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Assessing the knowledge of, attitudes towards, and practices in, food safety among migrant workers in Klang Valley, Malaysia

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ABSTRACT

Background: Annually, 600 million individuals are affected by food-borne diseases (FBD), alongside 425,000 fatalities. Improving the general public knowledge of, attitudes towards, and practices in, (KAP) food safety is necessary for minimizing FBD transmission. In Malaysia, migrant workers account for 11.1% of the workforce, with a high proportion involved in food and beverage services. Therefore, this study aimed (i) to evaluate the current food safety KAP, and (ii) to identify the strategies to promote food safety awareness, among migrant workers across occupational sectors in Klang Valley.

Method: A survey was conducted with 403 migrant workers through phone interviews and online self-administered questionnaires. Piecewise structural equation modelling and multinomial regression were applied to identify predictor variables for food safety KAP and to explore differences across nationalities.

Results: The respondents were Nepalese, Filipino and Indonesian. The majority were male, working in the services industry, had completed high school, aged between 30 and 39 years and had worked in Malaysia for less than ten years. Knowledge was significantly correlated with attitudes and practices. Female respondents had lower knowledge and attitude scores while younger respondents had lower knowledge scores. Indonesian and Filipino respondents had lower knowledge and attitudes scores than Nepalese respondents. Understanding food safety information from social media was positively correlated with the respondents' food safety knowledge and practices.

Conclusion: These findings highlighted: (i) the need to target female, younger, Indonesian and Filipino migrant workers, and (ii) the potential of social media to improve public awareness of food safety and hygienic practices.

1. Introduction

Approximately 600 million individuals are affected annually by food-borne diseases (FBD) [1]. Around 425,000 lives are lost yearly, of which 125,000 are children aged below five [1]. In low- and middle-income countries (LMICs) within Southeast Asia, Sub-Saharan Africa and South Asia, 75% of FBD resulted in fatalities [2]. FBD occurs through the ingestion of pathogens or non-infectious agents (e.g., toxins), such as the hepatitis A virus which spreads through the fecal-oral route, causing liver damage, jaundice and extreme fatigue [3]. *Salmonella enterica serovar* Typhi, through sewage contamination of food, causes typhoid fever, headache, and appetite loss [3]. Dysentery, resulting from consumption of drinking water contaminated with either parasitic *Entamoeba histolytica* or bacterial *Shigella dysenteriae*, causes severe diarrhoea, vomiting, blood in faeces/vomit [3]. In Malaysia, food safety is a health concern with the incidence rate per 100,000 population of 0.14 for hepatitis A, 0.20 for typhoid and paratyphi, 0.48 for dysentery, and 28.93 for food poisoning; while all have a mortality rate of 0.00, food poisoning has a mortality rate of 0.02 [4]. However, the official FBD incidence figures are likely to be underestimated. Incidents may go unreported as individuals may not consult medical professionals, considering their symptoms as a common occurrence and transient inconvenience rather than signs of a potentially life-threatening disease

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Abbreviations

FBD	Food-Borne Diseases
KAP	Knowledge Attitudes and Practices
LMIC	Low- and Middle-Income Countries
MCO	Movement Control Order; MoH, Ministry of Health
PSEM	Piecewise Structural Equation Modelling

[3,5].

Globally, approximately 70% of all FBD are linked to catering and food service establishments [6]. In Malaysia, the percentage of food premises shut down due to unsanitary practices rose from 1.80% in 2018 to 2.58% in 2020 [7,8], and more than 50% of the food poisoning incidents were due to unhygienic food handling procedures [3,5]. This association between FBD and restaurants is worrying as 67% of Malaysians dine out at least once a week [9]. Furthermore, the Malaysian food services industry is highly reliant on migrant workers [10]. In Malaysia, migrant workers are non-citizens or permanent residents who have been granted a Visit Pass (Temporary Employment) [10,11]. They account for 11.1% of the Malaysian workforce, with the majority being Indonesian (34%), Bangladeshi (28.3%) and Nepalese (15.3%) [12], and are mostly employed in the manufacturing (36%), construction (19%), plantation (15%) and services (14%) sectors [13]. In the past, studies have detected FBD-causing pathogens in migrant workers involved in food handling in Malaysia, highlighting the increased risk of transmission to the general public [14–16]. Although the detection rate of FBD pathogens varied between the studies [14–16], the reported figures are nevertheless higher than similar studies from Portugal [17], Qatar [18], South Africa [19], Iran [20] and Spain [21].

Oftentimes, migrant workers are unable to access health-related information, therefore exhibiting poor health literacy, which results in their poor healthcare [22]. This may be attributed to language barriers, cultural differences and limited knowledge of their rights, as seen in Sweden [23], Thailand [24,25] and Italy [26]. In Malaysia, only 9.1% of 383 migrant workers went for medical check-ups every six months, likely due to poor comprehension of the local language [27]. Therefore, migrant workers are vulnerable to FBD, and those that are involved in food handling may risk transmitting FBD to the public.

To determine strategies for curbing the spread of FBD, numerous studies have evaluated the knowledge of, attitudes towards, and practices in, (KAP) food safety [28–34]. In Malaysia, the food safety KAP among students, consumers and local food handlers have been investigated [35–37], but understudied among migrant workers in the food service industry [27]. Therefore, this study examined the food safety KAP among migrant workers across occupational sectors in Klang Valley, Malaysia to (i) better understand how knowledge improves attitudes and practices, with implications for public health, (ii) to identify specific cohorts to target for awareness campaigns, and (iii) to examine the potential of social media as a platform for raising food safety awareness.

2. Methods

2.1. Ethical consideration

This study was approved by the Universiti Malaya Research Ethics Committee (UM.TNC2/UMREC_1162). Informed consent was obtained from all participants prior to the completion of the online questionnaire or phone interview.

2.2. Questionnaire development

A preliminary questionnaire was first developed in English, following [27], and modified to suit the current demographics of our respondents, who were employed in various sectors including the food service industry. The final questionnaire consisted of six parts (Supplementary File 1). Part A contained seven demographic questions about gender, age, nationality, level of education, district of residence, current occupation sector and date of commencing work in Malaysia. Part B contained five questions to elicit the illness history of the respondents. Part C examined the respondents' knowledge of food safety and comprised ten statements, each requiring respondents to choose 'True', 'False' or 'I am not sure' as their response. Part D explored the attitudes towards food safety of respondents and contained five statements, each requiring respondents to choose 'Strongly agreed', 'Agreed', 'Neutral', 'Disagreed', or 'Strongly disagreed' as their response. Part E evaluated the practices in food safety of respondents and contained six statements, each requiring respondents to choose 'Usually', 'Sometimes' or 'Never' as their response. Part F assessed what sources respondents used to obtain food safety information and their understanding of the information from these sources; it contained eight questions, each requiring respondents to choose either 'Yes' or 'No'.

2.3. Questionnaire survey

Data collection occurred in Klang Valley, between mid-2020 and 2021, during the government-imposed Movement Control Order (MCO) in Malaysia as a response to the COVID-19 pandemic. The questionnaire was distributed using Google Form and was shared with the coordinators to distribute to the respondents. Filipino and Nepalese respondents completed the questionnaire in English. Due to limited English proficiency among Nepalese and Indonesian respondents, Nepalese respondents underwent a phone interview conducted by their coordinator, whereas Indonesian respondents completed the questionnaire in the Indonesian language. A total of 455 individuals were approached for this study; 428 consented to complete the survey, of which 403 responses were appropriately recorded without erroneous or incomplete data, and used for data analyses.

2.4. Data analyses

All data analyses [38] were conducted using R version 4.2.1 [39]. The internal consistency of the responses was assessed using Cronbach's Alpha test, using 'alpha ' from the 'psych' package [40]. As Cronbach's alpha value of $\geq$0.7 indicates acceptable internal consistency of the responses to represent a single construct [9,34,36], while >0.8 indicates good internal consistency [35], 0.75 was used as the cut-off point here. An initial Cronbach's alpha of 0.67 was obtained for Part C. Upon removal of two statements: '*Taking the vaccine can prevent typhoid infections*' and '*Every individual needs to see, smell and taste a little of food before starting to eat it*', the value improved to 0.75, and therefore, the remaining eight statements were averaged to represent a construct C = 'Knowledge'. The Cronbach's alpha values calculated for Parts D and E were 0.99 and 0.89, therefore, the scores for all statements were averaged to represent the constructs, D = 'Attitude', and E = 'Practice'.

The normality of the data was assessed with Shapiro-Wilk tests using 'shapiro_test' from the 'rstatix' package [41]; 'Knowledge' ($W(403) = 0.77$, p-value<0.001), 'Attitude' ($W(403) = 0.67$, p-value<0.001) and 'Practice' ($W(403) = 0.57$, p-value<0.001) were not normally distributed. Linear regression analysis [6,9,33,34,39,42,43] was conducted using 'lm' to identify significant explanatory variables for response variables. The explanatory variables were 'Gender', 'Age', 'Years Working in Malaysia', 'Education', 'Occupation' and 'Understanding of Food Safety Information from Social Media', whereas the response variables were food safety 'Knowledge', 'Attitude' and 'Practice'. A global model was first constructed for each response variable with all explanatory variables and 'dredge' from 'MuMIn' package was used to extract the best models from the global model [44]. The predicted residual error sum of squares (PRESS) was determined using 'PRESS' from the 'qPCR' package [45]. Selection of the final model was based on the

Table 1
Socio-demographic profile of the 403 respondents.

Variable	Nepalese		Indonesian		Filipino		Overall	
	n	%	*n*	%	*n*	%	*n*	%
Sex								
Male	201	96.2	22	23.9	20	19.6	243	60.3
Female	8	3.8	70	76.1	82	80.4	160	39.7
Education								
No formal education	0	0	7	7.6	2	2.0	9	2.2
Primary school	89	42.6	26	28.3	2	2.0	117	29.0
High school	111	53.1	58	63.0	44	43.1	213	52.9
University	9	4.3	1	1.1	54	52.9	64	15.9
Age								
<20	0	0	6	6.5	0	0	6	1.5
20 – 29	38	18.2	44	47.8	4	3.9	86	21.3
30 – 39	146	69.9	25	27.2	40	39.2	211	52.3
40 – 49	25	12.0	14	15.2	41	40.2	80	19.9
>49	0	0	3	3.3	17	16.7	20	5.0
Occupation								
Construction	6	2.9	4	4.3	5	4.9	15	3.7
Domestic helpers	0	0	14	15.2	74	72.5	88	21.8
Manufacturing	42	20.1	0	0	10	9.8	52	12.9
Plantation	3	1.4	2	2.2	0	0	5	1.2
Services[a]	158	75.6	72	78.3	13	12.7	243	60.3
Years Working in Malaysia								
<10	208	99.5	81	88.0	66	64.7	355	88.1
10 – 20	0	0	8	8.7	23	22.5	31	7.7
>20	1	0.5	3	3.3	13	12.7	17	4.2

[a] Includes retail workers, restaurant staff and pump attendants.

lowest delta AIC, highest AIC weight [46], highest adjusted R^2 [47,48] and the lowest PRESS statistic [49]. The selected models were also supported by the stepwise regression procedure, performed using 'stepAIC' with the stepwise selection technique (direction = 'both') from the 'MASS' package [48,50]. The variation inflation factor (VIF) was determined using the manually created function '1/(1-summary (*model*) $r.squared)' to assess multicollinearity between model variables [51]. 'ggplot ' from the 'ggplot2' package was used to visualise the data [52].

The final linear regressions models were then used to create an overarching model via PSEM [31,37,39,53], using 'psem ' from the 'piecewiseSEM' package [54]. Based on the linear regression modelling results, 'Knowledge', 'Attitude' and 'Practice' were considered to be correlated rather than directly causally associated, and therefore were indicated as correlated errors in the PSEM. Note that tests of directed separation ($p > 0.05$) indicated all of the variables were independent of one another whereas Fisher's C test ($p > 0.05$) confirmed that all potential paths were included in the model; this criteria was used to select the final model [54]. The comparative fit index (CFI), Tucker–Lewis index (TLI) and standardized root mean square residual (SRMR) were obtained to assess whether the PSEM fit the data well [29,31,39,55,56], using 'fitMeasures ' from the 'lavaan' package [57].

For post-hoc analyses, Wilcoxon rank-sum tests were conducted for explanatory variables with binary data using 'wilcox.test '. Kruskall-Wallis and Dunn's tests were conducted for variables with non-binary data, using 'kruskal.test ' and 'dunn_test ' from the 'rstatix' package [41]. Kruskall-Wallis and Dunn's tests indicated significant differences between 'Knowledge', 'Attitude' and 'Practice' among nationalities. To determine any association between nationalities and other socio-demographic variables, multinomial regression [27] was performed, using 'multinom' from the 'nnet' package [50]. Chi-square tests were also performed to assess any significant correlation between nationality and other socio-demographic variables using the 'chisq.test ' function.

3. Results

3.1. Socio-demographic profiles

Of the 403 respondents, the respondents were mostly Nepalese, followed by Filipino and Indonesian. The majority were male, working in

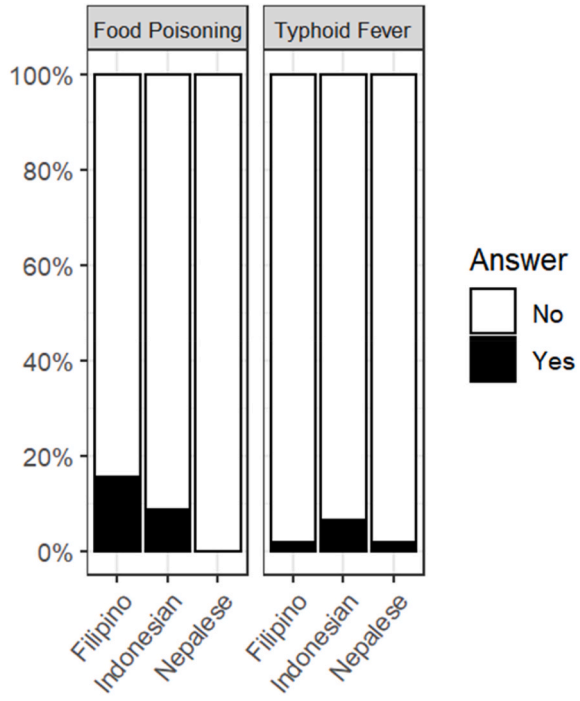

Fig. 1. Self-reported illness history of the 403 respondents by nationality.

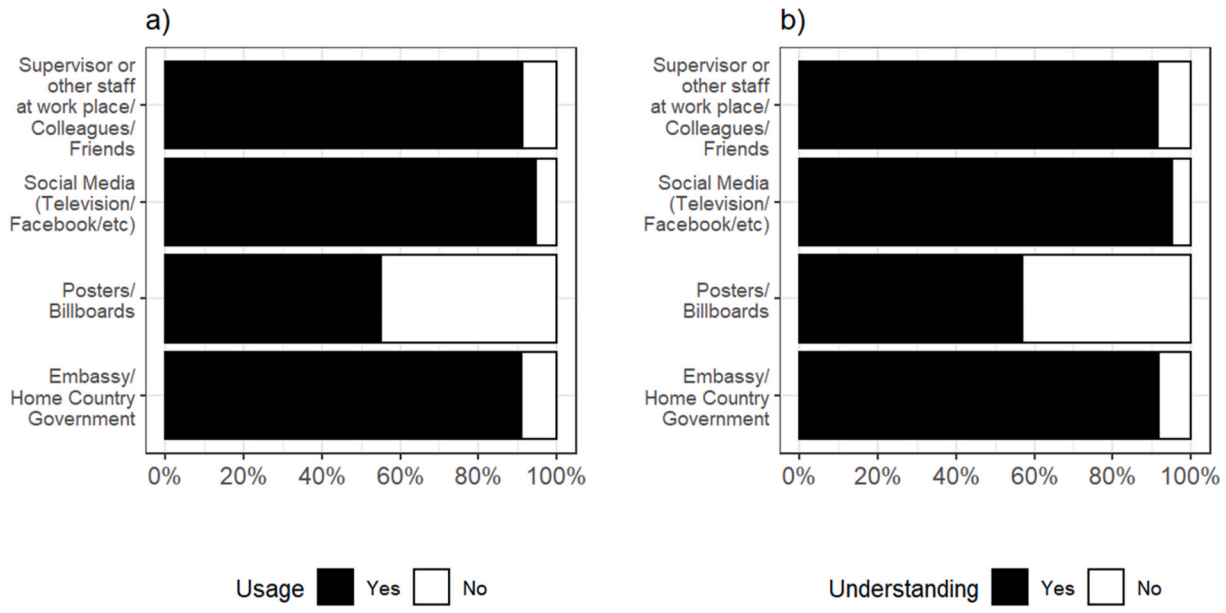

Fig. 2. Food Safety Information and Understanding from Different Sources. a) Percentage of the 403 respondents who obtained food safety information from these sources. b) Percentage of the 403 respondents who understood food safety information from these sources.

the services industry, had completed high school, aged between 30 and 39 years and had worked in Malaysia for less than ten years (Table 1). Of the 403 respondents, only 3.0% stated that they had previously suffered from typhoid fever and 6.0% from food poisoning (Fig. 1). Of those who had suffered from typhoid fever, 50.0% were Indonesian whilst 66.7% of those who had suffered from food poisoning were Filipino. Respondents mostly obtained food safety information from social media (94.8%) and least from posters/billboards (55.1%) (Fig. 2a). Similarly, 95.3% of respondents understood food safety information from social media, and 57.1% from posters/billboards (Fig. 2b).

3.2. Food safety KAP

The level of food safety knowledge amongst migrant workers was generally high, with an average percentage score of 81.6 ± 1.2 (Fig. 3a). Nearly all respondents correctly answered the statement '*food contaminated by house flies can cause food poisoning*' (90.3%). The least correctly answered statement was '*taking the vaccine can prevent typhoid infections*' (29.8%). Respondents mostly showed positive attitudes towards food safety, with an average percentage score of 81.1 ± 1.4 (Fig. 3b). The statement with the highest combined agreement rate was '*Clean restaurants are very important to prevent food poisoning*' (81.6%), whereas the statement with the lowest agreement rate was '*Food handlers can be a source of food poisoning*' (73.4%). Respondents frequently exercised appropriate food safety practices, with an average percentage score of 90.4 ± 0.9 (Fig. 3c). Nearly all respondents usually '*washed their hands and cut their fingernails*' (93.1%). However, only 69.5% of the respondents usually '*saw, smelled and tasted a little bit of food before eating it*', indicating the least exercised practice.

3.3. Identifying explanatory variables for KAP

The final PSEM model (i) based on the results of linear regression modelling (Table 2, Table A1 and Fig. 4), (ii) with lowest AIC value (38.107), (iii) p-value>0.05 for all directed separation tests and Fisher's C test (C (12) = 14.107, p = 0.881), and (iv) fitted the data well in post-hoc assessments (Table A2) was retained and visualised (Fig. 5). 'Knowledge' and 'Practices' (p-value<0.001; Fig. 4a), as well as 'Knowledge' and 'Attitude' (p-value<0.001; Fig. 4b) had positive association. 'Knowledge' was positively associated with 'Age' (p-value<0.001; Fig. 4e), with respondents aged <20 years having lower knowledge than those aged 30–39 (Dunn's test p-value = 0.002), 40–49 (Dunn's test p-value = 0.047), and >49 (Dunn's test p-value = 0.015). Those aged 30–39 had higher knowledge than those aged 20–29 (Dunn's test p-value<0.001) and 40–49 (Dunn's test p-value = 0.002). 'Knowledge' was associated with 'Understanding of Food Safety Information from Social Media' (p = 0.005; Fig. 4f), with respondents who understood food safety information from social media having higher knowledge. 'Knowledge' was associated with 'Gender' (p-value<0.001; Fig. 5d), with female respondents having lower knowledge. 'Attitude' was negatively associated with 'gender' (p < 0.001; Fig. 5h). 'Practice' was positively associated with 'Understanding of Food Safety Information from Social Media' (p < 0.002; Fig. 5i), with respondents who understood food safety information from social media exercised food safety practices more frequently. 'Gender' was associated with 'Education' (X^2 (3) = 50.16, p-value<0.001), with more male respondents having completed primary (37.0%) and high (55.0%) schools than female respondents (16.9% and 49.4%).

3.4. Comparison across nationalities

'Knowledge' (H (2) = 153.50, p-value<0.001), 'Attitude' (H (2) = 266.03, p-value<0.001) and ''Practice' (H (2) = 8.96, p-value<0.011) differed significantly across nationalities. Nepalese respondents demonstrated higher levels of knowledge than Indonesian (Dunn's Test p-value<0.001), and Filipino respondents (Dunn's Test p-value<0.001; Fig. 6a). Indonesian respondents showed higher levels of knowledge than Filipino respondents (Dunn's Test p-value<0.001; Fig. 6a). Nepalese respondents showed higher levels of attitudes than Indonesian (Dunn's Test p-value<0.001; Fig. 6b) and Filipino respondents (Dunn's Test p-value<0.001; Fig. 6b). Nepalese respondents demonstrated higher levels of practices than Indonesian respondents only (Dunn's Test p-value<0.016; Fig. 6c).

The final multinomial regression model with the lowest AIC value (246.234), lowest delta AIC (0.000) and highest AIC weight (0.360) revealed which cohort to target for further food safety awareness (Table 3). Occupation-wise, most Filipino respondents worked as domestic helpers whereas most Indonesian and Nepalese respondents worked in the service industries (X^2 (8) = 242.77, p-value<0.001). When compared to Nepalese respondents (also see Table 1).

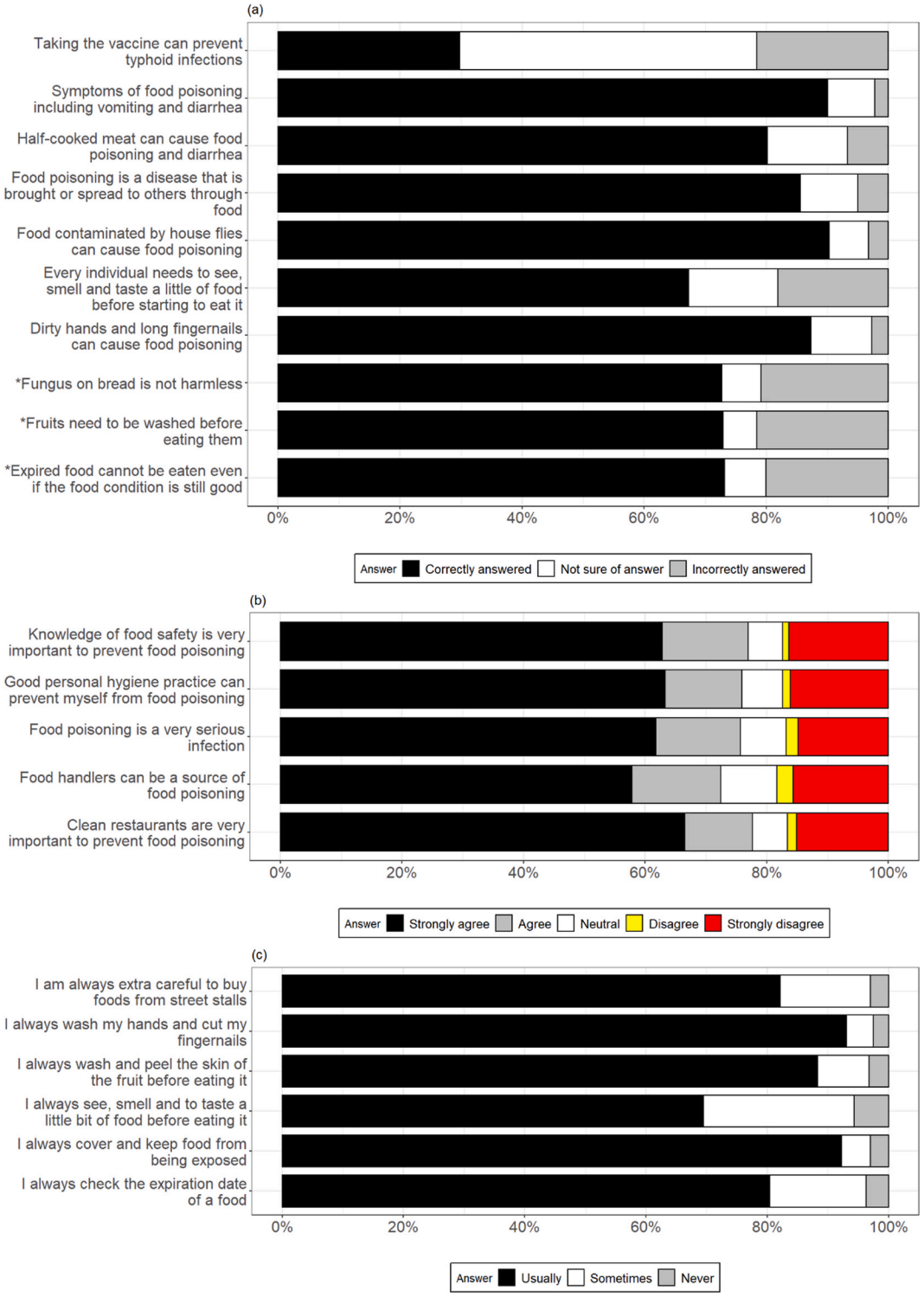

Fig. 3. Responses from 403 Respondents for the Food Safety KAP Statements. a) Knowledge of Food Safety. b) Attitudes Towards Food Safety. c) Practices in Food Safety. *These statements were originally negative but were reversely scored here and for the Linear Regression Modelling.

Table 2
Final Linear Regression Models. Three models were developed with the response variables 'Knowledge' 'Attitude' and 'Practice', respectively. Selection of the final model was based on the highest adjusted R2, lowest delta AIC, highest AIC weight, and the lowest PRESS statistic. Delta AIC of <2 signifies that there is substantial supporting evidence for the candidate model, whereas AIC weights reflect the probability of a model being the best amongst all other possible models [46]. The adjusted R^2 value reflects the goodness of fit of the model and charges a penalty for increasing the number of predictors in a model [47,48]. The PRESS statistic measures the predictive ability of a model, with the lowest value signifying the best model [49]. The selected models were also supported by the stepwise regression procedure with the stepwise selection technique. Predictors were added sequentially, ensuring that each predictor met the preselected significance level (p-value<0.05) until all predictors in the model met this criterion and all those outside did not [48].

Response Variable	Explanatory Variable	Estimate	Standard Error	P-Value
Knowledge[a]	Intercept	0.153	0.077	0.048
	Attitude[b]	0.064	0.007	<0.001
	Practice[c]	0.171	0.024	<0.001
	Age[d]	0.049	0.011	<0.001
	Gender[e]	− 0.092	0.022	<0.001
	Understand.Social. Media[f]	0.080	0.044	0.068
Attitude[b]	Intercept	4.209	0.423	<0.001
	Knowledge[a]	2.618	0.285	<0.001
	Practice[c]	− 0.311	0.164	0.059
	Education[g]	− 0.187	0.084	0.027
	Gender[e]	− 0.861	0.131	<0.001
Practice[c]	Intercept	1.291	0.095	<0.001
	Attitude[b]	− 0.035	0.014	0.014
	Knowledge[a]	0.624	0.089	<0.001
	Understand.Social. Media[f]	0.157	0.084	0.063

[a] Knowledge of Food Safety of Respondents.
[b] Attitudes Towards Food Safety of Respondents.
[c] Practices in Food Safety of Respondents.
[d] Age Group of Respondents (Years).
[e] Gender of Respondents.
[f] Understanding Food Safety Information from Social Media.
[g] Education Level of Respondents.

(i) female respondents were mostly Indonesian or Filipino (X^2 (2) = 233.78, p-value<0.001),
(ii) Indonesian respondents were younger whilst Filipino respondents were older (X^2 (8) = 160.62, p-value<0.001),
(iii) Filipino and Indonesian respondents have worked in Malaysia for a longer time (X^2 (4) = 79.61, p-value<0.001), and
(iv) Indonesians received lower levels of education whilst Filipinos received higher levels of education (X^2 (6) = 177.75, p-value<0.001).

4. Discussion

4.1. Food safety KAP

The food safety knowledge score here (81.6%) is similar to other studies in Malaysia [9,35,58]. However, lower knowledge scores have been reported by studies involving food handlers in Bangladesh (59.7%) [6], Ireland (73%) [59], Brazil (64%) [60], Turkey (43.4%) [61] and migrant workers in Malaysia [27]. The higher knowledge score obtained here can be attributed to the straightforward nature of the questionnaire, which excluded questions that require extensive knowledge of food safety, such as foodborne pathogens, food storage, preparation and handling methods, as seen in the aforementioned studies. Only 29.8% of our respondents correctly identified the statement '*taking the vaccine can prevent typhoid infections*' to be true, similar to past studies that have reported poor health literacy among migrant workers [23–26]. Thus, it is essential to ensure that migrant workers are well-aware of FBD vaccines to prevent FBD transmission.

Here, respondents generally have positive attitudes towards food safety (81.1%), similar to other studies in Malaysia [9,35,62]. On the other hand, university students in Kuala Lumpur obtained a lower mean attitude score (69.5%) [58]. This discrepancy is likely because [58] assessed subjective topics (e.g., pesticides, genetically-modified food) whereas the current study used more appropriate and comprehensive statements related to food poisoning.

Respondents obtained an excellent average score for food safety practices (90.4%). In contrast, other studies in Malaysia reported lower scores for local and foreign food handlers (79.5%) [9], Malay food handlers (77.04%) [35] and university students (77.3%) [58]. Interestingly [9], also observed a higher practice score amongst non-Malaysians (83.7%) as compared to locals (77.7%). This is likely due to their stricter adherence and compliance to existing governmental regulations, to ensure that their legal rights to work in the country are not revoked [9]. However, the 'self-reported' practices here may not reflect their actual practices; thus, monitoring their daily routine would provide a more accurate score [29]. Furthermore, the use of multiple-choice questions may have resulted in the over/-underestimation of the respondents' food safety KAP, due to limited availability of responses, use of absolute terms and coincidentally correct answers [63].

4.2. Relationship between KAP

Here, knowledge of food safety and attitudes towards food safety are correlated, similar to studies from Malaysia [9,35,37,64,65], Bangladesh [6], Turkey [31], Vietnam [30] and across Africa and Asia [66]. Thus, possessing knowledge of food safety could lead to improved attitudes towards food safety, indirectly leading to behavioural change. Despite obtaining high scores for food safety knowledge especially regarding possible causes of FBD (Fig. 3a), only 73.4% of respondents agreed or strongly agreed with the attitude statement that '*food handlers can be a source of food poisoning*'. This may be due to personal bias, as 60.3% of respondents worked in the service industries and likely did not consider themselves as potential threats to public health. Globally, 70% of all FBD are linked to food service establishments and more than 50% of all food poisoning incidents in Malaysia result from unhygienic food handling procedures [3,5,6]. Thus, it is vital to ensure that respondents understand the potential role of food handlers in FBD transmission, so that they can take appropriate precautionary measures.

4.3. Relationship between knowledge and practices

Knowledge of, and practices in, food safety were correlated here, similar to other studies [28,30,35,66]. Of our respondents, 87.3% correctly identified the statement '*Dirty hands and long fingernails can cause food poisoning*', and subsequently, 93.1% stated that they usually '*washed their hands and cut their fingernails*'. This is congruent with [9] who reported that 98.8% of their respondents washed their hands before handling food, while [27] reported that 94.3% did not keep '*long and coloured nails*'. However, a study reported a high score of 85.6% for the statement '*To determine the safety of food, you should taste/smell/check the expiry date before you eat*' [27]. Whereas, only 67.2% of our respondents correctly identified the knowledge statement '*every individual needs to see, smell and taste a little of food before starting to eat it*' as true, and only 69.5% stated that they usually '*saw, smelled and tasted a little bit of food before eating it*'. Our lower scores may be because our statements did not mention expiry dates, thus our statements are subjected to personal preferences. Of our respondents, 80.4% usually '*checked the expiration date of a food*', similar to figure (84.0%) reported by Ref. [58]. In contrast, only 73.2% correctly identified the statement '*Expired food can still be eaten if the food condition is still good*' as false. Despite being aware of the consequences of consuming expired food, it is likely that our respondents may continue to do so to save money, as past studies have

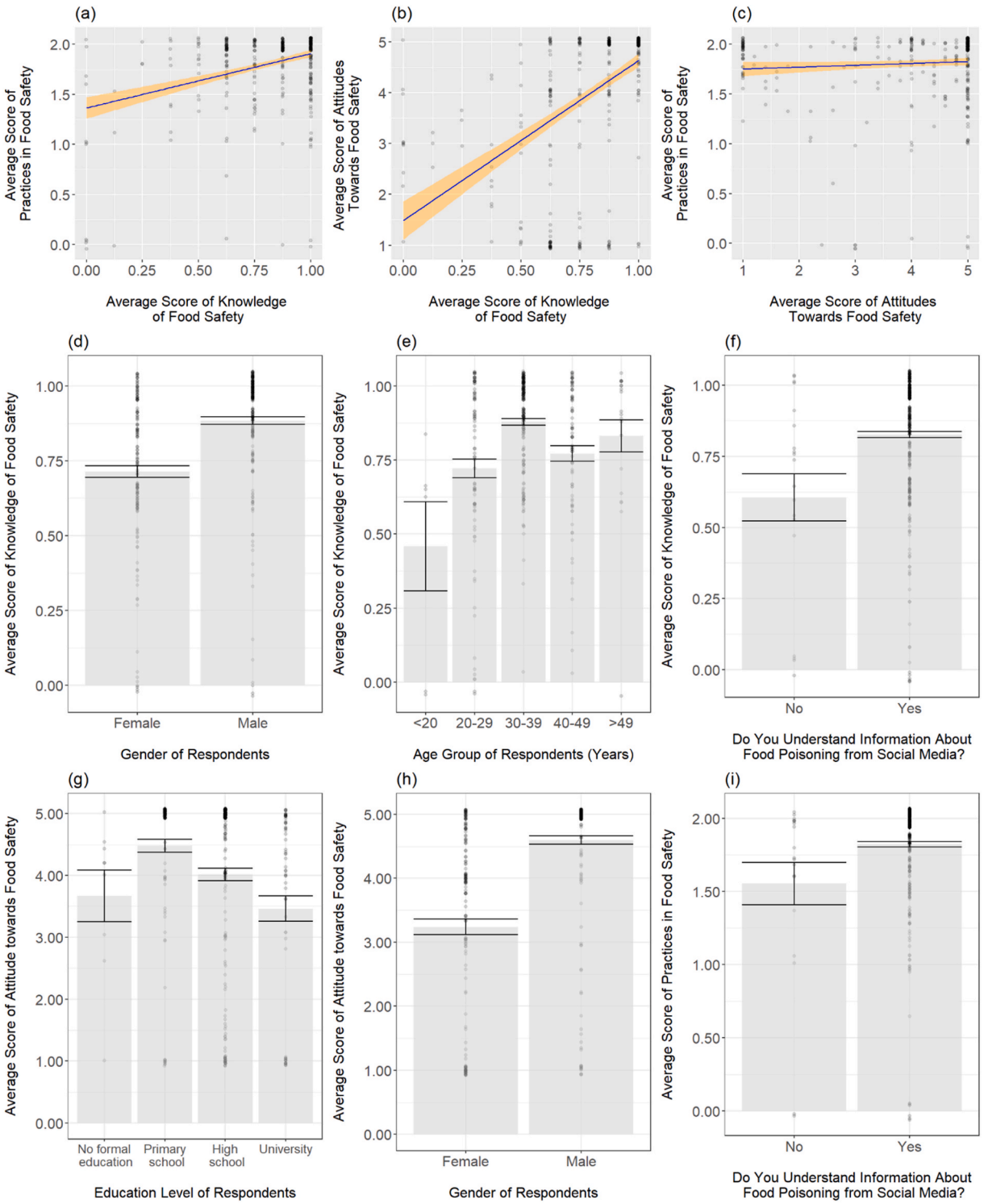

Fig. 4. Descriptive Analyses Based on the Three Linear Regression Models Constructed from 403 Responses. (a) 'Practice' plotted against 'Knowledge', (b) 'Attitude' plotted against 'Knowledge', (c) 'Practice plotted against 'Attitude', (d) 'Knowledge' plotted against 'Gender', (e) 'Knowledge' plotted against 'Age', (f) 'Knowledge' plotted against 'Understanding Food Safety Information from Social Media', (g) 'Attitude' plotted against 'Education', (h) 'Attitude' plotted against 'Gender', (i) 'Practice' plotted against 'Understanding Food Safety Information from Social Media'. Line of best fit (blue) with 90% confidence interval (orange) was plotted for (a), (b) and (c). Responses were superimposed on predicted group mean (grey) and standard error of means (blue bar) for (d), (e), (f), (g), (h) and (i).

revealed that low-income households generate less food waste than high-income households [67–69]. This indicated that food safety knowledge does not always translate into food safety practices among migrant workers [9,32,70], which may be attributed to food insecurity, inadequate facilities at workplace (e.g., limited towels, shared workstations, lack of first aid) and limited proficiency in the language used by food safety awareness campaigns [5,9]. Overall, this implies that employers and the government should provide incentives (e.g., leftover food for takeaway, personal towels and uniforms) and intervention (e.g., educational material and training in particular languages) to nurture food safety compliant practices.

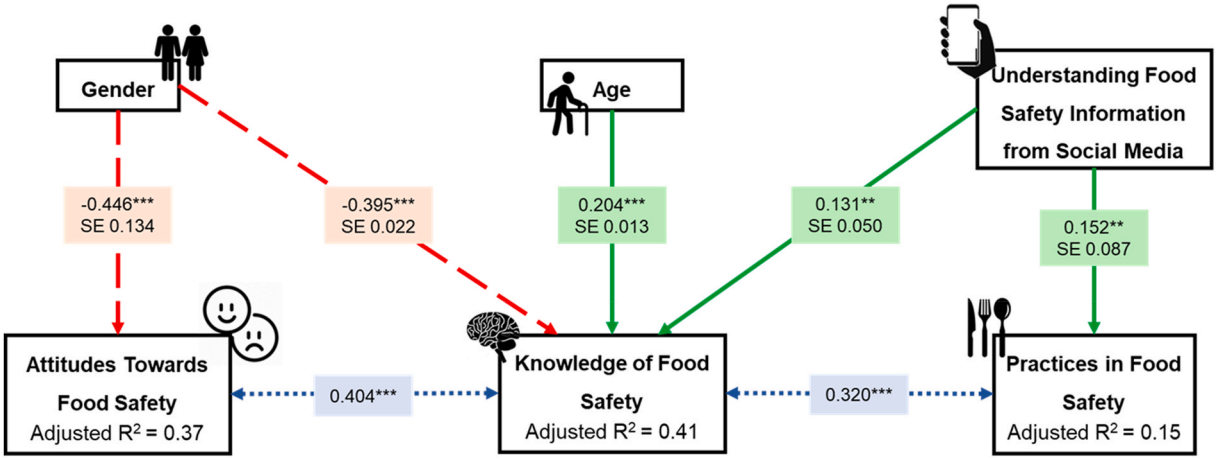

Fig. 5. Piecewise Structural Equation Modelling for Food Safety KAP. Arrowheads indicate the pathway of the relationship, where one variable influenced another. Green arrows with solid lines indicate a positive relationship between the two variables, red arrows with dashed lines indicate a negative relationship between the two variables whereas blue arrows with dotted lines indicate a positive correlation between the two variables. Note that the variables with binary responses were coded in such: Female/Yes = 1; Male/No = 0. Asterisks represent the significance levels of p-values in increasing order: * = $p < 0.05$, ** = $p < 0.01$ and *** = $p < 0.001$. SE indicates standard error. The adjusted R^2 value indicates the goodness of fit of the model, similar to R^2, but it charges a penalty for increasing the number of predictors in a model [47,48].

4.4. Targeted groups for training based on socio-demographic analyses

Here, the lowest scores were obtained by respondents <30 years of age and the highest scores by those aged >30, similar to other studies [9,34,71–73]. These findings highlighted the need to target younger individuals for increased food safety education, especially since they are the most active working members of society and thus, pose a greater risk of transmitting diseases to others.

Male respondents showed higher levels of food safety knowledge and positive attitudes than female respondents, similar to findings by Refs. [6,71,74]. Studies have reported positive association between education and food safety KAP [9,27,30,32,35,43,65,70], and gender disparities in education exist in our study. More male respondents had completed primary (37.0%) and high schools (55.0%) compared to female respondents (16.9% and 49.4%), which may have contributed to the greater food safety knowledge among the former. Hence, this study highlighted the need to provide further education and training of FBD to female migrant workers.

Nepalese respondents demonstrated higher levels of food safety knowledge and attitudes than Indonesian and Filipino respondents. However, Nepalese respondents underwent a phone interview to complete the questionnaire, where a coordinator was available to clarify their thoughts. This may also have contributed to gendered differences in education, as most Nepalese respondents (96.2%) were male and received higher levels of education, whereas most Indonesian (76.1%) and Filipino (80.4%) respondents were female and received lower levels of education. In addition, among respondents affected by typhoid fever and food poisoning, most were Indonesian and Filipino, respectively. Most of our Filipino respondents worked as domestic helpers whereas most Indonesian respondents worked in the services industry. Thus, it is essential to raise food safety awareness among Filipino and Indonesian migrant workers so that they can minimize FBD transmission through their food-handling occupations.

Attendance of food safety training programs can increase the food

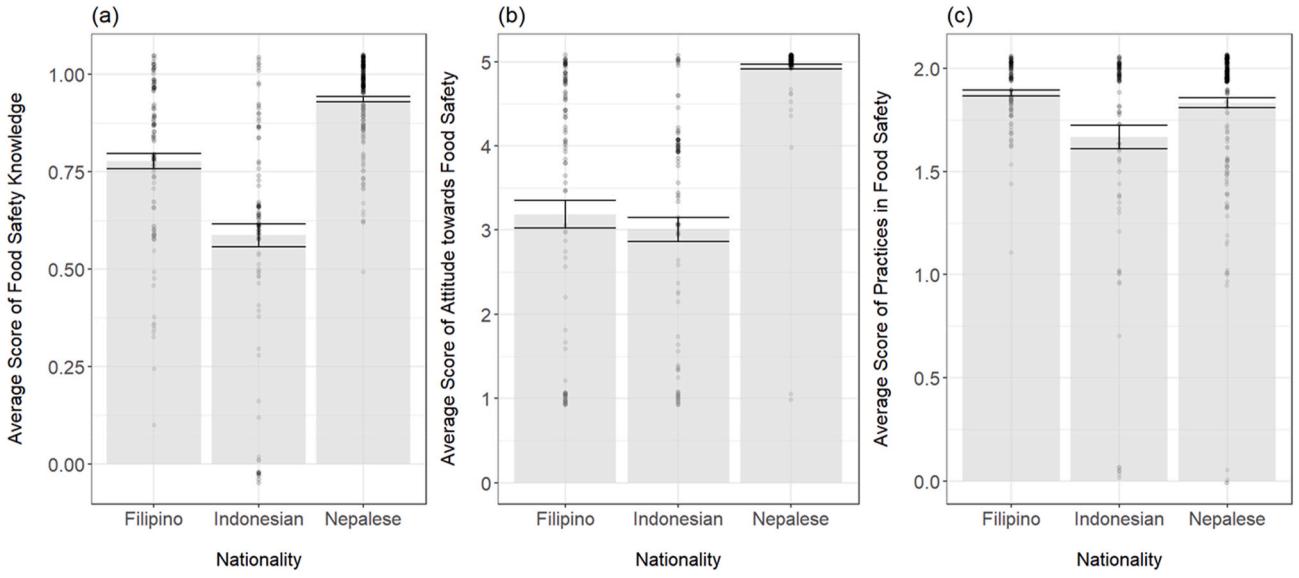

Fig. 6. Comparison of Averaged Food Safety KAP Across Nationalities Based on 403 Respondents. (a) 'Knowledge' plotted against Nationality, (b) 'Attitude' plotted against Nationality, (c) 'Practice' plotted against Nationality.

Table 3
Multinomial Regression Model for Nationality. Selection of the final model was based on the lowest AIC value, lowest delta AIC and highest AIC weight. 'Nepalese' was set as the base/reference category as Nepalese respondents had significantly higher levels of 'Knowledge' and 'Attitude', based on Dunn's test and descriptive analyses.

Explanatory Variable	Indonesian		Filipino	
	Coefficient	Standard Error	Coefficient	Standard Error
Intercept	6.169	2.868	−2.941	3.259
Knowledge	−5.444	1.930	−2.446	2.006
Attitude	−1.554	0.427	−1.587	0.425
Gender (Base = Male)	4.745	0.753	2.145	0.785
Education	−0.131	0.484	1.832	0.484
Age	−0.849	0.505	0.566	0.468
Occupation				
Domestic helpers	7.657	84.303	10.909	84.303
Manufacturing	−20.482	9.748×10^{-6}	−1.025	1.035
Plantation	−1.032	1.735	−13.689	5.800×10^{-4}
Services	−1.706	1.035	−1.776	0.943
Years Working in Malaysia	2.032	0.834	2.003	0.882

safety knowledge of individuals to ensure safe food handling practices and meet hygiene standards [9,27,75,76]. Therefore, the MoH should develop a food safety training program targeting the youth, women, Indonesian and Filipino migrant workers to increase awareness of food safety and inculcate safer food handling practices.

4.5. Social media as a tool for food safety awareness

Our study ascertained that 95% of our respondents used social media to get information on food poisoning, and that the respondents' understanding of food safety information from social media positively influenced their knowledge of, and practices in, food safety, congruent to Refs. [77,78]. These consequently highlighted the potential of social media to raise food safety awareness and relay information. The benefits of social media include wider public outreach, engagement with audiences (e.g., commenting, reposting), provision of timely information, targeting specific cohorts and low cost [79]. Another study investigating the use of social media in disseminating food safety news amongst Malaysian consumers found that 62% of respondents agreed or strongly agreed that the use of social media can aid in preventing food poisoning through food reviews [80]. Thus, social media is ideal for creating a tailored, targeted awareness campaign for specific members of society. Platforms such as TikTok (www.tiktok.com) and Instagram (www.instagram.com) would be suitable as they allow dissemination of information in creative ways, through infographics, videos and reels which can attract youth and women.

In Malaysia, the MoH has verified accounts on Twitter (www.twitter.com/kkmputrajaya), Instagram (www.instagram.com/kementerian kesihatanmalaysia/) and Facebook (www.facebook.com/kementerian kesihatanmalaysia/). The MoH frequently posts colourful, educational infographics and animated clips on health-related topics. During the COVID-19 pandemic, the MoH used social media prominently for public service announcements, including health precautions, updates on travel requirements and vaccine availability. However, most of the content on the MoH's social media accounts is in Malay language, hindering migrant workers from benefiting from it. Therefore, the MoH could work with the respective embassies of migrant workers to create targeted food safety awareness campaigns in particular native languages.

Drawbacks of using social media include information overload and the inability of users to identify credible information [79,80]. Therefore, health authorities should assure social media users of the credibility of their information by providing reliable references or sources (e.g., scientific articles with clickable links) in their educational material. Another study observed that the highest food safety KAP scores were obtained by participants who underwent a combination of Facebook and lecture intervention as compared to Facebook alone [77]. Thus, social media must be used as a complement to traditional methods (e.g., physical posters and lectures, local radio), rather than a replacement. Moreover, knowledge scores often attenuates post-intervention, as seen in trained food handlers [75] and high schoolers [76], suggesting the need for long-term intervention strategies such as posting on social media continuously to allow positive feedback loop between knowledge, attitudes and practices.

5. Conclusion and future work

Generally, migrant workers across different occupational sectors in Klang Valley, Malaysia showed high levels of knowledge of, attitudes towards, and practices in, food safety. Our results revealed that improving food safety knowledge through training programs and social media awareness campaigns can foster hygienic food handling practices among migrant workers. To assess the effectiveness of social media in raising food safety awareness, pre- and post-evaluations should be conducted to observe any improvement in food safety KAP scores. Our study also revealed that female, younger, Indonesian and Filipino migrant workers should be targeted for food safety interventions. Future work should involve migrant workers of other nationalities commonly found in Malaysia, such as Bangladeshi, Indian and Burmese [13]. Overall, these findings can aid respective embassies and the Malaysian government in developing targeted food safety interventions for migrant workers as a means to minimize FBD transmission to the public and to protect their own health.

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CRediT authorship contribution statement

Maryam Nazir Chaudhary: Formal analysis, Methodology, Data curation, Validation, Visualization, Writing - Original Draft. **Voon-Ching Lim:** Supervision, Formal analysis, Methodology, Validation, Writing - original draft. **Norhidayu Sahimin:** Conceptualization, Project administration, Methodology, Investigation, Resources, Validation, Writing - review & editing, Funding acquisition. **Erwin Martinez Faller:** Validation, Writing - review & editing. **Pramod Regmi:** Validation, Writing - review & editing. **Nirmal Aryal:** Validation, Writing - review & editing. **Adzzie Shazleen Azman:** Conceptualization, Supervision, Methodology, Investigation, Resources, Validation, Writing - original draft, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.tmaid.2023.102620.

Appendix

1). Additional Statistical Methodology Details

Selection of the final linear regression model for PSEM was based on the highest adjusted R^2, lowest delta AIC, highest AIC weight, and the lowest PRESS statistic. Delta AIC of <2 signifies that there is substantial supporting evidence for the candidate model, whereas AIC weights reflect the probability of a model being the best amongst all other possible models [46]. The adjusted R^2 value reflects the goodness of fit of the model and charges a penalty for increasing the number of predictors in a model [47,48]. The PRESS statistic measures the predictive ability of a model, with the lowest value signifying the best model [49]. The selected models were also supported by the stepwise regression procedure with the stepwise selection technique. Predictors were added sequentially, ensuring that each predictor met the preselected significance level (p-value<0.05) until all predictors in the model met this criterion and all those outside did not [48]. All models had a VIF <5, indicating the absence of any multicollinearity [51].

To assess whether the PSEM fit the data well, the comparative fit index (CFI), Tucker–Lewis index (TLI) and standardized root mean square residual (SRMR) were obtained. TLI allows for comparisons between the proposed and null model whilst CFI, more specifically, measures the improvement in non-centrality between the two models [57]. SRMR assesses the extent to which the sample variance-covariance data fits the PSEM [57].

2). Additional Results

Table A1
Top Three Regression Models. The final regression models used for piecewise structural equation modelling are highlighted in yellow. Selection of the final model was based on the highest adjusted R^2, lowest delta AIC, highest AIC weight, and the lowest PRESS statistic. The selected models were also supported by the stepwise regression procedure with the stepwise selection technique. All models had a variation inflation factor (VIF) < 5, indicating the absence of any multicollinearity.

Linear Regression Models	Adjusted R^2	Delta AIC	AIC weight	PRESS Statistic	VIF
Response Variable: Knowledge					
Knowledge ~ age + Attitude + Practice + Sex + Understand.Social.Media	0.3929	0.00	0.221	13.52	1.67
Knowledge ~ age + Attitude + Education + Practice + Sex + Understand.Social.Media	0.3926	1.24	0.118	13.57	1.67
Knowledge ~ age + Attitude + Practice + Sex + Occupation + Understand.Social.Media	0.3974	1.30	0.115	13.55	1.70
Response Variable: Attitude					
Attitude ~ Education + Knowledge + Practice + Sex	0.3555	0.00	0.211	544.97	1.57
Attitude ~ Education + Knowledge + Sex	0.3508	1.56	0.097	548.23	1.55
Attitude ~ age + Education + Knowledge + Practice + Sex	0.3539	1.79	0.086	548.28	1.57
Response Variable: Practice					
Practice ~ Attitude + Knowledge + Understand.Social.Media	0.1266	0.00	0.127	50.47	1.15
Practice ~ Attitude + Knowledge + Understand.Social.Media + Education	0.1279	0.46	0.101	50.49	1.15
Practice ~ Attitude + Knowledge + Understand.Social.Media + Sex	0.1260	1.33	0.065	50.59	1.16

Table A2
Post Hoc Analysis of PSEM Model. To assess whether the PSEM fit the data well, the comparative fit index (CFI), Tucker–Lewis index (TLI) and standardized root mean square residual (SRMR) were obtained.

Fit Indices	Model Value	Accepted Value
CFI	1.000	CFI >0.9
TLI	1.022	TLI >0.9
SRMR	0.010	SRMR <0.05

References

[1] World Health Organization. Food safety. https://www.who.int/news-room/fact-sheets/detail/food-safety. [Accessed 5 June 2023].
[2] Jaffee S, Henson S, Unnevehr L, Grace D, Cassou E. The safe food imperative : accelerating progress in low- and middle-income countries. Washington, DC: World Bank; 2019. https://openknowledge.worldbank.org/handle/10986/30568.
[3] Abdul-Mutalib NA, Syafinaz AN, Sakai K, Shirai Y. An overview of foodborne illness and food safety in Malaysia. Int Food Res J 2015;22(3):896–901.
[4] Ministry of Health. Health facts 2021: reference data for 2020. https://www.moh.gov.my/index.php/pages/view/58?mid=19;. [Accessed 29 January 2023].
[5] Soon JM, Singh H, Baines R. Foodborne diseases in Malaysia: a review. Food Control 2011;22(6):823–30. https://doi.org/10.1016/j.foodcont.2010.12.011.
[6] Al Banna MH, Khan MSI, Rezyona H, Seidu A-A, Abid MT, Ara T, et al. Assessment of food safety knowledge, attitudes and practices of food service staff in Bangladeshi hospitals: a cross-sectional study. Nutrients 2022;14(12):2540. https://www.mdpi.com/2072-6643/14/12/2540.

[7] Ministry of Health. Annual report. https://www.moh.gov.my/moh/modules_resources/bookshelf/MOH_Annual_Report_2020_min/index.html#page/1;. [Accessed 29 January 2023].

[8] Ministry of Health. Annual report. https://www.moh.gov.my/moh/resources/Penerbitan/Penerbitan%20Utama/ANNUAL%20REPORT/ANNUAL%20REPORT%202018.pdf. [Accessed 5 June 2023].

[9] Siau AMF, Son R, Mohhiddin O, Toh PS, Chai LC. Food court hygiene assessment and food safety knowledge, attitudes and practices of food handlers in Putrajaya. Int Food Res J 2015;22(5):1843–54. http://www.ifrj.upm.edu.my/22%20(05)%202015/(16).pdf.

[10] Malaysian Employers Federation. Practical guidelines for employers on the recruitment, placement, employment and repatriation of foreign workers in Malaysia. https://www.mef.org.my/Attachments/MEFReport_PGERPERFWM.pdf;. [Accessed 29 January 2023].

[11] Simon J, Kiss N, Łaszewska A, Mayer S. Public health aspects of migrant health: a review of the evidence on health status for labour migrants in the European region. In: WHO health evidence network synthesis reports (43). Copenhagen: WHO Regional Office for Europe; 2015. https://www.ncbi.nlm.nih.gov/books/NBK379432/.

[12] Ministry of Finance. Chapter 3: macroeconomic outlook. Economic outlook 2021. https://www.mof.gov.my/portal/arkib/economy/ec_Main.html. [Accessed 5 June 2023].

[13] Yi S, Simler K, Loh WS, Tan Wei K. Who is keeping score estimating the number of foreign workers in Malaysia (English). Malaysia: World Bank Group; 2020. https://doi.org/10.1596/33730.

[14] Woh PY, Thong KL, Behnke JM, Lewis JW, Mohd Zain SN. Characterization of nontyphoidal Salmonella isolates from asymptomatic migrant food handlers in peninsular Malaysia. J Food Protect 2017;80(8):1378–83. https://doi.org/10.4315/0362-028x.Jfp-16-342.

[15] Woh PY, Thong KL, Lim YAL, Behnke JM, Lewis JW, Mohd ZSN. Microorganisms as an indicator of hygiene status among migrant food handlers in peninsular Malaysia. Asia Pac J Publ Health 2017;29(7):599–607. https://doi.org/10.1177/1010539517735856.

[16] Sahimin N, Douadi B, Yvonne Lim AL, Behnke JM, Mohd Zain SN. Distribution of *Giardia duodenalis* (Assemblages A and B) and *Cryptosporidium parvum* amongst migrant workers in Peninsular Malaysia. Acta Trop 2018;182:178–84. https://doi.org/10.1016/j.actatropica.2018.02.033.

[17] Castro A, Santos C, Meireles H, Silva J, Teixeira P. Food handlers as potential sources of dissemination of virulent strains of *Staphylococcus aureus* in the community. Journal of Infection and Public Health 2016;9(2):153–60. https://doi.org/10.1016/j.jiph.2015.08.001.

[18] Eltai NO, Yassine HM, Al Thani AA, Abu Madi MA, Ismail A, Ibrahim E, et al. Prevalence of antibiotic resistant *Escherichia coli* isolates from fecal samples of food handlers in Qatar. Antimicrob Resist Infect Control 2018;7(1):78. https://doi.org/10.1186/s13756-018-0369-2.

[19] Lambrechts AA, Human IS, Doughari JH, Lues JFR. Bacterial contamination of the hands of food handlers as indicator of hand washing efficacy in some convenient food industries in South Africa. Pakistan J Med Sci 2014;30(4):755–8. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4121692/.

[20] Motazedian MH, Najjari M, Ebrahimipour M, Asgari Q, Mojtabavi S, Mansouri M. Prevalence of intestinal parasites among food-handlers in shiraz, Iran. Iran J Parasitol 2015;10(4):652–7. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4724844/.

[21] Valero A, Ortiz JC, Fongaro G, Hernández M, Rodríguez-Lázaro D. Definition of sampling procedures for collective-eating establishments based on the distribution of environmental microbiological contamination on food handlers, utensils and surfaces. Food Control 2017;77:8–16. https://doi.org/10.1016/j.foodcont.2017.01.013.

[22] Sørensen K, Van den Broucke S, Fullam J, Doyle G, Pelikan J, Slonska Z, et al. Health literacy and public health: a systematic review and integration of definitions and models. BMC Publ Health 2012;12:80. https://doi.org/10.1186/1471-2458-12-80.

[23] Bergman L, Nilsson U, Dahlberg K, Jaensson M, Wångdahl J. Health literacy and e-health literacy among Arabic-speaking migrants in Sweden: a cross-sectional study. BMC Publ Health 2021;21(1):2165. https://doi.org/10.1186/s12889-021-12187-5.

[24] Gilder ME, Moo P, Hashmi A, Norda P, Wai K, Pimanpanarak M, et al. "I can't read and don't understand": health literacy and health messaging about folic acid for neural tube defect prevention in a migrant population on the Myanmar-Thailand border. PLoS One 2019;14(6). https://doi.org/10.1371/journal.pone.0218138.

[25] Kosiyaporn H, Julchoo S, Sinam P, Phaiyarom M, Kunpeuk W, Pudpong N, et al. Health literacy and its related determinants in migrant health workers and migrant health volunteers: a case study of Thailand, 2019. Int J Environ Res Publ Health 2020;17(6):2105. https://doi.org/10.3390/ijerph17062105.

[26] Vianello FA, Zaccagnini F, Pinato C, Maculan P, Buja A. Health status of female Moldovan migrants to Italy by health literacy level and age group: a descriptive study. BMC Publ Health 2020;20. https://doi.org/10.1186/s12889-020-09582-9.

[27] Woh PY, Thong KL, Behnke JM, Lewis JW, Mohd Zain SN. Evaluation of basic knowledge on food safety and food handling practices amongst migrant food handlers in Peninsular Malaysia. Food Control 2016;70:64–73. https://doi.org/10.1016/j.foodcont.2016.05.033.

[28] Ahmed MH, Akbar A, Sadiq MB. Cross sectional study on food safety knowledge, attitudes, and practices of food handlers in Lahore district, Pakistan. Heliyon 2021;7(11):e08420. https://doi.org/10.1016/j.heliyon.2021.e08420.

[29] da Cunha DT, de Rosso VV, Pereira MB, Stedefeldt E. The differences between observed and self-reported food safety practices: a study with food handlers using structural equation modeling. Food Res Int 2019;125:108637. https://doi.org/10.1016/j.foodres.2019.108637.

[30] Vo TH, Le NH, Le ATN, Tran Minh NN, Nuorti JP. Knowledge, attitudes, practices and training needs of food-handlers in large canteens in Southern Vietnam. Food Control 2015;57:190–4. https://doi.org/10.1016/j.foodcont.2015.03.042.

[31] Baser F, Ture H, Abubakirova A, Sanlier N, Cil B. Structural modeling of the relationship among food safety knowledge, attitude and behavior of hotel staff in Turkey. Food Control 2017;73:438–44. https://doi.org/10.1016/j.foodcont.2016.08.032.

[32] Angelillo IF, Viggiani NMA, Rizzo L, Bianco A. Food handlers and foodborne diseases: knowledge, attitudes, and reported behavior in Italy. J Food Protect 2000;63(3):381–5. https://doi.org/10.4315/0362-028x-63.3.381.

[33] da Vitória AG, de Souza Couto Oliveira J, de Almeida Pereira LC, de Faria CP, de São José JFB. Food safety knowledge, attitudes and practices of food handlers: a cross-sectional study in school kitchens in Espírito Santo, Brazil. BMC Publ Health 2021;21(1):349. https://doi.org/10.1186/s12889-021-10282-1.

[34] Rossvoll EH, Lavik R, Ueland Ø, Jacobsen E, Hagtvedt T, Langsrud S. Food safety practices among Norwegian consumers. J Food Protect 2013;76(11):1939–47. https://doi.org/10.4315/0362-028x.Jfp-12-269.

[35] Abdul-Mutalib N-A, Abdul-Rashid M-F, Mustafa S, Amin-Nordin S, Hamat RA, Osman M. Knowledge, attitude and practices regarding food hygiene and sanitation of food handlers in Kuala Pilah, Malaysia. Food Control 2012;27(2):289–93. https://doi.org/10.1016/j.foodcont.2012.04.001.

[36] Ali AN, William AF, Prajapati SK, Ahmed NZ. A KAP study on food safety and hygiene among private university students in kedah state, Malaysia. J Nat Remedies 2018;18(3). https://doi.org/10.18311/jnr/2018/22289.

[37] Ruby GE, Ungku Zainal Abidin UF, Lihan S, Jambari NN, Radu S. Predicting intention on safe food handling among adult consumers: a cross sectional study in Sibu district, Malaysia. Food Control 2019;106:106696. https://doi.org/10.1016/j.foodcont.2019.06.022.

[38] Lim V-C, Sing K-W, Chong KY, Jaturas N, Dong H, Lee P-S, et al. Familiarity with, perceptions of and attitudes toward butterflies of urban park users in megacities across East and Southeast Asia. R Soc Open Sci 2022;9(11):220161. https://doi.org/10.1098/rsos.220161.

[39] R Core Team. A language and environment for statistical computing. In: R foundation for statistical computing; 2022. https://www.R-project.org/;. [Accessed 29 January 2023].

[40] Revelle W. Psych: procedures for psychological, psychometric, and personality Research. R package version 2.2.9. Northwestern University; 2022. https://CRAN.R-project.org/package=psych.

[41] Kassambara A. Rstatix: pipe-friendly framework for basic statistical tests. R package version 0.7.0, https://rpkgs.datanovia.com/rstatix/; 2021.

[42] Lee HY, Chik WNW, Bakar FA, Saari N, Mahyudin NA. Sanitation practices among food handlers in a military food service institution, Malaysia. Food Nutr Sci 2012;3(11):24497. https://doi.org/10.4236/fns.2012.311204.

[43] Madaki YM, Bavorova M. Food safety knowledge of food vendors of higher educational institutions in Bauchi state, Nigeria. Food Control 2019;106:106703. https://doi.org/10.1016/j.foodcont.2019.06.029.

[44] Bartoń K. MuMIn: multi-model inference. R package version 1.47.1, https://CRAN.R-project.org/package=MuMIn; 2022.

[45] Spiess A-N. qpcR: modelling and analysis of real-time PCR data. R package version 1.4-1, https://CRAN.R-project.org/package=qpcR; 2018.

[46] Fabozzi FJ, Focardi SM, Rachev ST, Arshanapalli BG, Hoechstoetter M. Appendix E: model selection criterion: AIC and BIC. In: Fabozzi FJ, Focardi SM, Rachev ST, Arshanapalli BG, Hoechstoetter M, editors. The basics of financial econometrics: tools, concepts, and asset management applications. 1 ed. New York: John Wiley & Sons; 2014. https://doi.org/10.1002/9781118856406.app5. Incorporated.

[47] Jawlik AA r. Multiple R, r^2, R^2, R square, R^2 adjusted. In: Jawlik AA, editor. Statistics from A to Z : confusing concepts clarified. New York: John Wiley & Sons Incorporated; 2016. https://doi.org/10.1002/9781119272021.ch12.

[48] Surez E, Prez CM, Rivera R, Martnez MN. Selection of variables in a multiple linear regression model. In: Surez E, Prez CM, Rivera R, Martnez MN, editors. Applications of regression models in epidemiology. New York: John Wiley & Sons Incorporated; 2017. https://doi.org/10.1002/9781119212515.ch5.

[49] Miller A. Subset selection in regression. second ed. New York: CRC Press LLC; 2002. https://doi.org/10.1201/9781420035933.

[50] Venables WN, Ripley BD. Modern applied statistics with S. fourth ed. New York: Springer; 2002. https://www.stats.ox.ac.uk/pub/MASS4/.

[51] Kacapyr E. A guide to basic econometric techniques. second ed. New York: Routledge; 2014. https://doi.org/10.4324/9781315706856.

[52] Wickham H. ggplot2: elegant graphics for data analysis. Springer-Verlag; 2016. https://ggplot2.tidyverse.org.

[53] Lim T-P, Chye FY, Sulaiman MR, Suki NM, Lee J-S. A structural modeling on food safety knowledge, attitude, and behaviour among Bum Bum Island community of Semporna, Sabah. Food Control 2016;60:241–6. https://doi.org/10.1016/j.foodcont.2015.07.042.

[54] Lefcheck JS. piecewiseSEM: piecewise structural equation modelling in r for ecology, evolution, and systematics. Methods Ecol Evol 2016;7(5):573–9. https://doi.org/10.1111/2041-210X.12512.

[55] Soon JM, Wahab IRA, Hamdan RH, Jamaludin MH. Structural equation modelling of food safety knowledge, attitude and practices among consumers in Malaysia. PLoS One 2020;15(7):e0235870. https://doi.org/10.1371/journal.pone.0235870.

[56] Schumacker RE, Lomax RG, Schumacker R. A beginner's guide to structural equation modeling. fourth ed. London: Taylor and Francis; 2015. https://doi.org/10.4324/9781315749105.

[57] Rosseel Y. {lavaan}: an {R} package for structural equation modeling. J Stat Software 2012;48(2):1–36. https://doi.org/10.18637/jss.v048.i02.
[58] Moy FM, Alias AA, Jani R, Abdul Halim H, Low WY. Determinants of self-reported food safety practices among youths: a cross-sectional online study in Kuala Lumpur, Malaysia. Br Food J 2018;120(4):891–900. https://doi.org/10.1108/BFJ-04-2017-0224. 1966.
[59] Gruenfeldova J, Domijan K, Walsh C. A study of food safety knowledge, practice and training among food handlers in Ireland. Food Control 2019;105:131–40. https://doi.org/10.1016/j.foodcont.2019.05.023.
[60] da Cunha DT, Stedefeldt E, de Rosso VV. The role of theoretical food safety training on Brazilian food handlers' knowledge, attitude and practice. Food Control 2014; 43:167–74. https://doi.org/10.1016/j.foodcont.2014.03.012.
[61] Baş M, Şafak Ersun A, Kıvanç G. The evaluation of food hygiene knowledge, attitudes, and practices of food handlers' in food businesses in Turkey. Food Control 2006;17(4):317–22. https://doi.org/10.1016/j.foodcont.2004.11.006.
[62] Albattat A. Food safety knowledge, attitude and practices among management and science university students, Shah Alam. Management Science Letters 2019;10. https://doi.org/10.5267/j.msl.2019.10.002.
[63] Al-Faris EA, Alorainy IA, Abdel-Hameed AA, Al-Rukban MO. A practical discussion to avoid common pitfalls when constructing multiple choice questions items. J Family Community Med 2010;17(2):96–102. https://doi.org/10.4103/1319-1683.71992.
[64] Ali A, Jie J, Prajapati S, Ahmed N, Iqbal M, Alshammari T. A KAP study on food safety and hygiene among private university students in kedah state, Malaysia. J Nat Remedies 2019;18:113–21. https://doi.org/10.18311/jnr/2018/22289.
[65] Toh PS, Birchenough A. Food safety knowledge and attitudes: culture and environment impact on hawkers in Malaysia.: knowledge and attitudes are key attributes of concern in hawker foodhandling practices and outbreaks of food poisoning and their prevention. Food Control 2000;11(6):447–52. https://doi.org/10.1016/S0956-7135(00)00008-6.
[66] Odeyemi OA, Sani NA, Obadina AO, Saba CKS, Bamidele FA, Abughoush M, et al. Food safety knowledge, attitudes and practices among consumers in developing countries: an international survey. Food Res Int 2019;116:1386–90. https://doi.org/10.1016/j.foodres.2018.10.030.
[67] Stancu V, Haugaard P, Lähteenmäki L. Determinants of consumer food waste behaviour: two routes to food waste. Appetite 2016;96:7–17. https://doi.org/10.1016/j.appet.2015.08.025.
[68] Szabó-Bódi B, Kasza G, Szakos D. Assessment of household food waste in Hungary. Br Food J 2018;120(3):625–38. https://doi.org/10.1108/bfj-04-2017-0255.
[69] Lopez Barrera E, Hertel T. Global food waste across the income spectrum: implications for food prices, production and resource use. Food Pol 2021;98: 101874. https://doi.org/10.1016/j.foodpol.2020.101874.
[70] Akabanda F, Hlortsi EH, Owusu-Kwarteng J. Food safety knowledge, attitudes and practices of institutional food-handlers in Ghana. BMC Publ Health 2017;17(1):40. https://doi.org/10.1186/s12889-016-3986-9.
[71] Courtney SM, Majowicz SE, Dubin JA. Food safety knowledge of undergraduate students at a Canadian university: results of an online survey. BMC Publ Health 2016;16(1):1147. https://doi.org/10.1186/s12889-016-3818-y.
[72] Low WY, Jani R, Halim HA, Alias AA, Moy FM. Determinants of food hygiene knowledge among youths: a cross-sectional online study. Food Control 2016;59: 88–93. https://doi.org/10.1016/j.foodcont.2015.04.032.
[73] Fein SB, Lando AM, Levy AS, Teisl MF, Noblet C. Trends in U.S. Consumers' safe handling and consumption of food and their risk perceptions, 1988 through 2010. J Food Protect 2011;74(9):513–1523. https://doi.org/10.4315/0362-028x.Jfp-11-017.
[74] Amoah PA, Phillips DR. Socio-demographic and behavioral correlates of health literacy: a gender perspective in Ghana. Women Health 2020;60(2):123–39. https://doi.org/10.1080/03630242.2019.1613471.
[75] McIntyre L, Vallaster L, Wilcott L, Henderson SB, Kosatsky T. Evaluation of food safety knowledge, attitudes and self-reported hand washing practices in FOODSAFE trained and untrained food handlers in British Columbia, Canada. Food Control 2013;30(1):150–6. https://doi.org/10.1016/j.foodcont.2012.06.034.
[76] Majowicz SE, Hammond D, Dubin JA, Diplock KJ, Jones-Bitton A, Rebellato S, et al. A longitudinal evaluation of food safety knowledge and attitudes among Ontario high school students following a food handler training program. Food Control 2017;76:108–16. https://doi.org/10.1016/j.foodcont.2017.01.011.
[77] Mayer AB, Harrison JA. Safe eats: an evaluation of the use of social media for food safety education. J Food Protect 2012;75(8):1453–63. https://doi.org/10.4315/0362-028X.11-551.
[78] James KJ, Albrecht JA, Litchfield RE, Weishaar CA. A summative evaluation of a food safety social marketing campaign "4-day throw-away" using traditional and social media. J Food Sci Educ 2013;12(3):48–55. https://doi.org/10.1111/1541-4329.12010.
[79] Overbey KN, Jaykus L-A, Chapman BJ. A systematic review of the use of social media for food safety risk communication. J Food Protect 2017;80(9):1537–49. https://doi.org/10.4315/0362-028X.JFP-16-345.
[80] Soon JM. Consumers' awareness and trust toward food safety news on social media in Malaysia. J Food Protect 2020;83(3):452–9. https://doi.org/10.4315/0362-028X.JFP-19-415.