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Street-vended food safety in Southeast Asia: consumers' strategies to ensure food safety and vendors' hygiene practices

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ABSTRACT

Street-vended foods contribute to food security and livelihood developments in many countries, including Southeast Asia (SEA). However, street-vended food is a major source of foodborne illness in the region. This study aims to investigate Southeast Asian consumers' street-vended food consumption practices, their confidence in street-vended food safety, and their food safety strategies when purchasing or eating street-vended food. It also aims to assess street food vendors' hygiene practices using observations. A mixed-method design was employed, with data collected from a cross-sectional survey on 4096 consumers across seven SEA countries. It is followed by observations of 163 street food vendors using the Rapid Food Hygiene Inspection Tool (RFHiT) in Indonesia, Malaysia, the Philippines, and Thailand. More than 65% would utilise risk mitigating strategies to ensure food safety when purchasing street-vended foods. Participants from Laos, females and those with higher education were less confident in street-vended food safety. Overall, 95 street food vendors were rated as 5.0–6.9 (moderate and some improvement required). Based on the observations from our study, access to potable water is a recurring challenge faced by street food vendors. This study presents the first empirical findings on consumers' food safety strategies when purchasing street-vended food in Southeast Asia.

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Introduction

Street foods are ready-to-eat (RTE) foods and beverages prepared and/or sold by vendors and hawkers in public places, especially in streets (FAO 1989). Approximately, 2.5 million people consume street food daily as they are low cost and conveniently available for many people in developing countries (Salamandane et al. 2023). The Southeast Asia region is the world's third most populous economy, and the population is expected to reach over 720 million people by 2030 (World Economic Forum 2020). Street-vended food remains a major part of Southeast Asian food environments, although the proportion varies by country. In Thailand, street stalls/kiosks accounted for 65% of all foodservice outlets compared to 35% restaurants, cafes, and bars (USDA Foreign Agricultural Service 2024). Meanwhile, Malaysia (22.0%), the Philippines (14.2%), Vietnam (12.2%), and Indonesia (5.4%) showed smaller street food shares based on foodservice sales (Agriculture and Agri-Food Canada 2025). It is evident that street foods contribute to the formal and informal economies and the livelihood of vendors and their supply chain (Turner et al. 2021). Despite the benefits, street-vended foods remain a major source

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of foodborne illnesses in the region (Dewanti-Hariyadi and Gitapratwi 2014). There are more than 150 million foodborne illnesses and over 175,000 fatalities every year in the region. The main causes are due to diarrheal diseases attributed to norovirus, non-typhoidal *Salmonella* and pathogenic *Escherichia coli* (WHO 2019).

Most street-vended food studies in the world focused on street food vendors' knowledge, attitude and practices (Aba et al. 2023; Desye et al. 2023), microbiological and chemical contamination of RTE street-vended foods (Lues et al. 2006; Rakha et al. 2022) and observation studies based on questionnaire (Galiwango et al. 2025). Similarly, most studies of SEA consumers were focused on their general food safety knowledge, attitudes, and practices (Odeyemi et al. 2019) and were centred on single countries only (Kasza et al. 2024). There were studies on observation of street food vendors' hygiene practices using checklists and interviews such as those carried out in Thailand (Trafialek et al. 2018), Indonesia (Utami et al. 2019), the Philippines (Alamo-Tonelada et al. 2018), Malaysia (Jores et al. 2018), and Vietnam (Huynh-Van et al. 2022). Their findings varied depending on countries of observation and types of street food vendors (e.g. fixed stalls or mobile vendors). The observations carried out in the Philippines revealed that street foods were sold in relatively good sanitary conditions and Thailand street food vendors recorded the highest level of conformity in personal hygiene (Alamo-Tonelada et al. 2018; Trafialek et al. 2018). Meanwhile, the findings from Indonesia, Malaysia, and Vietnam revealed poor hygiene and sanitary practices among the observed street food vendors (Jores et al. 2018; Utami et al. 2019; Huynh-Van et al. 2022). Most of these observational studies determined the compliance rate for specific areas using "yes" and "no" observation checklists. It will be beneficial to provide an overall hygiene compliance score or index for the specific street food vendors or region. This overall hygiene compliance score or index would serve as an indicator of the level of cleanliness and hygiene practices of street food vendors. It could potentially be used by public health policymakers or local authorities to establish that vendors met the necessary food hygiene standards. Similarly, such indices could be utilised by consumers to make informed choices when purchasing from street food vendors. For this reason, this study adapted the Rapid Food Hygiene Inspection Tool (RFHiT) to assess the level of hygiene compliance among the street food vendors (Soon 2019). This will enable comparisons of hygiene conformance similar to "Scores on Doors" between countries, types of street food vendors, and/or food categories. Scores on Doors or Food Hygiene Rating Scheme (FHRS) was introduced in England, Wales, and Northern Ireland to provide information about hygiene standards at food outlets. Ratings ranged from 0 to 5, where 0 indicates that urgent improvement is necessary and 5 indicates that hygiene standards are very good (FSA 2026). The hygiene index could be publicly disclosed and provides consumers with "at-a-glance" information about the hygiene standards which might influence their food purchasing decisions (Flanagan and Soon-Sinclair 2025).

To date, there is no comparison study between Southeast Asian countries on consumers' food safety strategies when purchasing street-vended food nor were there any studies predicting consumers' confidence in street-vended food safety. Similarly, there is no regional study that compared the hygiene practices of street food vendors in selected Southeast Asian countries and determined their hygiene compliance indices. Hence, this study aims to investigate Southeast Asian consumers' street-vended food consumption practices, their strategies to ensure the safety of street-vended food, and their confidence in street-vended food safety. It also aims to assess street food vendors' hygiene practices via observations through the Rapid Food Hygiene Inspection Tool (RFHiT).

Methodology

In this study, mixed method was employed with data from an online survey on consumers and observations of street food vendors in some selected Southeast Asian countries. The consumer survey captured data on street food consumption and consumers' food safety strategies while observations gathered data on street vendors' food hygiene practices. The survey was conducted in seven countries including Cambodia, Indonesia, Laos, Malaysia, the Philippines, Thailand, and Vietnam. The selection criteria were countries located in Southeast Asia and with rich street food vending market, but where local authorities may face reduced capacity to monitor and enforce the safety and hygiene level of such informal markets. Observations were carried out in Thailand, Indonesia, the Philippines, and Malaysia. The observations

were limited to these four countries due to the high number of street food vendors (including informal street vendors) (Soon 2019; Leahy et al. 2021), lack of resources, and funding.

Questionnaire development for the online consumer survey

The questionnaire was developed based on CODEX ALIMENTARIUS (2017) and Wiatrowski et al. (2021). Some of the questions on demographics and street-vended food consumption practices were adapted from Adeosun et al. (2022) and Kolanowski et al. (2021). The questionnaire was divided into four sections: (i) Demographics (9 questions); (ii) Street-vended food consumption practices (4 questions); (iii) Food safety strategies adopted by consumers (premises and environment: 8 items and food hygiene practices: 10 items); and (iv) consumers' own observation of street food vendors (9 questions). The questionnaire was pilot tested with 21 respondents who did not take part in the actual study. The pilot-test was based on convenience sampling of participants from Indonesia. The scaled items in Section (iii) Food safety strategies adopted by consumers were subjected to reliability analyses. The final Cronbach's alpha was 0.848 for Premises and Environment and 0.865 for food hygiene practices. The questionnaire was translated into key local languages, reviewed by local food safety experts and back translated into English. The English questionnaire is available in Supplementary Material 1.

All questionnaires were uploaded onto onlinesurveys.ac.uk and pre-tested to ensure accuracy and the interface was suitable for mobile applications. The online questionnaires were distributed widely using social media (e.g. Facebook, Messenger, and Whatsapp) in each country, and snowball sampling approach was utilised to collect responses. The eligibility criteria include 18 years or older and purchase and/or consume street-vended food. Participants who selected the response "Never" in the screening question "How often do you consume street-vended foods?" were thanked for their participation and were not included in the study. The online survey was conducted between February to June 2024.

Observation of street food vendors' food hygiene practices

The observation of food hygiene practices of street food vendors in Thailand, Indonesia, the Philippines, and Malaysia was conducted using the Rapid Food Hygiene Inspection Tool (RFHiT) developed by Soon (2019), Santana et al. (2009) and Trafialek et al. (2017). RFHiT was proposed as it allows rapid and discrete assessment of hygiene compliance among street food vendors. This is due to the high number of street food vendors vs a low number of environmental health officers or inspectors and limited time which remain a challenge in most SEA countries. The tool was also selected due to its ability to reduce Hawthorne effect as the observation could be conducted discretely using a mobile phone (with internet connection) and is rapid. Accordingly, the observations include the following parts: (i) Premises (8 questions); (ii) Preparation area (4 questions); (iii) Food Preparation (5 questions) (iv) Storage (6 questions); (v) Serving (4 questions); and (vi) Hygiene practices (11 questions). We also ensured that the criteria fulfilled the Regional Code of Hygienic Practice for Street-Vended Foods in Asia (CODEX ALIMENTARIUS 2017). The criteria for the definition of each food scoring were based on WHO 5 Keys to Safer Food (WHO 2006). Seven research assistants well versed in food safety topics were trained and validation of their observation were based on the WHO hand hygiene observation method (Sax et al. 2009; Stewardson et al. 2013). The Intra-Class Correlation Coefficient (ICC) between the users in the training measured 0.775, $F(5, 30) = 25.095, p < 0.001$ indicating acceptable inter-rater reliability. The Kaiser–Meyer–Olkin (KMO) measures of sampling value were 0.686. According to Hair et al. (2010), the criterion of validity should be >0.60 and the KMO fulfils the requirement. The observed street food vendors were selected based on the following criteria: they operated on or adjacent to a public street or other public area, used either fixed or mobile stalls/kiosks, sold ready-to-eat foods or beverages or food prepared to order, and were in urban areas. Street-vended food stalls were selected at random (~40 in each country) from the selected cities and their surrounding areas in the four participating countries and were evaluated. Observers were able to remain discrete while carrying out the observation since the stalls were located on a public street or public area. The street food vendors were mostly located in or near city centres such as Bangkok (Thailand), Surabaya (Indonesia), Batac and Laoag City (the Philippines), and Kota Bharu (Malaysia). The observations were only carried out in countries that

volunteered to take part in the observational study. Each observation took on average 15 minutes to complete and was conducted by one observer per street food vendor. The observation was conducted in May–July 2024.

Compliance with food hygiene requirements

The street food vendors' hygiene compliance and conformance indices calculations are shown in Supplementary Material 2.

Statistical analysis

Descriptive statistics were conducted using SPSS version 29.0 (IBM, USA). Stata version 17 with `gologit2` command (Williams 2006) was used to perform generalized ordered logistic regression for predicting Southeast Asian consumers' confidence in street-vended food safety. The question "How confident are you in the safety of street-vended foods?" was used as the dependent variable. Responses were rated on a 5-point Likert scale (1 = Not confident at all, 2 = Not confident, 3 = A little confident, 4 = Quite confident, 5 = Very confident). Main independent variables of our interest include country, frequency of consumption of street-vended food, experience of food poisoning, complaints about street-vended foods, and adoption of any food safety strategies when purchasing or consuming street-vended food. Demographic characteristics including gender, age, education level, employment, residence, living situation, and distance of nearest street-vended food from home were used as control variables.

The choice of generalized ordered logistic regression was informed by the ordinal nature of the dependent variable (confidence in street-vended food safety) and the assessment of parallel lines assumption. This assumption implies that the effect of each independent variable is similar across all thresholds of the ordered outcomes. The Wald test of parallel lines assumption was significant ($p < 0.05$) for independent variables including country, gender, age, and food poisoning experience indicating the parallel line assumption did not hold. Therefore, generalized ordered logistic regression was more appropriate for this analysis. The generalised ordered logistic regression is sensitive to outcome categories with low frequencies. In this study, categories 1 (not confident at all) and 5 (very confident) had few responses across most countries (Supplementary Material 3). To address this, the responses were grouped into a 3-point Likert scale ranging from 1 = Not confident (merging categories 1 and 2), 2 = A little confident (category 3) and 3 = Confident (merging categories 4 and 5). P -value < 0.05 was considered statistically significant. Since the dependent variable has three levels, there are two estimated cumulative logits and two corresponding cut points. For ease of interpretation, we report odd ratio. Odd ratio > 1 implies that as the value of an independent variable increases, the likelihood of the respondent being in a higher outcome category also increases. Odd ratio < 1 suggests that a higher value of an independent variable is associated with a greater likelihood of remaining in the current or lower outcome category.

Descriptive statistics were also used for observation data. In each participating country, the distribution or percentage of street food vendors by food safety practice performed and food hygiene scales were presented. Street food vendors' hygiene conformance indexes by countries and food categories were calculated to compare among studied countries and food types, respectively.

Survey results

Ninety-two survey participants responded "Never" in the "How often do you consume street-vended food?" question and were not included in the study. A total of 4,096 responses were eligible for data analyses. The demographic characteristics of participants are shown in Table 1. A breakdown of the sociodemographic characteristics is presented for each country in Supplementary Material 4.

More than 78% of participants consumed street-vended food at least one to four times a month. Although a large majority reported that they were either unsure or had not experienced food poisoning incidents upon consuming street-vended food, there were reports of finding foreign objects, flies, and mould in street-vended food. Among those who experienced visible contamination or bad taste, less than

Table 1. Demographic characteristics of consumers from participating Southeast Asian countries (n = 4096).

Variables	Descriptions	Frequencies (%)
Country	Cambodia	147 (3.6)
	Indonesia	603 (14.7)
	Laos	70 (1.7)
	Malaysia	521 (12.7)
	Philippines	1756 (42.9)
	Thailand	526 (12.8)
	Vietnam	473 (11.5)
Gender	Male	1508 (36.8)
	Female	2588 (63.2)
Age	18–29	2411 (58.9)
	30–39	776 (18.9)
	40–49	535 (13.1)
	50–59	267 (6.5)
	60 and above	107 (2.6)
Education	Primary	18 (0.4)
	Secondary	594 (14.5)
	Tertiary	3484 (85.1)
Employment	Self-employed	512 (12.5)
	Employed	1517 (37.0)
	Unemployed/Retired	251 (6.1)
	Student	1816 (44.3)
Residence	Urban	2160 (52.7)
	Sub-urban	1158 (28.3)
	Rural	778 (19.0)
Whom do you live with?	Live alone	318 (7.8)
	Living with family members	3513 (85.8)
	Living with non-family members	265 (6.5)
Distance of nearest street food vendor to home	Less than 1 km	1471 (35.9)
	1–2 km	1194 (29.2)
	3–4 km	671 (16.4)
	≥5 km	760 (18.6)

Table 2. Food safety and consumption of street-vended food (n = 4096).

Food safety and consumption of street-vended food	Frequencies (%)	
Frequency of consuming street-vended food	Rarely (less than once a month)	869 (21.2)
	Sometimes (1–4 times a month)	1712 (41.8)
	Often (1–3 times a week)	1137 (27.8)
	Regularly (daily or most days each week)	378 (9.2)
Experienced food poisoning	Yes	1104 (27.0)
	No or Unsure	2992 (73.0)
Have you experienced the following when eating street-vended foods*	Foreign objects from environment (stone, glass, plastics, wood splinters, staples)	1278 (31.2)
	Foreign objects from food handler (hair, fingernail, button)	1922 (46.9)
	Flies	1265 (30.9)
	Mould	283 (6.9)
If you experienced any of the features above, did you complain to the street food vendor	Strange or bad taste	1858 (45.4)
	Yes	1732 (42.3)
Do you use any strategies to ensure food safety when purchasing street-vended foods?	No	2249 (54.9)
	Not applicable	115 (2.8)
How confident are you in the safety of street-vended foods?	Yes	2693 (65.7)
	No	1403 (34.3)
	Not confident at all	100 (2.4)
	Not confident	197 (4.8)
	A little confident	899 (21.9)
Quite confident	1518 (37.1)	
Very confident	1382 (33.7)	

*Participants could choose more than one option.

half of the participants would complain to the street food vendors. Thus, when purchasing street-vended foods, more than 65% of the participants adopted certain strategies to ensure food safety (Table 2).

Table 3 shows consumers' food safety strategies when purchasing street-vended foods. Participants reported frequently using the following strategies, i.e. assessing the cleanliness of the street food vendor

Table 3. Consumers' use of food safety strategies when purchasing street-vended foods (n = 2693).

Food safety strategies	Never	Rarely	Sometimes	Often	Always
Environment					
Frequencies (%)					
Street food vending stall is clean	34 (1.3)	150 (5.6)	463 (17.2)	732 (27.2)	1314 (48.8)
Environment is free from pests	82 (3.0)	214 (7.9)	450 (16.7)	667 (24.8)	1280 (47.5)
Environment is free from stray animals	114 (4.2)	216 (8.0)	500 (18.6)	685 (25.4)	1178 (43.7)
Stall is not situated near open drains	150 (5.6)	251 (9.3)	520 (9.3)	640 (23.8)	1132 (42.0)
Not situated near open rubbish bins	163 (6.1)	219 (8.1)	413 (15.3)	571 (21.2)	1327 (49.3)
Not exposed to heavy traffic fumes	134 (5.0)	283 (10.5)	637 (23.7)	768 (28.5)	871 (32.3)
No previous incident of food poisoning	327 (12.1)	262 (9.7)	421 (15.6)	517 (19.2)	1166 (43.3)
Displays official license about their food business*	320 (12.1)	367 (13.9)	573 (21.7)	529 (20.1)	848 (32.2)
Food hygiene					
Foods are covered appropriately	62 (2.3)	171 (6.3)	507 (18.8)	810 (30.1)	1143 (42.4)
Foods are kept at suitable temperature	81 (3.0)	227 (8.4)	617 (22.9)	837 (31.1)	931 (34.6)
Hot street foods are served piping hot	68 (2.5)	168 (6.2)	562 (20.9)	859 (31.9)	1036 (38.5)
Clean water is used at the stall	60 (2.2)	177 (6.6)	465 (17.3)	749 (27.8)	1242 (46.1)
Food handler					
Does not use bare hands (e.g. without clean gloves or utensils) to prepare food	184 (6.8)	319 (11.8)	716 (26.6)	721 (26.8)	753 (28.0)
Wears protective hair cover	166 (6.2)	418 (15.5)	711 (26.4)	658 (24.4)	740 (27.5)
Has short, clean nails	80 (3.0)	304 (11.3)	645 (24.0)	707 (26.3)	957 (35.5)
Does not cough or sneeze onto foods	119 (4.4)	247 (9.2)	563 (20.9)	582 (21.6)	1182 (43.9)
Wears clean apron or protective covers	101 (3.8)	306 (11.4)	672 (25.0)	711 (26.4)	903 (33.5)
Does not smoke at the stall	165 (6.1)	256 (9.5)	518 (19.2)	545 (20.2)	1209 (44.9)

*Based on n = 2637 as street food vendors in Cambodia often do not register and display their official food business license.

Table 4. Generalized ordered logit regression predicting consumers' confidence in street-vended food safety.

Dependent variables	1 st cut point (confidence level 1 versus levels 2 and 3)		2 nd cut point (confidence level 1 and 2 versus 3)	
	Odd ratio (SE)	95% CI	Odd ratio (SE)	95% CI
Country				
Vietnam		Base level		
Indonesia	1.809**(0.231)	[1.408–2.324]	1.809**(0.231)	[1.408–2.324]
Laos	0.54*(0.136)	[0.33–0.886]	0.54*(0.136)	[0.33–0.886]
Malaysia	3.444**(0.607)	[2.438–4.865]	2.028**(0.287)	[1.537–2.675]
Philippines	3.814**(0.551)	[2.874–5.061]	5.946**(0.754)	[4.637–7.625]
Thailand	1.304*(0.176)	[1–1.7]	1.304*(0.176)	[1–1.7]
Cambodia	1.22(0.279)	[0.78–1.909]	0.432*(0.132)	[0.237–0.788]
Gender	0.642**(0.066)	[0.526–0.785]	0.83*(0.061)	[0.719–0.958]
Age	0.916(0.046)	[0.831–1.01]	1.061(0.047)	[0.972–1.158]
Education	0.812*(0.071)	[0.683–0.965]	0.812*(0.071)	[0.683–0.965]
Employment	0.987(0.036)	[0.92–1.059]	0.987(0.036)	[0.92–1.059]
Residence	1.017(0.042)	[0.937–1.104]	1.017(0.042)	[0.937–1.104]
Living situation	1.115(0.094)	[0.944–1.316]	1.115(0.094)	[0.944–1.316]
Distance from home	0.976(0.028)	[0.923–1.032]	0.976(0.028)	[0.923–1.032]
Consume street-vended food	1.757**(0.068)	[1.629–1.895]	1.757**(0.068)	[1.629–1.895]
Food poisoning experience	1.806**(0.181)	[1.484–2.198]	2.365**(0.198)	[2.007–2.787]
Complaints about street-vended food	1.226*(0.075)	[1.088–1.381]	1.226*(0.075)	[1.088–1.381]
Use food safety strategies when purchasing street-vended foods	0.909(0.063)	[0.794–1.041]	0.909(0.063)	[0.794–1.041]
cons	0.577(0.267)	[0.233–1.428]	0.014**(0.006)	[0.006–0.033]

Note: ** $p < 0.001$; * $p < 0.05$; 1 = Not confident; 2 = A little confident; 3 = Confident.

Source: Authors' own work.

(76%), ensure stalls were free from pests (72.3%) and not situated near opened rubbish bins (70.5%). In terms of food hygiene practices, more than 70% reported that they would ensure the foods were covered appropriately and clean water was used at the stall. However, only about half of the participants frequently paid attention to the display of official license of food business at food stalls, vendors' use of clean gloves and utensils to prepare foods, and vendors' hair being covered.

The variables shown in Table 4 were used as independent variables in the generalized ordered logistic regression to predict consumers' confidence in street-vended food safety. The likelihood ratio chi-square test [$\chi^2(23)=1001.41, p < 0.001$] indicated a significant improvement in fit compared with the null (no predictors) model. The likelihood ratio chi-square tests were significant for the following variables: country, gender, education, frequency of consumption of street-vended foods, experience of food poisoning, and raising complaints to the street food vendor due to food safety or quality issue associated with their street food. In addition, it is worth noting that some

independent variables including country (Malaysia, the Philippines, and Cambodia), gender, age, and previous experience of food poisoning had different coefficients across the two cut points since they did not satisfy the parallel lines assumption.

Participants from Indonesia ($p < 0.001$) and Thailand ($p < 0.05$) were significantly more confident in the safety of street-vended food compared to participants from Vietnam (Vietnam is coded as the reference value). For Malaysia, the positive effect on confidence in street food safety was higher in the first cut point, suggesting they were more likely to report either a little confidence or fairly high confidence rather than no confidence at all. For participants from the Philippines, the positive effect was stronger at the second cut point, indicating a higher likelihood of having the highest level of confidence compared to little or no confidence, as compared to Vietnamese participants. Laotian participants, in contrast, were especially unlikely to report the highest level of confidence in street food safety, relative to Vietnamese respondents. We also predict probability of reporting each level of confidence across countries (Supplementary Material 5 Figure S1). Consistent with Table 4, predicted probability of reporting highest level of confidence was highest for the Philippines sample (Supplementary Material 5 Figure S2).

Female respondents showed less confidence in street food safety than male respondents, with a greater likelihood of reporting the lowest level of confidence compared to higher levels. The association between age and confidence in street food safety was negative, with variations in magnitudes across the two cut points and were not statistically significant. Participants who had previously experienced food poisoning were more confident in the safety of street-vended food and were more likely to report the highest level of confidence, compared to those who did not experience food poisoning. Among the 1,104 participants who reported previous experience of food poisoning, 66.8% adopted food safety strategies when purchasing or consuming street-ended food. Those, who consumed street food more frequently or had previously raised a complaint about food safety or quality, also reported greater confidence in street-vended food safety. Respondents with higher education levels were likely to be less confident in street-vended food safety, compared to those with lower education levels. Additionally, participants who utilised food safety strategies when purchasing street-vended foods reported lower confidence in the safety of street foods although this association was not statistically significant.

Observation results

A total of 163 street food vendors (Thailand = 40; Indonesia = 41; Philippines = 42 and Malaysia = 40) were evaluated using the Rapid Food Hygiene Inspection Tool (RFHiT). Pests are a major issue faced by the street food vendors as foods are exposed to the environment, often uncovered, and attract pests. There was some evidence of pests in 55% of the observed street food stalls (see Supplementary Material 6 Figure S1a and S1b). Less than 10% of the street food vendors have any form of pest deterring devices such as fly traps located at the food stall. However, as shown in Figure 1c (Supplementary Material 6), there is potential for cross contamination of food due to the vicinity of the sticky fly trap.

Only 14.7% of street food vendors had access to toilet facilities and running water. Amongst those with access to toilet facilities, 9.8% provided soap for handwashing. Figure 1 shows the hygiene ratings (calculated from Formula 1) of street food vendors in Thailand, Indonesia, Malaysia, and the Philippines. Overall, 95 street food vendors (58.2%) were rated as 5.0–6.9 (moderate and some improvements required) (Figure 1). The percentage of street food vendors that have a hygiene rating of at least 7 (good and excellent) was the highest for Thailand.

The street food vendors' hygiene conformance indices are further shown in Table 5. Street food vendors in Thailand demonstrated the highest hygiene conformance for the overall evaluation criterion under analysis. When the assessments are scrutinised according to specific categories, Thailand recorded the highest conformance in terms of premises. This is due to the availability of toilets for food handlers and customers and hygienic preparation area. Indonesia recorded the highest conformance in food preparation and handling practices such as cooking appliances being maintained in good condition and separate utensils being used for handling raw food and cooked

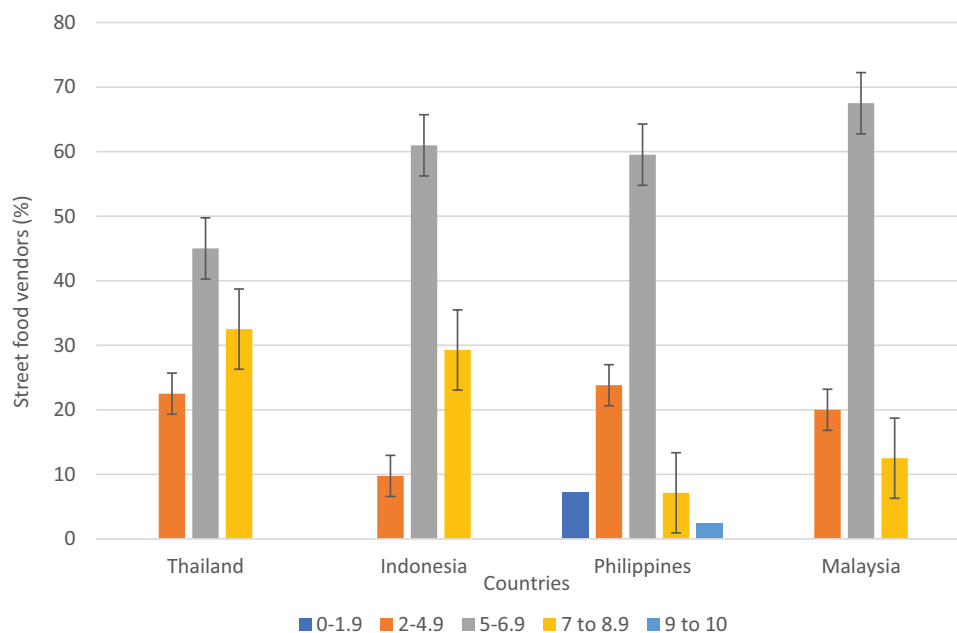


Figure 1. Street food vendors hygiene ratings (n = 163) note: 0–1.9 (very poor: urgent improvement necessary); 2.0–4.9 (poor: major improvement necessary); 5.0–6.9 (moderate; some improvement required); 7.0–8.9 (good) and 9.0–10.0 (excellent). Source: Authors' own work.

Table 5. Street food vendors' hygiene conformance index according to countries and food categories (n = 163).

Categories	Thailand (n = 40)	Indonesia (n = 41)	Philippines (n = 42)	Malaysia (n = 40)
	Conformance Index (%)			
Overall	62.82	62.53	51.69	58.73
Premises	40.77	28.71	21.43	15.77
Preparation Area	78.81	52.32	57.40	68.89
Food Preparation	86.92	94.47	73.64	85.30
Food Storage	69.20	68.21	69.79	45.78
Serving	71.25	88.13	87.08	94.52
Food Hygiene	51.51	64.48	48.62	73.85
Food categories	Conformance Index (%)			
Freshly prepared food (n = 52)	62.72			
Ready-to-eat food (n = 29)	58.23			
Others/More than 1 type of food categories (n = 59)	57.78			
Beverages (n = 12)	56.03			
Desserts (n = 6)	52.98			
Fresh or preserved fruits (5)	49.53			

or RTE food. However, there were 9.76% (n = 4) street food vendors in Indonesia with poor food hygiene practices as shown in Supplementary Material 6 Figure 1d. The premises and preparation area of Indonesia's street food vendors received the poorest scores. This was largely due to the lack of handwashing and toilet facilities for the vendors. There was also a high reliance on re-using water from buckets.

The observed street food vendors in the Philippines demonstrated good food storage practices such as raw foods being kept separated from RTE food and a fridge/ice box was used to keep perishable foods. Another example of good practice includes covering RTE food with a plastic sheet to prevent pests (Supplementary Material 6 Figure S1e). However, the food hygiene practices of these vendors received the lowest average score compared to those in other countries. Street food vendors observed in Malaysia demonstrated good serving practices where food was served with clean utensils or clean and safe packaging materials (e.g. no newspaper in direct contact with food) were used. Similarly, they scored the highest conformance index in good hygiene practices such as not using bare hands to handle unwrapped, RTE food.

Discussion

More than 70% of the participants in our consumer survey reported they did not experience food poisoning or were unsure. In Malaysia, food poisoning incidents were 70.00 cases per 100,000 population. The Ministry of Health Malaysia (2024) reported that food and waterborne diseases in Malaysia remain low due to treated water supply and high sanitation coverage. Another possible reason is the lack of resources to investigate the foodborne illnesses or underreporting of mild and common illnesses (Soon et al. 2011). This is also supported by Devleeschauwer et al. (2018) who reported food poisoning incidents remain low in Southeast Asia due to lack of data.

Previous studies revealed that consumers would utilise food safety strategies when purchasing fresh produce, meat, or seafood. For example, consumers in Cambodia and Vietnam would utilise certain purchasing and cleaning strategies such as choosing fresh produce with evidence of worm damage as an indicator of food safety. Other strategies include washing fresh produce and meat with salt and blanching (Wertheim-Heck et al. 2014; Brown et al. 2022). Similarly, we believe that such food safety strategies extend to purchasing street-vended foods by selecting the street foods that were prepared or sold in a clean environment and RTE foods were covered. This was demonstrated by Liu et al. (2014) who recommended that consumers should utilise their senses when purchasing street-vended foods and to observe that street food vendors follow food hygiene practices. Food safety is a credence attribute, which is hard for consumers to judge at the point of purchase. To reduce this complexity, it is likely that consumers would rely on visible cues such as the appearance of street food (e.g. whether the food is covered) and the surrounding environment (e.g. whether there is the presence of pests and eating utensils are clean at the food stall).

Our findings revealed that participants from Laos were significantly less confident in street-vended food safety compared to other Southeast Asian participants. Laos has one of the highest prevalence of foodborne illnesses among Southeast Asian countries with 332 cases per 100,000 people (Pires et al. 2015; Kasza et al. 2024). This lack of confidence could potentially be caused by the lack of safety controls of imported food which flooded the market with unsafe food (Ministry of Health, Lao People's Democratic Republic 2009; Wiemann et al. 2009). However, the finding that Laos was significantly less confident in street-vended food safety compared to other countries should be interpreted with caution due to the very small sample size. According to Kasza et al. (2024), Lao consumers tend to assign more responsibility to ensure the consumption of safe food themselves rather than relying on food producers and the government. Our results also imply that after Laos, the confidence in the safety of street vended food in Vietnam is also low, as compared to other studied countries. This finding is consistent with previous studies which show a high level of concern about food safety in Vietnam (Wertheim-Heck et al. 2014; Ha et al. 2019). Females were less confident in street food safety in our study, and this could be attributed by women reporting higher food risk perception and is more likely to take protective food safety strategies (Soon et al. 2022) and lower perceived control over food risks especially foods purchased from informal food environments (Ha et al. 2019). Similarly, according to Ha et al. (2019), more educated consumers may be more exposed to food risk information and thus less confident in street food safety.

There was significant association between participants who frequently consumed street-vended foods and their level of confidence in street food safety. Further research is required to understand the drivers affecting their level of confidence. This study cannot rule out the possibility that consumer confidence leads to increased street-vended food consumption. It is likely that consumers purchased street-vended foods from trusted sellers which boosted their level of confidence in the perceived safety and quality of the food. Trust is a major factor in the street food vendor–customer relation that is developed over time due to social interactions and provision of added services such as credit or free food (Wertheim-Heck et al. 2014). Our study further revealed an interesting point where those who reported previous experience of food poisoning were more confident in street food safety. A larger proportion of those who experienced food poisoning episodes were more likely to practise food safety strategies when purchasing or consuming street-vended food. It is also likely that the participants were subjected to the effect of optimistic bias, where they considered that they have control over the risks after the incident (Frewer et al. 1994) and believed that their negative experience was an isolated incident. According to Soon et al. (2011), gastroenteritis symptoms such as diarrhoea were often treated as a transient inconvenience rather than a symptom of food poisoning. Participants may normalise the risk and accept that such incidences are associated with street food.

Our observations of street food vendors' hygiene practices conducted in four SEA countries demonstrated that the overall food hygiene compliance was moderate, and thus some improvements were required. The observed street food vendors in Bangkok, Thailand, demonstrated the highest level of overall hygiene conformance index. This was due to access to running water, including handwashing and toilet facilities. It is possible that the location of the street food vendors in the capital and as a main tourist attraction contributed to better access to facilities, coupled with frequent enforcement and food safety certification, the Bangkok Metropolitan Administration (BMA) (WHO Regional Office for South-East Asia 2012). Recently, BMA introduced the Bangkok Food Policy 2023–2027 which addresses food safety, quality, and sustainability (IURC 2023) which may have helped to improve the level of food safety compliance in the area. In Thailand, the 2018 and Public Health Act B.E. 2535 (1992) vendors to comply with local hygienic criteria, licensing, and potable water. Similarly, the national standards in Malaysia, the Philippines, and Indonesia converge on the same core controls including licensing, food handler training, hygiene compliance, health certification, pest control, and use of potable/drinking quality water (Malaysia Food Hygiene Regulations 2009; 1975; Peraturan Menteri Kesehatan Nomor 2; 2023).

Limitations of the study

The study was limited to self-reported data and thus is subjected to social desirability bias. We have supplemented this with observational data, although this was limited to four SEA countries. The observations were based on a single point of time and thus only captured a snapshot of the hygiene practices of the street food vendors. However, the observation using RFHiT is discreet and reduces the Hawthorne effect among street food vendors. Another limitation was the small number of participants from Laos compared to other SEA countries. The study was unable to collect responses from other Southeast Asian countries including Brunei, Myanmar, Singapore, and Timor-Leste. More than 80% of the survey respondents reported being college and/or university educated. It is possible that the higher concentration of highly educated participants was due to the snowball sampling approach and that most of the participants reside in urban and sub-urban areas. Additionally, the number of participants from each country is not a representative sample in relation to the population size. The study observed limited ($n = 163$) number of street food vendors in selected cities of four SEA countries only. This is due to a lack of funding to support data collection in remote and/or less accessible areas in the SEA countries and to conduct observational studies across all seven SEA countries.

Conclusion

This is the first regional study that utilises a mixed-method approach to investigate street-vended food safety in Southeast Asia. Our findings revealed that a large proportion of SEA consumers reported adopting food safety strategies such as assessing the cleanliness of the street food vendor when purchasing street-vended foods. Females and those with high level of education were less confident in street-vended food safety. Based on the observation studies in the selected SEA countries, most street food vendors were rated as moderate, and some improvements were required. Thailand demonstrated the highest level of hygiene conformance for the overall evaluation criterion. Access to potable water, toilet facilities, and presence of pests were major challenges faced by street food vendors in the region. Our approach has significant, practical implications as RFHiT could be utilised to assess the food hygiene practices of street food vendors rapidly and reduce the Hawthorne effect among street food vendors. Potential interventions include improving consumer knowledge on food safety strategies, enhancing food safety management of street vended foods in Laos and Vietnam, strengthening vendors' food hygiene practices in Thailand, and addressing premises conditions in Indonesia, the Philippines, and Malaysia. It is recommended that the observation studies be supplemented with microbial analyses of food/drinks and swabbing of food contact surfaces in future studies. Moreover, semi-structured interviews can be conducted with consumers to understand consumers' food safety strategies when purchasing or eating street-vended food.

Author contributions

CRedit: **Jan Mei Soon-Sinclair**: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Validation, Writing – original draft, Writing – review & editing; **Mark Raguindin Limon**: Data curation, Investigation, Writing – review & editing; **Iwan Vanany**: Data curation, Investigation, Writing – review & editing; **Pornthipa Ongkunaruk**: Data curation, Investigation, Writing – review & editing; **Pisidh Voe**: Data curation, Investigation, Writing – review & editing; **Sayvisene Boulom**: Data curation, Investigation, Writing – review & editing; **Fue Yang**: Data curation, Investigation, Writing – review & editing; **Ikarastika Rahayu Abdul Wahab**: Data curation, Investigation, Writing – review & editing; **Ruhil Hayati Hamdan**: Data curation, Investigation, Writing – review & editing; **Mohd Hafiz Jamaludin**: Data curation, Investigation, Writing – review & editing; **Cong Duan Dao**: Data curation, Investigation, Writing – review & editing; **Thanh Mai Ha**: Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing.

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Data availability statement

The datasets used in the current study are not publicly available but are available from the corresponding author at reasonable request.

Ethical approval

Informed consents were obtained from all participants and street food vendors. The study received ethical approval from University of Lancashire HEALTH Ethics committee (HEALTH 0456).

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