchasing choices among students, whereby price reductions and increased food variety were the most common recommendations for the campus food environment (Tam et al., 2017).

By definition, knowledge is the information that people are aware of, understand, or are familiar with and usually comes from experience, while attitude is defined as a relatively enduring and general evaluation of something that is usually derived from specific beliefs, emotions, and past behaviours. Perception, on the other hand, is defined as when a person becomes aware of something, which then leads them to interpret knowledge and act in a coordinated manner (American Psychological Association, 2022). Information had a fundamental role in changing consumer perception (Pereira et al., 2019). The adequacy of food safety information resources is important in reducing the risks of foodborne disease (Evans & Redmond, 2017). Therefore, the strategies for delivering food safety information may enhance consumers' knowledge, where information that is easily accessible to consumers may actively help them to form the right attitude in assessing which food premises are more worthy of a visit, stimulating the right perception when selecting commercial eateries.

This paper will discuss the strategy of delivering food safety information to consumers by using FOODAlyzer©, a newly developed web-based application system created for Malaysian use with the main function of increasing consumers' awareness of the criteria for hygienic food premises through the online food premises evaluation section and food safety education content. The main objective of this current study was to evaluate the improvement in knowledge, attitude, and perception level when selecting commercial eateries after exposure to food safety education in the FOODAlyzer©. The food service industry is divided into two sectors: commercial and non-commercial food service establishments (Vespia, 2021). This study is only focusing on commercial eateries which are any eateries that serve and sell food to the general public. As shown in the previous study, students from food/health-related fields were identified to have higher scores in food safety knowledge and food handling practices than students of non-food/health-related fields (Smigic et al., 2021). Thus, this study targeted students from non-health-related courses.

2. Method

This research is an interventional study where pre- and post-intervention outcomes for two groups (intervention and control groups) were measured from June to August 2021. The study was conducted among student communities from higher education institutions in Peninsular Malaysia who attended the virtual infectious diseases workshop organized by the Universiti Putra Malaysia. The inclusion criteria were Malaysian students studying in non-health-related courses, aged 18–24 years old, and registered in public or private education institutions. Those students who did not consent to participate or had not completed the workshop session and those who had participated in the pilot test were excluded from this study.

2.1. Ethical approval

This research was approved by the Ethics Committee for Research Involving Human Subjects Universiti Putra Malaysia (JKEUPM-2019-302).

2.2. Instruments

2.2.1. FOODAlyzer© web-based application

The FoodAlyzer© was developed in collaboration with our multidisciplinary research team. Medical and public health experts defined the content idea; an environmental health practitioner did the storyboard writing; the animator team designed the animation graphic; and the information technology experts made the software, the interface, and the database arrangements. The main content is divided into the 'Food Premises Evaluation Section' and the 'Education Section'. All users can access the FOODAlyzer© by going to https://myfoodalyzer.net/and signing up for free without the membership fee. The only required personal information was a valid email address, and users needed to create their own password. After email verification, users can sign in (log in) to the FOODAlyzer© by using their registered email and password. The FOODAlyzer© interface is shown in Fig. 1.

For the 'Food Premises Evaluation Section', users need to fill in the name and address of the food premises that they want to rate according to their self-rating based on the criteria of clean food premises. The evaluation score given by users varied depending on consumers' knowledge of the criteria for clean food premises. The evaluation score was only generated for admin view and not for public sharing to avoid intentional libel or uncontrolled defamation by unethical users. In the 'Education Section', users can explore through a cartoon graphic illustrating the restaurant's environment, in which they can see several '+' signs. Users can click on all the plus signs to watch all 5 animated videos and 4 pieces of colourful posters. All the videos in this education section had a short duration, totalling 4.59 min [video on food handlers' cleanliness (1.56 min), video on selecting safe food at eateries (2.12 min), video on restaurant environment (1.50 min), video on food poisoning (2.06 min), video on handwashing (1.03 min)]; whereas the poster reading needed less than 10 min. As for the purposes of this study, the column for the restaurant name was written as "ONLINE", and the respondents were needed to watch a video showing the environment of a restaurant, assuming that they were physically in the "ONLINE" restaurant while completing the evaluation section.

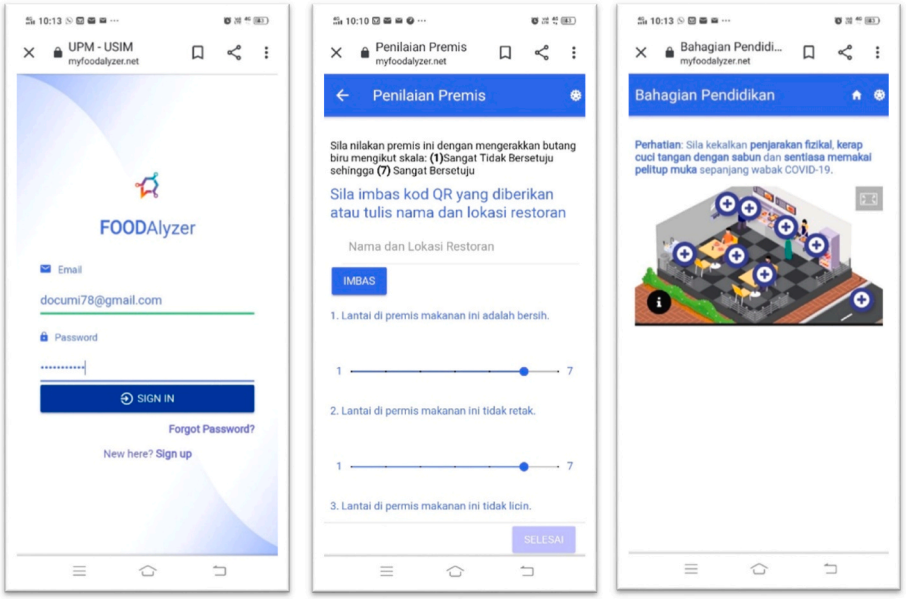

Fig. 1. The interface of the FOODAlyzer© application system.

2.2.2. *Questionnaire*

The questionnaire was adapted based on previous studies (Al-Shabib et al., 2017; Mamot et al., 2021; Mohd Shahib et al., 2019; Odeyemi et al., 2019) and also based on food premises grading guidelines set by the Ministry of Housing and Local Authority, Malaysia (Makhilan et al., 2021). It consists of four sections. Section 1 is for the socio-demographic characteristics (respondents' details, age, gender, living with family, having parents work as food handlers, food poisoning experience, and frequency of buying food at eateries). Section 2 is for the knowledge domain, which consisted of 15 items on food poisoning causes and complications related to commercial eateries. It had three options, 'yes', 'no', and 'unsure'. Each 'yes' option was given 1 mark, whereas the other options receive 0 marks. The total correct answers are converted into a knowledge score (da Cunha et al., 2022) which makes the lowest score for knowledge is 0, and the maximum score is 15. Section 3 is for the attitude domain, and Section 4 is for the perception domain. Sections 3 and 4 followed a 5-point Likert scale format ranging from strongly disagree (1) to strongly agree (5). All points were summed up, and negative items were reverse-scored. The attitude domain consisted of 15 items, of which the lowest score was 15, and the maximum score was 75. The perception domain consisted of 10 items, with 10 as the lowest score and 50 as the maximum score. The questionnaire was in Malay and English. A pilot test was conducted using a similar method as the actual survey, involving 50 college students. The test resulted in minimal modifications to the wording of questions, and all samples were excluded from the actual survey. Cronbach's alpha results demonstrated acceptable reliability and consistency for knowledge (Cronbach $\alpha = 0.62$), attitude (Cronbach $\alpha = 0.89$), and perception (Cronbach $\alpha = 0.84$).

2.3. *Recruitment and data collection*

As the data collection was done during the movement control order due to the COVID-19 pandemic, the face-to-face interview in the real setting of commercial eateries was restricted. Hence, respondent recruitment was done through the virtual infectious diseases workshop held by Universiti Putra Malaysia (UPM), with the participants comprising students from several higher education institutions in Peninsular Malaysia. The list of 529 students who registered as participants were utilised for computer-generated randomisation. The single-blind randomisation was done on the registered participants for groupings, that is, the intervention and control groups. Only the organiser knew which group the participants were getting. They were then notified by email, along with the Zoom link to the virtual infectious disease workshop. Different links separated both groups (intervention and control groups).

On the day of the workshop, three activities were set for all the participants. They were informed of the study aims and goals through the opening remarks by the programme moderator. The first activity was the pre-test session. The link to the pre-test questionnaire was given to the two groups: the intervention and control groups. 'Consent Declaration' and the research details were included as an introduction part in the pre-test to ensure the participants' awareness regarding the voluntary nature of their participation and the guaranteed confidentiality of their responses. The second activity was for the intervention session in which the intervention group was requested to explore food safety education using the FOODAlyzer©, whilst the control group was given another intervention through games and animation videos on Zoonosis diseases. Their presence was recorded by the system administrator based on their responses to activities and log-in history.

The third activity was done after the intervention. The respondents were given the link to the post-test, which took approximately 20 min to complete. At the end of the programme, the participants were reminded to check their email after two weeks which was linked to the follow-up post-test. After two weeks of the virtual infectious diseases workshop, a friendly reminder e-mail was sent only to all the participants who had completed both pre-and post-tests. They were also requested to submit the follow-up post-test within one week. Both the intervention and control groups were given the same pre-tests, post-tests, and follow-up post-test questionnaires. Each respondent was awarded a token of appreciation upon completing all the questionnaires. Fig. 2 shows the flow diagram of the study.

2.4. *Sample size calculation*

To calculate the required sample size, we referred to the pilot test results for this study. Open Epi online calculator (Open-Source Epidemiologic Statistics for Public Health) was used to determine the sample size with the estimation of 95% CI, 5% margin of error, and 80% power of the study (which can be accessed at the link https://www.openepi.com/Menu/OE_Menu.htm). After adjusting for a 20% dropout rate, the sample size calculated was 118 respondents, or 59 per arm.

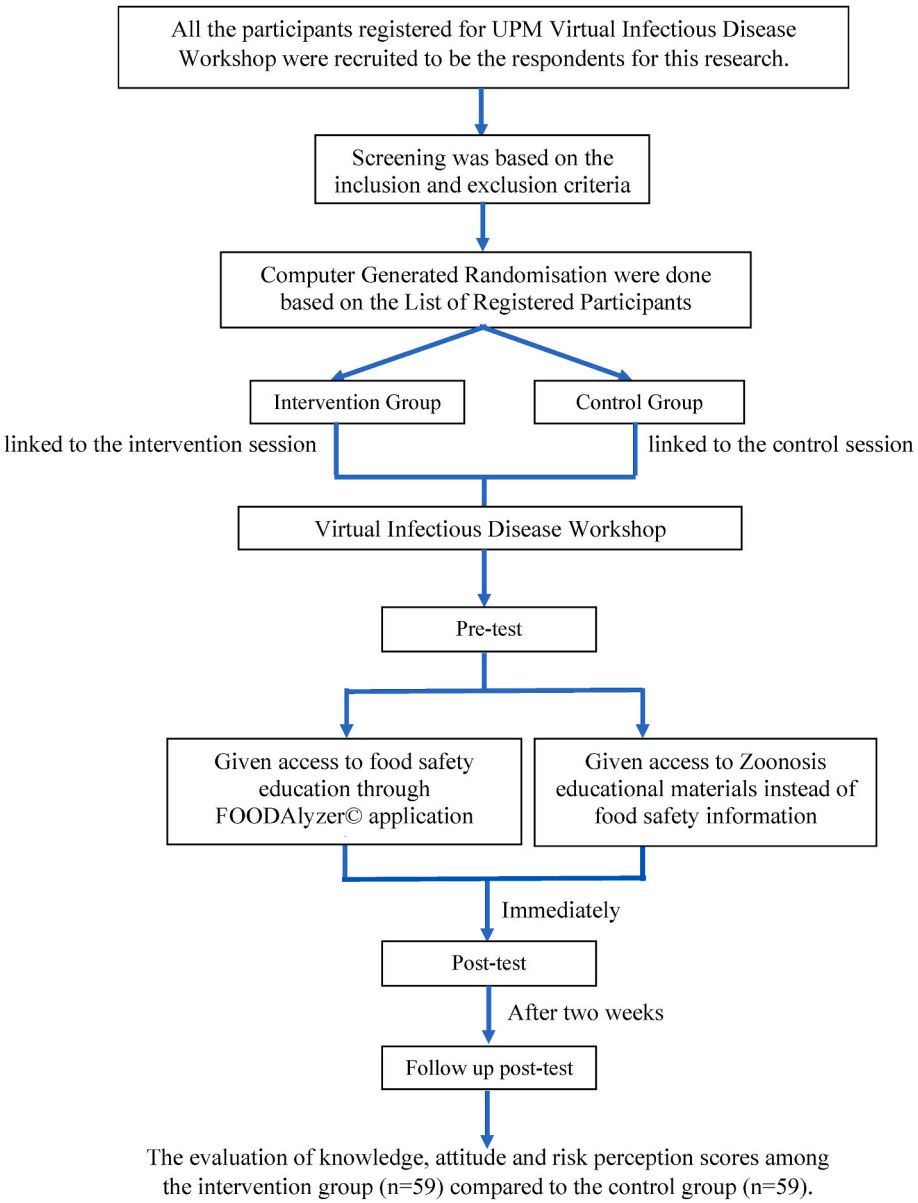

Fig. 2. The flow diagram of the study.

3. Data analysis

Statistical Package for the Social Sciences (SPSS) version 23 was used to perform the analysis. The primary outcome was the changes in knowledge, attitude, and perceptions translated by the total score between the pre-test, post-test, and follow-up post-test for the intervention and control groups. The scores according to gender, the status of living with family, parents working as food handlers, frequency of buying food from eateries, and food poisoning experience were also compared. As the data did not pass the normality distribution test, the Mann-Whitney *U* Test was used to assess the differences in mean rank scores between the independent groups, particularly the intervention and control groups. Meanwhile, the Friedman test was used to analyse the effect of the pre-test, post-test, and follow-up post-test within the individual subject, and finally, the post hoc test was done by using a pairwise Wilcoxon signed rank test with Bonferroni adjustment for multiple comparisons to determine which groups were substantially different.

4. Results

4.1. Socio-demographic characteristics

Results were based on 118 valid respondents, which comprises the intervention group ($n = 59$) who have access to food safety education through the FOODAlyzer© and the control group ($n = 59$) who have not been given access to the FOODAlyzer©. The mean age of the respondents was 20.83 years, $SD \pm 1.23$. Table 1 shows the social and demographic characteristics of the study participants. Both the control and intervention groups have an almost equal number in characteristic distribution. Females made up 66.1% of the sample (64.4% females in the control group and 67.8% in the intervention group), whereas 33.9% were males (35.6% in the control group and 32.2% in the intervention group). The majority of the participants (89.8% in the control group and 93.2% in the intervention group) lived with their families. Overall, 92.4% (109/118) of their parents were not working as food handlers, 61% (72/118) were frequently buying food from commercial eateries and only 42.4% (50/118) had ever experienced eatery-related food poisoning.

Table 1
Sociodemographic characteristics, (N = 118).

Sociodemographic profiles	Groups			
	Intervention $n = 59$		Control $n = 59$	
	n	%	n	%
Gender				
Male	19	32.2	21	35.6
Female	40	67.8	38	64.4
Living with family				
Yes	55	93.2	53	89.8
No	4	6.8	6	10.2
Parent(s) work as a food handler				
Yes	4	6.8	4	6.8
No	55	93.2	55	93.2
Frequency of buying from eateries				
Occasional	19	32.2	23	39.0
Frequent	40	67.8	36	61.0
Food poisoning experience				
No	36	61.0	37	62.7
Yes	23	39.1	22	37.3

4.2. The baseline score

The students' baseline scores in knowledge, attitude, and perception were translated by the total score for each domain in the pre-test questionnaire. Table 2 demonstrates no significant differences in baseline scores between the control and intervention groups, whereby no differences existed in the baseline knowledge scores ($p = 0.754$), the baseline attitude score ($p = 0.753$), and the baseline perception score ($p = 0.852$).

In terms of socio-demographic characteristics, results shown in Table 3 revealed that the differences in baseline knowledge, attitude, and perception scores were significantly similar among them, except for attitude scores among different genders (male or female), and also for perception scores among different genders (male or female) and different status of living with family (yes or not). Baseline attitude scores were significantly lower among male respondents ($Mdn = 45.00$) compared to females ($Mdn = 49.00$). Baseline perception scores were significantly different among different genders and the status of living with family. Male respondents significantly showed lower perception scores ($Mdn = 44.61$) compared to females ($Mdn = 67.13$), whereas perception scores were significantly lower among students who are living with family ($Mdn = 57.57$) compared to students who are not ($Mdn = 80.35$).

Tables 4–6 provide the frequency tabulation of baseline responses from all 118 respondents for each item in the questionnaire. The majority of the respondents answered correctly for all items of knowledge in the questionnaire, reflecting that they have good knowledge of eatery-related foodborne diseases. There was also a majority of respondents who answered correctly for all the attitude items in the questionnaire, reflecting that they may have a good attitude toward selecting commercial eateries based on food safety when eating out. In addition, the majority of the respondents showed a good level of perception toward selecting commercial eateries when eating out. However, there are some items in the questionnaire showed that many respondents still do not have enough knowledge, have a poor attitude, and have a low level of perception. 23.7% did not answer accurately the questions about dehydration, and 35.6% did not answer correctly the questions about kidneys, as an example of complications that can occur due to foodborne disease. Despite the fact that only 17.8% of respondents gave incorrect responses to the knowledge question about the hazard of the wood-cutting board, it is concerning to note that 27% of the respondents may still purchase food even if there is a wood-cutting board used in the food premises. Regarding the questions on rubber-host pipe water, 24% of the respondents were not aware that rubber-host pipe water can contaminate food, and they still might purchase food from premises where rubber-host pipe water is being used to clean food. Overall, from the perception questionnaire, results showed that 27.9% of the respondents may think that the risk of getting eatery-related foodborne disease in Malaysia is still low, and 25.3% of them believe that all food prepared at eateries is safe to be consumed.

Table 2
The Mann-Whitney U Test results on the baseline knowledge, attitude, and perception scores, the differences between control and intervention groups (N=118).

Variable	Group		z	p
	Control $n = 59$	Intervention $n = 59$		
	Mdn (IQR)	Mdn (IQR)		
Knowledge	12.00 (1.0)	12.00 (3.0)	−0.313	0.754
Attitude	62.00 (6.0)	61.00 (11.0)	−0.315	0.753
Perception	45.00 (3.0)	45.00 (7.0)	−0.222	0.825

Note: Mdn = Median, IQR = Interquartile range, z = z-score.
p = significant level, $p < 0.05$.

4.3. Test of within subjects Effects–The scores among the control group

As shown in Table 7, a Friedman test revealed significant differences in pre-test scores, post-test, and follow-up post-test on student's knowledge [X^2 (2, $n = 59$) = 46.88, $p < 0.001$]; attitude [X^2 (2, $n = 59$) = 38.04, $p < 0.001$], and perception [X^2 (2, $n = 59$) = 25.40, $p < 0.001$]. The baseline knowledge scores were lower ($Mdn = 12.00$) than the post-test ($Mdn = 14.00$) and follow-up post-test ($Mdn = 13.00$). The baseline attitude scores were lower ($Mdn = 62.00$) than the post-test ($Mdn = 69.00$) and follow-up post-test ($Mdn = 66.00$). The baseline perception scores were lower ($Mdn = 45.00$) than the post-test ($Mdn = 48.00$) and follow-up post-test ($Mdn = 48.00$). These results indicate that the pre-test score was lower than the post-test score. Post-hoc test (Table 8) using a Wilcoxon signed-ranked test with a Bonferroni-adjusted alpha level of 0.017 (0.05/3) showed a significant improvement with large effect size in knowledge scores between pre- and post-tests ($z = -5.194$, $p < 0.001$, $r = 1.5$) and also between pre-test and follow-up post-test ($z = -5.193$, $p < 0.001$, $r = 1.5$). Meanwhile, a significant improvement in attitude score was seen between pre- and post-tests ($z = -5.395$, $p < 0.001$, $r = 1.5$) and also between the pre-test and follow-up post-test ($z = -3.359$, $p = 0.001$, $r = 1.0$). A significant improvement also occurred in the perception scores between the pre-test and post-test ($z = -4.552$, $p < 0.001$, $r = 1.3$) and also between the pre-test and follow-up post-test ($z = -3.025$, $p = 0.02$, $r = 0.9$). This research found an improvement in scores for the post-test compared with pre-test scores among the control group even though they had not been given access to the FOODAlyzer©.

4.4. Test of within subjects Effects–The scores among the intervention group

As shown in Table 7, a Friedman test revealed significant differences between baseline scores, post-test, and follow-up post-test on student's knowledge [X^2 (2, $n = 59$) = 72.80, $p < 0.001$]; attitude [X^2 (2, $n = 59$) = 54.24, $p < 0.001$] and perception [X^2 (2, $n = 59$) = 51.06, $p < 0.001$]. Baseline knowledge scores were lower ($Mdn = 12.00$) than the post-test ($Mdn = 14.00$) and follow-up post-test ($Mdn = 15.00$). The baseline attitude scores were lower ($Mdn = 61.00$) than the post-test ($Mdn = 74.00$) and follow-up post-test ($Mdn = 73.00$). Baseline perception scores were lower ($Mdn = 45.00$) than the post-test ($Mdn = 49.00$) and follow-up post-test ($Mdn = 48.00$).

Post-hoc test (Table 8) using a Wilcoxon signed-ranked test with a Bonferroni-adjusted alpha level of 0.017 (0.05/3) showed a significant improvement with large effect size in knowledge scores between pre-test and post-test ($z = -5.89$, $p < 0.001$, $r = 1.7$), between the post-test and follow-up post-test ($z = -2.52$, $p < 0.012$, $r = 0.7$) and also between pre-

Table 3
The results of the Mann-Whitney *U* Test on the differences in baseline knowledge, attitude, and perception scores based on sociodemographic characteristics (N = 118).

Socio-demographic profiles	Knowledge				Attitude				Perception			
	Mdn (IQR)	U	z	p	Mdn (IQR)	U	z	p	Mdn (IQR)	U	z	p
Gender												
Male	12.00 (3.0)	1417.5	−.820	0.41	58.50 (12.0)	1150.0	−2.333	0.02	42.00 (7.0)	964.5	−3.399	0.001
Female	11.00 (3.0)				62.00 (12.0)				45.50 (5.0)			
Living with family												
No	13.00 (3.0)	393.5	−1.433	0.15	64.50 (9.0)	424.5	−1.117	0.26	49.50 (9.0)	331.5	−2.023	0.04
Yes	11.50 (3.0)				61.00 (11.0)				44.50 (7.0)			
Parent(s) work as a food handler												
No	11.50 (3.0)	289.0	−1.636	0.10	62.00 (12.0)	400.0	−.429	0.67	45.00 (7.0)	405.5	−.371	0.71
Yes	12.50 (4.0)				60.50 (8.0)				46.00 (8.0)			
Frequency of buying from eateries												
Occasional	11.50 (3.0)	1591.0	−.028	0.98	62.00 (9.0)	1531.5	−.363	0.72	44.50 (6.0)	1497.0	−.559	0.58
Frequent	12.00 (3.0)				61.50 (13.0)				45.00 (8.0)			
Food poisoning experience												
No	12.00 (3.0)	1593.5	−.275	0.78	63.00 (15)	1470.5	−.954	0.34	45.00 (7)	1510.5	−.734	0.46
Yes	12.00 (3.0)				60.00 (10)				44.00 (7)			

Note: Mdn = Median; IQR = Interquartile range; U = Mann-Whitney test value; z = z-score; p = significant level, $p < 0.05$.

Table 4
Students' responses to the questionnaire on knowledge questions (N = 118).

Item number	Questions	Yes *n* (%)	No *n* (%)	Don't know *n* (%)
1	Parasites are the cause of food poisoning	98 (83.1)	19 (16.1)	1 (0.8)
2	Chemicals are the cause of food poisoning	104 (88.1)	9 (7.6)	5 (4.2)
3	Fever and vomiting may be the symptoms of food poisoning	115 (97.5)	3(2.5)	–
4	Dehydration due to food poisoning could cause death.	90 (76.3)	19 (16.1)	9 (7.6)
5	Kidney failure may be caused due to the complication of food poisoning.	76 (64.4)	27 (22.9)	15 (12.7)
6	Spoilage food could be detected by SEE-SMELL-TASTE.	117 99.2)	1 (0.8)	–
7	Food that is not properly covered would be contaminated and lead to food poisoning.	118 (100.0)	–	–
8	Food that is not properly kept at the proper temperature would be contaminated and lead to food poisoning.	114 (96.6)	3 (2.5)	1 (0.8)
9	Water from the rubber host pipe may cause contamination.	89 (75.4)	13 (11.0)	16 (13.6)
10	The wooden chopping board has a higher risk to hold germs which could lead to food contamination.	97 (82.2)	13 (11.0)	8 (6.8)
11	Eateries' staff who handle food is compulsory to wear headcovers.	116 (98.3)	1 (0.8)	1 (0.8)
12	Hand accessories like a ring, watch, wristlet, and so forth are not allowed while handling food.	108 (91.5)	9 (7.6)	1 (0.8)
13	Food handlers must hold the food using hand gloves or proper tools.	118 (100.0)	–	–
14	Eateries-related food poisoning must be reported to the local authority.	118 (100.0)	–	–
15	Eateries must have a cleanliness grading certificate A/B/C that should be visible and displayed to the customer.	118 (100.0)	–	–

test and follow-up post-test ($z = -6.17, p < 0.001, r = 1.8$). A significant improvement in attitude scores was found between the pre-test and post-test ($z = -6.239, p < 0.001, r = 1.8$) and also between the pre-test and follow-up post-test ($z = -5.882, p < 0.001, r = 1.7$). A significant improvement in perception scores was found between the pre-test and post-test ($z = -5.483, p < 0.001, r = 1.6$) and also between the pre-test and follow-up post-test ($z = -4.043, p < 0.001, r = 1.2$). Even though no significant improvement was seen between the post-test and follow-up post-test in knowledge scores, attitude, and perception, a significant improvement in baseline scores was found compared with the follow-up post-test. In conclusion, these results indicate that post-intervention might be more effective than before the intervention to improve students' knowledge, attitude, and perception.

4.5. Test of between subjects effects

4.5.1. Comparison of scores between the control and intervention groups

A Mann-Whitney *U* Test (Tables 9 and 10) was performed to assess the impact of food safety education in the intervention group compared with the control group. The scores among the intervention group were higher than the control group. In the post-test, a significantly higher attitude score was seen among the intervention group ($Mdn = 74.00$, $n = 59$) than the control group ($Mdn = 69.00$, $n = 59$), $U = 1328.5$, $z = -2.29$, $p = 0.022$. In the follow-up post-test, knowledge scores were significantly higher among the intervention group ($Mdn = 15.00$, $n = 59$) than the knowledge scores in the control group ($Mdn = 13.00$, $n = 59$), $U = 1204.0$, $z = -3.01$, $p = 0.003$; and the attitude scores were significantly higher in the intervention group ($Mdn = 73.00$, $n = 59$) than the attitude scores in the control group ($Mdn = 66.00$, $n = 59$), $U = 1212.5$, $z = -2.90$, $p = 0.004$. These results indicate that the intervention group might have more improvements than the control group to increase students' knowledge, attitude, and perception.

5. Discussion

The main objective of this study was to assess the improvement in knowledge, attitude, and perception level toward food safety when selecting commercial eateries among the intervention group compared with the control group. Regarding the baseline score derived from the pre-test, the distribution of knowledge, attitude, and perception scores between the control and intervention groups were nearly identical. The lower level of baseline score compared with the post-test among all the students in this study revealed that young consumers, particularly those who regularly buy food at commercial eateries, should seek additional food safety information on food poisoning related to food premises. Food safety education should be made more attractive to this population group. They may need to be the main target group, as many still have low food safety knowledge levels.

The current study discovered that knowledge levels did not differ

Table 5
Students' responses to the questionnaire on attitude questions (N = 118).

Item number	Questions	Strongly disagree *n* (%)	Disagree *n* (%)	Unsure *n* (%)	Agree *n* (%)	Strongly agree *n* (%)
1	I will not take food that is not properly covered).	3 (2.5)	1 (0.8)	4 (3.4)	25 (21.2)	85 (72.0)
2	I will not take food that is left without proper temperature control.	2 (1.7)	1 (0.8)	5 (4.2)	41 (34.7)	69 (58.5)
3	I will not buy food from the eatery that is using rubber host pipe at the sink.	3 (2.5)	5 (4.2)	22 (18.6)	36 (30.5)	52 (44.1)
4	I will not buy food from the eatery that is using a wood chopping board.	3 (2.5)	9 (7.6)	20 (16.9)	34 (28.8)	52 (44.1)
5	I will not buy food from the eatery where the food handlers are not wearing head cover	2 (1.7)	5 (4.2)	10 (8.5)	34 (28.8)	67 (56.8)
6	I will not buy food from the eatery in which the food handlers are wearing hand accessories.	2 (1.7)	4 (3.4)	14 (11.9)	35 (29.7)	63 (53.4)
7	I will not buy food from the eatery where the food handlers are having wounds on their hands.	3 (2.5)	–	5 (4.2)	29 (24.6)	81 (68.6)
8	I will not buy food from an eatery in which the food handlers are not wearing aprons.	2 (1.7)	4 (3.4)	17 (14.4)	36 (30.5)	59 (50.0)
9	I will not buy food from the eatery in which the toilet door is directly opened to the kitchen.	3 (2.5)	–	9 (7.6)	27 (22.9)	79 (66.9)
10	In choosing an eatery, I will evaluate the cleanliness of the floor.	2 (1.7)	2 (1.7)	4 (3.4)	29 (24.6)	81 (68.6)
11	In choosing an eatery, I will evaluate the cleanliness of the ceiling.	3 (2.5)	–	6 (5.1)	36 (30.5)	73 (61.9)
12	In choosing an eatery, I will evaluate the cleanliness of the wall.	3 (2.5)	–	5 (4.2)	32 (27.1)	78 (66.1)
13	I will not buy food from the eatery with the sign of pest infestation.	3 (2.5)	–	1 (0.8)	22 (18.6)	92 (78.0)
14	In choosing an eatery, I will evaluate the cleanliness of the back lane.	2 (1.7)	1 (0.8)	13 (11.0)	34 (28.8)	68 (57.6)
15	I will not buy food from an eatery that does not display the cleanliness grading certificate A/B/C to be seen by the customer	4 (3.4)	1 (0.8)	12 (10.2)	33 (28.0)	68 (57.6)

Table 6
Students' responses to the questionnaire on perception questions (N = 118).

Item number	Questions	Strongly agree *n* (%)	Agree *n* (%)	Unsure *n* (%)	Disagree *n* (%)	Strongly disagree *n* (%)
1	I do not worry if there are pests (such as rodents/flies/cockroaches) in the eateries that I visit.	2 (1.7)	1 (0.8)	1 (0.8)	13 (11.0)	101 (85.6)
2	I don't care about the clean appearance of food handlers while they are handling food.	2 (1.7)	2 (1.7)	–	23 (19.5)	91 (77.1)
3	I do not worry if there is no grading certificate seen in the eatery that I visited.	3 (2.5)	4 (3.4)	2 (1.7)	27 (22.9)	82 (69.5)
4	I do not care about the level of cleanliness in the eatery that I visited.	2 (1.7)	2 (1.7)	1 (0.8)	21 (17.8)	92 (78.0)
5	I feel that the risk of me getting eateries related-food poisoning in Malaysia is low	4 (3.4)	7 (5.9)	22 (18.6)	22 (18.6)	63 (53.4)
6	I do not worry if I exhibit symptoms of food poisoning.	2 (1.7)	1 (0.8)	1 (0.8)	21 (17.8)	93 (78.8)
7	I think food poisoning is not life-threatening.	2 (1.7)	3 (2.5)	4 (3.4)	14 (11.9)	95 (80.5)
8	I believe that all food prepared at eateries is safe to be consumed.	3 (2.5)	3 (2.5)	24 (20.3)	31 (26.3)	57 (48.3)
9	I think there is no need to lodge a report to the relevant authorities (e.g., local authorities) if I witness any dirty eatery.	3 (2.5)	1 (0.8)	3 (2.5)	29 (24.6)	82 (69.5)
10	I do not worry about dining in an eatery that has ever had a history of food poisoning cases in recent times.	4 (3.4)	1 (0.8)	3 (2.5)	24 (20.3)	86 (72.9)

Table 7
Pairwise comparisons using Friedman Test on knowledge, attitude, and perception among the students (N=118).

	Mdn (IQR)			*n*	Chi-square	*df*	*p*
	Pre-test	Post-test	Follow-up post-test				
Control group				59			
Knowledge	12.00 (3.00)	14.00 (4.00)	13.00 (3.00)		46.88	2	<0.001
Attitude	62.00 (14.00)	69.00 (17.00)	66.00 (18.00)		38.04	2	<0.001
Perception	45.00 (7.00)	48.00 (5.00)	48.00 (7.00)		25.40	2	<0.001
Intervention group				59			
Knowledge	12.00 (3.00)	14.00 (3.00)	15.00 (2.00)		72.80	2	<0.001
Attitude	61.00 (11.00)	74.00 (9.00)	73.00 (9.00)		54.24	2	<0.001
Perception	45.00 (7.00)	49.00 (4.00)	48.00 (5.00)		51.06	2	<0.001

Note: Mdn = Median; IQR = Interquartile range; df = degrees of freedom; p = significant level, $p < 0.05$.

significantly across different sociodemographic characteristics. However, the attitude level and the perception level were different between genders; females showed higher attitude scores as well as higher perception scores than males, similar to the findings from other studies, which indicated that females are more selective to protect themselves from unsafe restaurants (Bai et al., 2019), whereas other findings showed that male adolescents have inadequate knowledge and practice about food safety and health (Mirzaei et al., 2018) than females (Odeyemi et al., 2019; Serrem et al., 2021). Females have traditionally been associated with food preparation and cooking abilities (Gooptu & Chakravarty, 2018; Ibrahim, 2018; Zeeshan et al., 2017). Thus, they are supposed to have a higher awareness of food safety. In contrast to the previous study, male students were found to be more likely than females to have good knowledge of food poisoning, and more males assumed that restaurants have a higher risk of causing food poisoning (Al-Shabib et al., 2017), which is consistent with the increase in the number of men

Table 8
Post-hoc test using the Wilcoxon signed-rank test on the knowledge, attitude, and perception scores among the students, (N = 118).

		Control group			Intervention group		
		n = 59			*n* = 59		
		Mdn (IQR)	z	p	Mdn (IQR)	z	p
Knowledge	pre-test post-test	12 (3.00) 14 (4.00)	−5.194	<0.001	12 (3.00) 14 (3.00)	−5.891	<0.001
	pre-test follow up post-test	12 (3.00) 13 (3.00)	−5.193	<0.001	12 (3.00) 15 (2.00)	−6.174	<0.001
	post-test follow up post-test	14 (4.00) 13 (3.00)	−0.109	0.913	14 (3.00) 15 (2.00)	−2.523	0.012
Attitude	pre-test post-test	62 (14.00) 69 (17.00)	−5.395	<0.001	61 (11.00) 74 (9.00)	−6.239	<0.001
	pre-test follow up post-test	62 (14.00) 66 (18.00)	−3.359	0.001	61 (11.00) 73 (9.00)	−5.882	<0.001
	post-test follow up post-test	69 (17.00) 66 (18.00)	−1.258	0.208	74 (9.00) 73 (9.00)	−1.384	0.166
Perception	pre-test post-test	45 (7.00) 48 (5.00)	−4.552	<0.001	45 (7.00) 49 (4.00)	−5.483	<0.001
	pre-test follow up post-test	45 (7.00) 48 (7.00)	−3.025	0.002	45 (7.00) 48 (5.00)	−4.043	<0.001
	post-test follow up post-test	48 (5.00) 48 (7.00)	−0.997	0.319	49 (4.00) 48 (5.00)	−2.042	0.041

Note: Mdn = Median; IQR = Interquartile range; z = z-score; p = significant level.
$p < 0.017$ Bonferroni-adjusted alpha level for multiple comparisons.

Table 9
The results of the Mann-Whitney *U* Test on the differences in knowledge, attitude, and perception scores between control and intervention groups in the post-test (N = 118).

Variable	Group		*U*	*z*	*p*
	Control *n* = 59	Intervention *n* = 59			
	Mdn (IQR)	Mdn (IQR)			
Knowledge	14.00 (4.00)	14.00 (3.00)	1574.5	−0.934	0.350
Attitude	69.00 (17.00)	74.00 (9.00)	1328.5	−2.292	0.022
Perception	48.00 (5.00)	49.00 (4.00)	1579.5	−0.903	0.366

Note: Mdn = Median; IQR=Interquartile range; U = Mann-Whitney test value.
z = z-score; p = significant level, $p < 0.05$.

Table 10
The results of the Mann-Whitney *U* Test on the differences in knowledge, attitude, and perception scores between control and intervention groups in the follow-up post-test (N = 118).

Variable	Group		*U*	*z*	*p*
	Control *n* = 59	Intervention *n* = 59			
	Mdn (IQR)	Mdn (IQR)			
Knowledge	13.00 (3.00)	15.00 (2.00)	1204.0	−3.006	0.003
Attitude	66.00 (18.00)	73.00 (9.00)	1212.5	−2.896	0.004
Perception	48.00 (7.00)	48.00 (5.00)	1664.5	−0.423	0.672

Note: Mdn = Median; IQR=Interquartile range; U = Mann-Whitney test value.
z = z-score; p = significant level, $p < 0.05$.

cooking. (Taillie, 2018).

Another interesting finding in this current study was that the level of perception was shown to be higher among students who were not living with family. Perhaps, the experience of living independently away from family has influenced their eating choices (Dhillon et al., 2019). This finding was contradicted by prior studies, which found that living with families will improve food safety knowledge than living in hostels (Zeeshan et al., 2017), and living with parents can increase knowledge scores than those students who live in a rented house or their own house (Mullan et al., 2015). This current study also found that the frequency of buying food from eateries or the experience of food poisoning have no significant effect on students' perceptions. This could be due to an optimistic bias that led them to believe that the risk of foodborne disease was lower for food prepared at the restaurant they were visiting than for food prepared in other restaurants (Zanetta et al., 2022), unless they had experienced the same risk as encountered by everyone else (Wang & Yueh, 2020), regardless of their frequency of dining out (Ali et al., 2019).

This current study showed a more significant improvement in the intervention group than in the control group. A similar study by (Zaujan et al., 2021) indicated that the significant impact of food safety intervention using an internet application system had increased consumers' knowledge, attitude, and practice toward foodborne disease prevention when dining out. Although many people still choose published materials, professional lectures, and classes, most prefer to obtain food safety knowledge from Internet sources, and only a small fraction choose TV, friends, or family (Hu et al., 2017). In addition, users are more likely to be interested in accessible technology that provides useful information, a good audio-visual presentation, and one that is repeatable at the desired time, straightforward and short (less than 5 min) (Strohbehn & RD). Thus, the FOODAlyzer© is relevant for food safety education tools. The videos and poster content in the FOODAlyzer© could be the attractive attributes for users as people are more interested in the usage of visual-based materials (Rajagopal et al., 2019).

Undoubtedly, every intervention tool requires assessment to increase the usability potential for users in the application of knowledge (Perry et al., 2017). The ongoing improvements to the FOODAlyzer© function can be implemented over time with easy navigation features for a huge impact on the users' behaviour (Prabhu & Soodan, 2020) and become the up-to-date option for food safety information with the latest scientific information (Bougioukas et al., 2020). Practically, the use of FOODAlyzer© should be introduced widely at the community level with support from the collaborative governance network (Soon et al., 2011), requiring the government, relevant authorities, local leaders, and stakeholders to play an important role in promoting active food premises

self-rating by the consumers and enforcing the laws and regulations for the evaluation of commercial eateries.

6. Limitation and future direction

It is challenging to provide a balanced proportion of respondents based on their socio-demographic characteristics due to the drawbacks of random sampling. The greater number of students living with their families may be because this study was conducted during the time of the Movement Control Order (MCO) and the policy of lockdown during the COVID-19 pandemic period (Sundarasen et al., 2020), suggesting further improvements in the sampling method for future research. Given that data collection was not carried out as a face-to-face survey, the online session has led to some limitations. The respondents might not ideally evaluate the questionnaires, which could contribute to social desirability bias as the data collection was not done in the natural environment of commercial eateries. The data relied on self-reporting from the respondents and thus might also be biased. Lastly, Internet disruptions and the functionality of tools might affect the participant's focus in completing the questionnaires and the intervention session. In addition, this current research does not compare other health education methods, such as printed materials and conventional health talks. However, the current research supports that the efficacy of application technology on food safety intervention is comparable with the traditional method (Seow et al., 2022).

As food safety risks related to food premises continue to bring a public health threat, further study is required to understand how to educate consumers on selecting food premises based on food safety. Future research could study the differences between self-reporting scores by the consumers compared with the actual rating score by the government to evaluate the understanding of food safety criteria for food premises and reflect a good level of knowledge and practices of selecting safe commercial eateries among consumers. In addition, a more experimental study is needed to critically analyse the relationships between food safety education and the behavioural outcomes in selecting food premises among consumers, particularly its related factors in influencing risk perceptions and protective behaviour. Finally, future research should provide other useful insights on strategies in food safety education for Malaysian consumers and on a global level for the formation of effective food safety directives (Bondoc, 2016). Enhancing the food safety education strategy for consumers might be a cost-effective approach in food safety governance to control the quality of food businesses for public health.

7. Conclusion

This study revealed that the students' baseline knowledge and attitude toward selecting commercial eateries based on food safety criteria remained lacking even though they believed that commercial eateries may have a high risk of causing foodborne disease. The finding suggests that eatery-related foodborne disease topics should be emphasised in food safety education for consumers. The government or educational institutions could empower consumers with the right to know the critical criteria for selecting commercial eateries based on food safety. The significant increase in respondents' knowledge, attitude, and perception score after the intervention using the FOODAlyzer© indicates the effectiveness of the food application system in enhancing consumers' awareness of foodborne disease prevention related to commercial eateries. The use of a food application system is relevant for convenient fingertip information as a guide for users in selecting commercial eateries to prevent foodborne disease. In addition, it can be an important strategy to complement the regulatory measures of local authorities in food safety control, as food business owners will want to showcase the best hygienic practices for their eateries to attract other customers.

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CRediT authorship contribution statement

Umi Kalsom Md Ariffin: Conceptualization, Methodology, Data curation, Formal analysis, Writing – original draft. **Shamarina Shohaimi:** Validation, Methodology, Writing – review & editing. **Nurul Azmawati Mohamed:** Supervision, Resources, Writing – review & editing. **Wen-Li Seow:** Data curation, Resources, Writing – review & editing. **Abdul Rahman Mohamad Gobil:** Validation, Writing – review & editing. **Noris Mohd Norowi:** Validation, Writing – review & editing. **Madihah Mohd Saudi:** Validation, Writing – review & editing. **Nor Afiah Mohd Zulkefli:** Validation, Methodology. **Tengku Zetty Maztura Tengku Jamaluddin:** Validation, Methodology. **Roshariza Haris:** Data curation, Resources. **Shing Wei Ng:** Data curation, Resources. **Syafinaz Amin-Nordin:** Supervision, Validation, Methodology, Resources, Writing – review & editing.

Declaration of competing interest

The authors declare no conflict of interest in the topic or resources discussed in this manuscript.

Data availability

Data will be made available on request.

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