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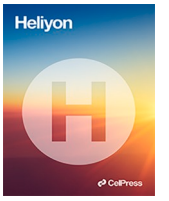

Research article

Consumer knowledge, attitudes, and behaviour regarding food safety – A perspective from Laos

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ABSTRACT

Primary research data on food chain safety at consumer level is needed to help policymakers to decrease the risk of foodborne infections in the Lao People's Democratic Republic. Therefore, the objectives of this study are to 1) determine Lao people's food safety knowledge, attitudes, and intentions and identify the most influential factors that shape their food safety behaviour, and 2) to support the government in the development of more efficient risk communication programmes. A paper-based consumer survey was implemented to collect quantitative data on the selected topics about Laotian consumers, as well as on the equipment of households regarding the conditions and tools necessary for safe food preparation and storage. A model was developed based on the extended Theory of Planned Behaviour (TPB), and partial least squares structural equation modelling (PLS-SEM) was applied to analyse the factors that affect food safety behaviour. The elements of Knowledge and Perceived Behavioural Control positively influence behaviours, such as using separate chopping boards for raw and ready-to-eat foods. According to the model, only 10 % of the Intentions would be translated into Behaviours, which gap can be explained by the lack of a hygienic environment. Although the survey indicated that Laotian people intend to follow food safety guidelines, participants felt they lacked sufficient knowledge. This perception

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was validated by the knowledge test and behavioural part of the study. In the light of these findings, it is essential to raise awareness and promote food safety knowledge and interventions, such as enhancing food safety education in childhood. This would help to facilitate and encourage adopting safe practices to improve overall food safety at the consumer level, delivering positive impacts also to the food business sector.

1. Introduction

Lao People's Democratic Republic (PDR) is a country in Southeast Asia with a developing economy [1,2]. While the fight against poverty is still a challenge in the country [3], the GDP/capita indicator has doubled in the last ten years, reaching 2600 USD [4]. The ratio of agriculture contributing to GDP dropped below 17 % and has remained below this level since 2017 [5]. In contrast, subsistence agriculture is widespread and relevant for approximately 60–80 % of Laotian households [6,7]. Furthermore, about 70 % of the population is related to agriculture, forestry, and rural development [8]. The country's urbanization rate is relatively low; however, it is continuously growing, topping 37 % by 2021 [9], with a significant increase of 6 % since 2011.

By 2045, many rural Laotian farmers are projected to migrate to urban areas due to urbanization, and the 15 largest cities will serve as domicile for 40 % of the population, resulting in several agricultural and wetland regions becoming residential [10]. This strains agriculture as land and labour decrease while food demand rises. Energy inefficiency is another challenge that requires improvement in better production performance [11].

With increasing pressure on Laos' agricultural industry, the Lao government and policymakers are taking rapid measures to address this problem [12–14]. One approach involves promoting infrastructure and technology as well as inviting international investors to enhance agricultural advancement [15,16]. Since 2008, Hungary has initiated Tied Aid Loan (TAL) Programmes in Laos to boost the performance of the livestock and aquaculture sectors and enhance food and agriculture [17], with two subsequent agreements focusing on the development of the Lao food safety system. This partnership facilitated extensive modernisation of the Laotian agriculture and the food chain safety supervision system. Modernisation was achieved through the renewal of national food safety legislation, improvement of the national laboratory system, creation of an IT system for livestock management, and launch of the first public awareness campaign on food chain safety in Laos [18]. Assisted by the government and international partners, agriculture in Laos grew by 3 % in 2022, becoming a primary contributor to GDP [19,20]. Integration into international organizations, associations and free trade agreements has expanded market opportunities for Laos' agricultural and forestry products (raw materials) [9,21,22]. This has prompted a need for heightened food safety regulations to enhance customer trust and encourage international trade [23–25].

The agricultural sector's development is crucial in decreasing hunger and poverty in Laos, offering significant employment opportunities [8,26,27]. Progress in lowering levels of hunger and poverty [28–30] has led to improved citizen welfare and Gross National Income (GNI) [31]. With these upgrades, consumers' focus on food safety issues increases, driven by rising income and well-being [32–36].

In addition, consumers' growing concern about food safety in Laos is due to the country's current food safety status. The quantity of domestically produced food is still insufficient to meet demand, which results in easy entry of imported products and lax safety controls on imported food [21,37]. This caused Lao markets to flood with unsafe food [21,37,38]. Common food safety issues in Laos from agricultural products include heavy metal contamination, pesticides, mycotoxins, improper or hazardous components, and preservatives, etc. [37,39]. The extensive use of formalin exposes local consumers to further risk. The formalin level in northern Laotian markets amounted to 6.00–12.77 % according to research [40]. Besides agricultural products, 90 % of meat in Laotian markets, especially pork, is contaminated by *Trichinella spiralis* larvae [41], and non-typhoidal *Salmonella* [42]. The preference for consuming wild animals (especially bushmeat) in Laos and improper handling practices contribute to food safety issues [43]. Moreover, raw meat and blood, as well as uncooked or fermented meat consumption are traditional [43], particularly at weddings and funeral ceremonies [44]. Additionally, people in this region usually do not consider raw meat consumption risky [45].

Laos has a long history of poor food safety, ranking among Southeast Asian nations with the highest prevalence of foodborne illnesses, with 332 cases per 100,000 people [46]. The high prevalence of nematode infections and foodborne diarrheal diseases contributes to malnutrition and is the leading cause of mortality in children [47]. Although a growing number of food safety incidents have been reported and have become a serious concern in Laos, documentation and studies on foodborne diseases are scarce [37,48]. Further research involving in-depth analysis of foodborne illnesses and consumer perceptions of food safety in Laos would be crucial for mitigating foodborne diseases. Missing data is not the only problem; consumers tend to consider chemical hazards (e.g., pesticides, hormones, additives) as the only food safety risk, while in fact, microbial hazards cause statistically more foodborne illnesses. However, microbial risks are generally underestimated [49,50]. Awareness of microbial risks would be essential, as safe household practices are key to the prevention of most foodborne illnesses [51]. Common risky practices leading to potential cross-contamination are lack of hand washing or inadequate hand washing methods, washing raw poultry in the sink, applying the same utensils to raw and ready-to-eat foods, and using unwashed fruits and vegetables. These behaviours should be targeted in risk-mitigation programmes [45, 52–55].

Effective consumer risk communication enhances at-home food safety practices and, in parallel drives demand for safety throughout the food chain [36,56,57]. Growing awareness of foodborne risks makes consumers more conscious of their food choices [58–60], potentially boosting food quality and safety in Laos. However, disparities in water access and sanitation limit the ability of some consumers to implement proper hygiene practices. In 2020, only 27 % of urban and 12.4 % of rural citizens in Laos had access to

safe drinking water. Handwashing facilities with soap and water are available for only 46 % of the population. Poor sanitary conditions and hand hygiene facilitate the spread of pathogens [7]. This can be a result of inequality in sociodemographic factors such as economic status, income level and location of residence within the country [61–64], but alow level of food safety knowledge is also a relevant factor [65].

While discussing Laotian consumer food safety behaviour, it cannot be isolated from the producer's perspective. Many households are small-scale farmers who produce and sell their products to the market [66,67]. Small-scale food production and cottage industries are typical forms of food manufacturing in Southeast Asia, where adequate equipment and evidence-based knowledge for safe food processing are often missing. Frequently, the traditional methods passed down through generations are merely the guidelines available at these farms [49]. Moreover, the structure of the domestic food processing sector is informal and food safety supervision is limited, resulting in a high prevalence of unsafe food [7]. As there are no boundaries between consumers and producers in Lao PDR regarding food safety, the target audience for risk communication overlaps. These overlaps in health risk communication would have substantial adverse effects as a lack of effective communication will impact consumer health [68].

Observing many issues and accidents linked to food chain safety in Lao PDR from farm to fork is not matched by the availability of current research to assist in resolving this problem. Studies on food chain safety, particularly consumer- and household-related issues in the Lao population, would be critical to help the government and policymakers lower the risk of foodborne infections. However, at present, such research is not yet available for many Asian areas [69]. This study aims to determine Lao people's food safety knowledge, risk perception and attitudes and identify which factors influence food safety behaviour most. Thus, our work also aims to help the policy- and decision-makers in which specific elements should be focused in the country's risk communication programs. The research was conducted within the framework of the 3rd Hungarian Tied Aid Loan Programme.

2. Methodology

A quantitative paper-based consumer survey was implemented to collect data on the food safety knowledge, attitudes, and behaviour of Laotian consumers, as well as about the household equipment in terms of the conditions and tools necessary for safe food preparation and storage.

A pilot study was conducted before the survey to identify issues to be addressed. The majority of the revealed problems were about questions of interpretation, such as the translation of food safety-related terms, cultural interpretation of the questions, and clarification of the meaning of some phrases (direct translation into Lao language was not possible in some cases, since in Lao many words have several different meanings, depending on the context). Solving these issues before the completion of the survey questionnaire was an iterative procedure.

2.1. Consumer survey

The survey was conducted by personal interviews in seven districts of Vientiane Capital (Chanthabouly, Hatsayphong, Naxaythong, Saythany, Sikhottabong, Sisattanark, Xaysettha) between March and April 2022. The districts of Vientiane Capital and the border of

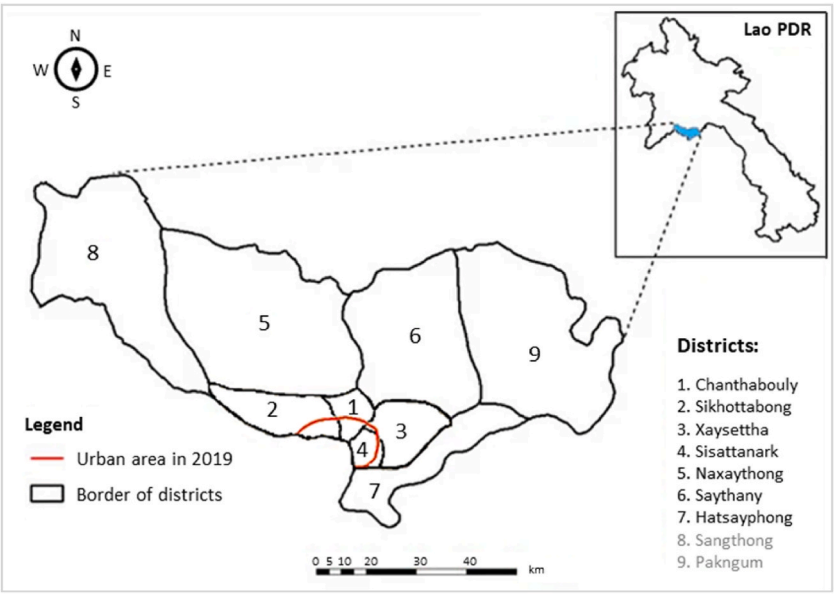

Fig. 1. Districts of Vientiane Capital and illustrating the location of the capital within the country. The districts involved in this study are shown with black letters. The red border indicates the urbanized area of the capital.

the urban area are shown in Fig. 1. Densely populated areas and frequented transport hubs were selected for personal interviews, where experienced interviewers randomly addressed potential individuals to participate in the survey. Respondents had the option to complete the questionnaire on their own; however, assistance was provided by the interviewers, and feedback was asked at the end.

Before participating in the survey, the interviewers provided information about the research purpose and subject, anonymous data handling and storage procedure, and analysis methods. The survey was implemented in compliance with the General Data Protection Regulation (GDPR), and the methodology was ethically verified by the Research and Innovation Committee of the University of Veterinary Medicine Budapest. All the respondents provided informed consent to participate in the survey verbally. After accepting the terms of voluntary participation, age, gender, and living area were recorded based on self-reporting.

The questionnaire principally consisted of close-ended questions using single-selection questions as well as 10-point Likert scales (1: strongly disagree; 10: strongly agree). Comprehension of a 10-point scale is self-explanatory for Laotian consumers as most state primary schools use this grading system for evaluation.

Personal interviews always face the challenge of the respondents' compulsion to comply. During the study design, this factor was considered, and most often, questions with factual answer options stripped from all ethical expectations were utilized to counterbalance this possible bias.

2.2. Characteristics of the sample

A total of 500 participants completed the questionnaire. The characteristics of the respondents' and their households' are summarised in Tables 1 and 2. The overrepresentation of those with above-average income levels (62.9 %) can be explained by the fact that the vast majority (85.2 %) of respondents live in the capital of Laos. Of the participants, 19.2 % indicated that they had food-related work, such as being a farmer, fisherman, or catering (e.g., food vendors or restaurant workers).

2.3. Model development and statistical analysis

Factors affecting food safety behaviour were analysed by partial least squares structural equation modelling (PLS-SEM) performed on a reflective model (Fig. 7), which was developed based on the Theory of Planned Behaviour (TPB) [70]. The TPB model [71] identifies predictors of behaviour as attitudes towards the behaviour (referring to the positive or negative evaluation of executing a behaviour), social factors such as subjective norms about the behaviour (referring to the perception of other people's expectations) and perceived behavioural control (referring to the perception of how implementing the behaviour is easy or not), which influence the so-called behavioural intention (referring to the motivational aspects that influence behaviour to be performed). These factors anticipate the intent to perform specific behaviours, including behaviours related to food safety [72]. The original TPB model was extended with the knowledge factor (referring to the information, experiences, and skills picked up by a person on food safety topics), which has also been proven to affect attitudes and behaviour [73,74]. Analysing the effect of the predictors on the intention to comply with safe food-handling practices can provide directions for developing targeted risk communication for consumers. Variables in the questionnaire for composing the elements of the model (Table 3) were formed based on previous research on the topic [75–79]. The indicators listed in Table 3 were narrowed down to the variables demonstrated by "V" letters based on preliminary screening using categorical principal component analysis (CATPCA) and the characteristics of the initial models. At the same time, preliminary

Table 1
The main demographic attributes (genders, age, living area, education level) of the sample, shown in percentage.

Attributes	Ratios (%)
Genders	
Woman	47.8
Man	41.6
Other	10.6
Age groups	
14–25 years	35.8
26–35 years	31.8
36–55 years	24.8
56–78 years	7.6
Type of living area	
Vientiane capital	85.2
Other City	14.4
Village	0.4
Highest completed education	
Less than 5 years primary school	3.8
Primary school	6.6
Junior high school	12.0
Secondary school	32.2
Vocational-technical school	15.8
Bachelor's degree	27.0
Master's degree	2.6
Doctorate (PhD)	0

Table 2
Characteristics of the participants' households: income level, size, and whether there are children under the age of 6 in the household.

Attributes of the households	Ratios (%)
Income level	
Very low	3.3
Low	8.2
Average	25.6
Above the average	23.3
Significantly above the average	39.6
Size of the household	
1 person	2.6
2 persons	7.2
3–4 persons	46.8
5 or more persons	41.6
College, youth's/workers' hostel, etc.	1.6
Children under age 6	
Yes	34.5
No	65.5

screening was also considered the most prominent topics from the point of view of food safety; therefore, variables related to chopping board usage were chosen as the target behaviour element because cross-contamination is one of the most problematic points in household food handling.

Path modelling was performed using SmartPLS 4 software [80]. A bootstrapping procedure was conducted with 1000 subsamples [81] to verify the significance of the paths, and the blindfolding process for the examination of the predictive relevance where omission distance was considered to be equal to 7, was also completed. Performance indicators such as the extracted average variance (AVE),

Table 3
Variables within each element of the TPB model ("Elements" column) are shown as they were worded in the questionnaire ("Indicators as manifest variables" column). Selected variables for the model are indicated by "V". The other variables, indicated by italics, were not included in the PLS-SEM analysis.

Elements (latent variables)	Indicators as manifest variables
Knowledge	V1 Some moulds can cause illness when found in food
	V2 Most of the illnesses are caused by bacteria and viruses
	Any bacteria in foods are harmful for your health
	Freezing kills bacteria and viruses
	Cooling helps to preserve the safety for longer time
Attitude	V3 I believe that eating safe food is part of being healthy
	V4 It is good to have knowledge on bacteria and viruses in food
	I am concerned about my health due to eating unsafe food in Laos
	I am more careful about food hygiene than most of the other people
	I am afraid of getting ill from uncooked food
	I am glad to see information on the packaging of the food
Subjective norms	V5 When I cook to my family/friends, they expect me to wash hands
	V6 My family and friends are careful about food hygiene
	People in Laos care about food safety a lot
	My family and friends expect me to handle food safely
	I believe that people think I should always rather eat all the food than throw it out even if it starts to smell
Perceived behavioural control	V7 It is easy for me to wash my hands properly
	V8 I am capable of making safe food
	Illnesses usually have a spiritual cause
	I am able to protect myself from foodborne illness
	I believe that I have a good knowledge about food safety
	I think I am responsible for the safety of the food I consume at home
Intention	V9 I aim to follow food safety advice when preparing food
	V10 I always want to wash my hands before eating or cooking
	V11 I intend to improve my food safety knowledge and practices
	I will make effort to cook food properly
	I try to avoid eating spoiled food
	I make efforts to store perishable foods in the fridge
Behaviour	V12 I use separate chopping boards to cut meat and vegetables
	V13 I use separate chopping boards to cut raw (e.g. meats, vegetables, fruits) and ready-to-eat foods (e.g. bakery and dairy products, cold cuts)
	I wash my hands before eating
	I read the labels on prepackaged food products before buying
	If I don't cook the meat immediately, I put it in the fridge
	I wash raw meat in the sink before cooking
	I cook/fry/roast meat thoroughly

discriminant validity (based on Fornell-Larcker criteria), composite reliability, Student's t-value, Pearson's determination coefficient (R^2), size of effects (f^2), predictive validity (Stone-Geisser's Q^2), path coefficients, and standardized root mean square residual (SRMR) were reported for the evaluation of the results [82–84].

To screen the variables and confirm the formed elements (presented in Table 3, indicated by "V"), CATPCA using Varimax rotation was also executed, which is adequate for ordinal data derived from Likert scales [85]. CATPCA and descriptive analysis for the general characterization of the results were conducted using the IBM SPSS software (version 26.0) [86]. SPSS software was used to confirm the consistency of the variables within the questionnaire using Cronbach's Alpha.

3. Results and discussions

3.1. Descriptive statistics

Most of the participating Lao consumers were aware of the prevalence of unsafe food and foodborne illnesses in the country, as 72 and 80 % indicated a 7–10 level of agreement on a 1–10 point Likert scale with the related statements. Additionally, people are somewhat concerned about consuming unsafe food in the Lao PDR (7.87 ± 2.136 on the 1-10-point Likert scale). They rated themselves as caring more about food hygiene than others (7.87 ± 1.957) and their family and friends even more than that (7.99 ± 1.889), while assessing Lao people, in general, to be less careful (7.51 ± 1.958). At the same time, they assign more responsibility to ensure the consumption of safe food themselves than to food producers and the government, as shown in Fig. 2, which presents the perception of Lao consumers on the responsibility of actors in the food chain to ensure food safety. Still, the survey participants perceived proper food safety supervision and control of Laos, and they evaluated the ability of the government to regulate food safety as 6.47 ± 2.616 on a 10-point Likert scale, which, considering the turbulent period of the world economy expressing a significant impact on the Lao food system, depicts a relatively good picture.

According to the respondents, childhood education on personal hygiene and food safety in Laotian schools was satisfactory. Approximately 75–78 % of the participants agreed with the statements on these topics respectively: "Children in Lao schools learn a lot about food safety" and "Children in Lao schools learn a lot about personal hygiene". Health and hygiene education or promotional activities are often part of national and international programmes that aim to improve general hygiene practices in addition to upgrading the sanitation status of the country [87,88]. However, based on a previous survey conducted in Laotian schools, students' knowledge of health and hygiene practices was low. For example, 32 % of the students could not name any related method, such as hand washing. In addition, what is even more worrying, is that two-third of the food preparers working in the schools have not received training on food handling and hygiene, and more than 90 % of them could not pass a test on safe food preparation and storage practices according to the former study [88]. An FAO report on the food system profile of the Lao PDR pointed out that people have little access to food safety information [7]. For example, there is no expiration date on food packaging, and food safety warnings in the Lao language are usually missing, contributing to the low knowledge level. However, our results showed that consumers would be glad to see information on food packaging (8.01 ± 2.098 out of 10 on the Likert scale).

Several statements on various food safety subjects were also included in the present questionnaire to test respondents' risk perception and knowledge, the results of which are presented in Fig. 3.

According to the results, the role and presence of bacteria in food and the causes and prevention of foodborne illnesses are not completely understood by Lao consumers (Fig. 3). Some ambivalence can be observed in the attitudes and intentions of the participants. This may be due to a lack of food safety knowledge and an understanding of the prevention of illnesses. Realizing the connections between foodborne diseases and the production, storage and preparation of food is also missing. For example, the relationship between the deterioration process of food, presence of pathogens, and cooled storage required to slow it down is probably not widely known among Lao consumers. Based on their answers, the participants knew that spoiled food could cause illness. Still, at the same time, they trust that if there are no sensory changes, the food can be consumed safely (Fig. 3); however, the presence of most pathogenic bacteria cannot be detected in this way [89]. Accordingly, most of them tried to avoid eating spoiled food (8.7 ± 2.191 on the 10-point scale). On the other hand, the statement "Cooling food helps to preserve the safety for a longer time" received a rating below 8,

Fig. 2. Perception of Lao consumers on the responsibility of actors in the food chain for ensuring food safety presented by Likert scales (1: I don't agree at all, 10: I totally agree -, means and standard deviations are presented).

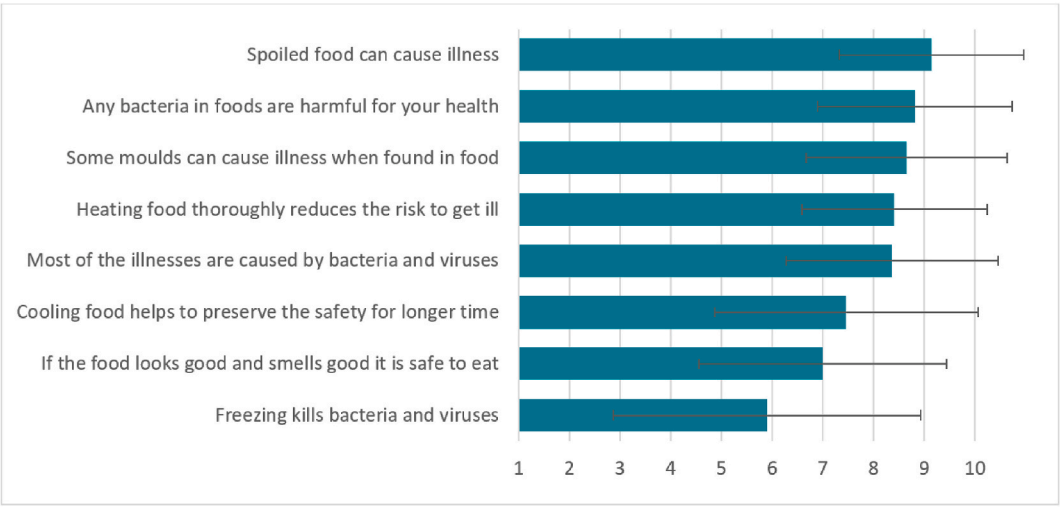

Fig. 3. Food safety knowledge and risk perception of the respondents indicated on Likert scales (1: I don't agree at all, 10: I totally agree). Means and standard deviations are presented on the figure.

while "I make efforts to store perishable foods in the fridge" received one of the lowest values on the Likert scale (5.69 ± 3.661).

Uncertainty related to cooking was also revealed. Participants were aware of the presence of unsafe food and the prevalence of foodborne illnesses in Laos, and they (correctly) linked the consumption of safe food to being healthy. The respondents aimed to follow food safety advice when preparing food, and make efforts to cook food properly, as the level of agreement with the related statements was above 8 on a 10-point scale. Although they generally felt capable of making safe food, the ability to protect themselves against foodborne illnesses reached only 7.27 out of 10 (statement: "I am able to protect myself from foodborne illness"). Additionally, respondents tended to be afraid of getting ill from uncooked food, and relatively many of the respondents agreed with the statement that "Illnesses usually have a spiritual cause", as it received an average value above 6 out of 10 on the scale (6.27 ± 2.919). Other

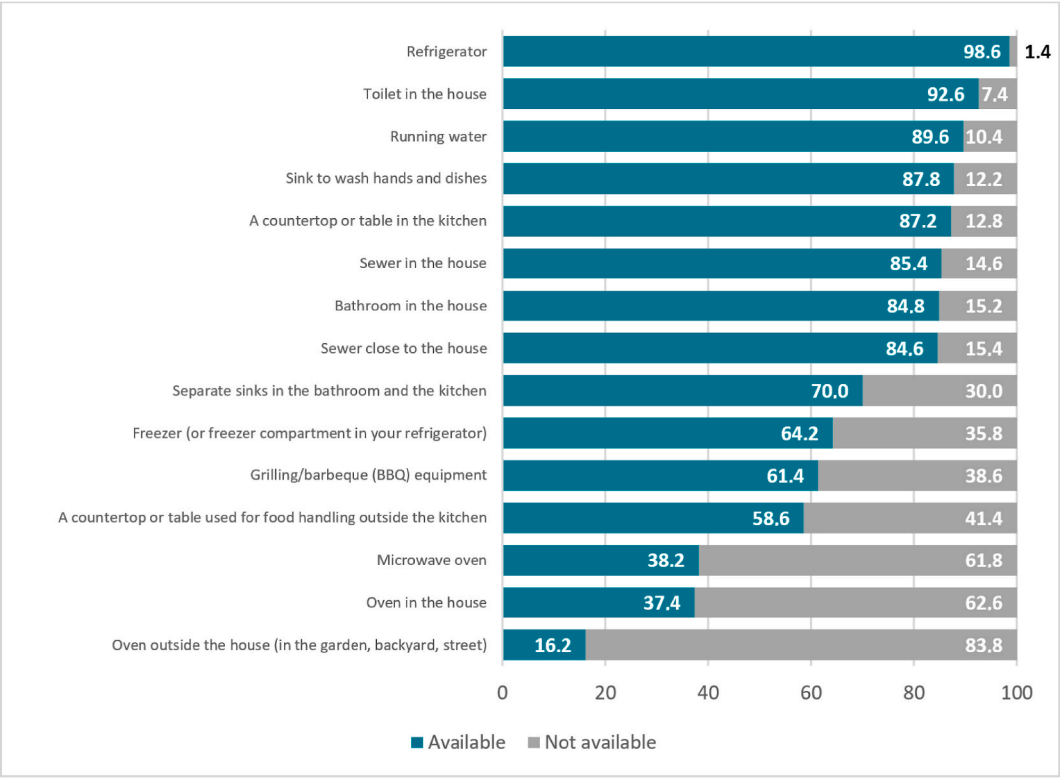

Fig. 4. Availability of different kitchen equipment in the respondents' households (%).

researchers have also concluded that in addition to the importance of personal hygiene, proper heat treatment and refrigerated food storage should be better educated in this region [45].

In light of these results, it is not surprising that the participants were also unconfident regarding the evaluation of their food safety knowledge. Both statements on this topic got mean scores below eight on the Likert-scale („I know a lot about bacteria and viruses in food": 6.83 ± 2.343; "I believe that I have a good knowledge about food safety": 7.81 ± 1.973). The lack of self-confidence can also be amplified, especially among the younger generations. Eating out or choosing takeaways is becoming more common, which means that people have less experience and, in parallel, less knowledge in preparing food at home [90].

Despite the confusion and lack of confidence, the survey participants evaluated the possession of food safety knowledge positively and seemed to be open to improvement according to the level of agreement in the case of related statements ("It is good to have knowledge on bacteria and viruses in food": 8.24 ± 1.957; "I intend to improve my food safety knowledge and practices": 8.40 ± 1.839). The need for safe food handling also derives from an external urge: the survey participants feel that their families and friends expect this (8.08 ± 2.105) as well as washing hands (8.26 ± 1.995).

Handwashing does not appear to be challenging for consumers regarding intentions and perceived behavioural control. 91.2 % of the participants were determined to always wash their hands before eating or cooking, and 87.6 % deemed proper handwashing as easy (they chose 7–10 on a 1-10-point scale). Personal hygiene, especially handwashing, is one of the weakest ways to prevent foodborne illnesses in Laos. As mentioned in the Introduction, access to safe water and soap, and generally to handwashing facilities, is insufficient [7]. The basics for ensuring a hygienic environment, such as running water, sewers in the house, separate toilets, sinks, and countertops, were available in 80–90 % of the respondents' households (Fig. 4). These results suggest that several Lao household kitchen appliances and environments should be appropriate for implementing proper food safety practices in Vientiane Capital [91–96]. However, even if there is running water, a sink, or a handwashing facility, their location in the house or kitchen is important. or example, if the sink is far from the place of food preparation and cooking, especially if it is in another room (e.g., 30 % of the respondents do not have a separate sink in the kitchen, only in the bathroom), people are less likely to wash their hands properly between processes [97]. It should also be noted that households are certainly less equipped in rural areas than in the surveyed urban districts. The availability of kitchen equipment in the participants' households and their cooled storage habits are shown in Figs. 4 and 5.

As expected, based on the statements regarding the role of refrigerated storage, a non-negligible portion of the respondents did not store perishable foods in the refrigerator (if they had one), such as meat and fish (4.89 %) and leftovers (10.14 %) (Fig. 5). Although almost all the participants had a refrigerator in their household (98.6 %), the freezer was only available at 64.2 % (Fig. 4). In economically less developed or developing countries, the sustenance of refrigerators can often encounter difficulties; for example, providing electricity can cost more than families can afford [98]. Another possible source of risky food preparation was the lack of ovens or stoves within the respondents' households, as only 37.4 % of the respondents had these appliances (Fig. 4).

The survey also investigated exact food safety practices, about which the participants had to state how often the behaviour occurred based on their own declaration evaluated on a 4-point scale. Fig. 6 shows the results of this self-evaluation of the participants' food safety-related behaviours. The three most frequent behaviours the respondents consistently or regularly performed were washing hands before eating, proper heat treatment of meats, and storing them chilled until use. In terms of preventing cross-contamination by using separate chopping boards for different product types, most participants (44.3 % and 41.8 %) answered that they paid attention to this sometimes (Fig. 6). According to the results, these two practices were carried out least regularly in households. Only 9.2–9.2 % of respondents reported that they always used separate chopping boards. However, according to experience and observational studies, there is a significant difference between self-reporting and actual behaviour. People either do not perform food safety risk prevention practices (e.g., handwashing) properly or not at all, whether they are living in European or Asian countries (for example, Hungary [55] or Malaysia [99]).

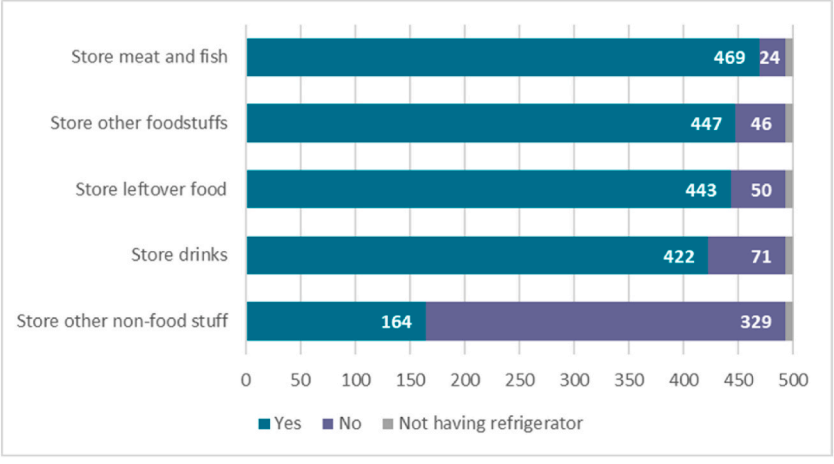

Fig. 5. What do respondents store in their refrigerators? – number of respondents is presented on the figure.

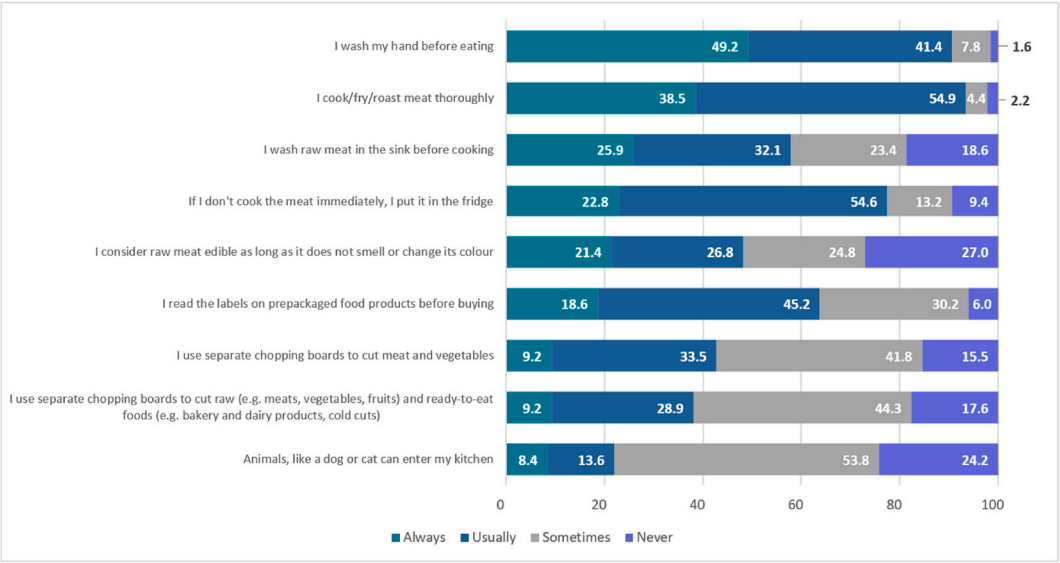

Fig. 6. The frequency (%) of certain behaviours carried out by the participants indicated on a 4-point scale (1: never, 2: sometimes, 3: usually, 4: always) based on self-report.

3.2. PLS-SEM model

The outer model's reliability (containing the indicators or so-called manifest variables built into the latent constructs) was evaluated based on the values of reliability, composite reliability, and Average Variance Extracted (AVE) (Table 4). The reliability of each manifest variable, presented by the standardized outer loading, was appropriate, as all variables exceeded 0.708 [100]. To monitor the convergent validity of the constructs, AVE is indicated in Table 4, where all the latent variables are higher than 0.50, which is the required minimum value [101]. According to the accepted interval of composite reliability (0.7–0.95) [102–104], all latent variables also correspond to the requirements of this index.

The discriminant validity of the outer model was confirmed using the Fornell-Larcker test [81,105]. As all the latent variables' square roots of AVEs are higher than the values from the test, the developed model is also appropriate in this regard. The model fit was assessed by the SRMR, which was under the threshold of 0.08 for the saturated model (0.076 in this case); therefore, it is also acceptable [106].

The path coefficients serve as the basis for evaluating the strength of the connections between the latent variables within the inner model. The significance of the path coefficients (correlations and regressions) and the empirical t-score estimated using the bootstrapping process are shown in Table 5. The most robust relationships were observed between the Perceived behavioural control and Intention elements, the Knowledge-Attitude, and Attitude-Intention elements. According to the results of Student's t-test, these paths

Table 4
Reliability of latent and manifest variables (indicators) of the TPB model based on the values of item reliability, AVE and composite reliability.

Latent variables	Indicator	Item reliability	AVE	Composite reliability
Knowledge			0.795	0.886
	V1	0.915		
	V2	0.867		
Attitude			0.694	0.819
	V3	0.808		
	V4	0.858		
Subjective norms			0.708	0.829
	V5	0.850		
	V6	0.833		
Perceived behavioural control			0.822	0.902
	V7	0.908		
	V8	0.905		
Intention			0.638	0.841
	V9	0.738		
	V10	0.848		
	V11	0.807		
Behaviour			0.780	0.875
	V12	0.790		
	V13	0.967		

showed the strongest significance ($p < 0.001$). Interestingly, only one element had a significant relationship with the target variable: the path coefficient between Perceived behavioural control and Behaviour was 0.200 ($p = 0.001$).

Cohen's f^2 values, which represent the size of the effects and show the contribution of the latent variables to the determination coefficient (R^2) of the explained variable, are also reported in Table 5. According to Cohen's recommendations about the effect sizes [107], the Perceived behavioural control had a moderate effect on the Intention construct; however, the other significant connections (Attitude-Intention, Knowledge-Attitude, Knowledge-Perceived behavioural control, Perceived behavioural control-Behaviour) were weak. Considering the results in Table 5, Knowledge, Attitude, and Perceived behavioural control latent variables appear to be the three most determinative elements of the model. For a better interpretation of the conclusions based on Table 5 for the inner model, Fig. 7 presents the results graphically.

The influence of the Knowledge element on Intention through Attitude and Perceived behavioural control is distinctly apparent in the strength of connections, significance, and sizes of effects (Fig. 7). Furthermore, the indirect connection between Knowledge and Behaviour is meaningful since Perceived behavioural control was the sole significant effect on target Behaviour. Similarly to these results, Mullan et al. (2013) identified Perceived behavioural control as the main contributor to the Behaviour in their study about the food hygiene behaviour of adolescents from Australia and the United Kingdom [77]. From the perspective of risk communication, improving Laotian consumers' food safety knowledge and strengthening their capability and confidence in safe food handling would be beneficial. In addition to the fact that the elements in the model have a noticeable influence on each other, the evaluation must consider the nearly most essential descriptors of the structural model. These are the determination coefficient (R^2) and the Stone-Geisser indicator (Q^2). R^2 refers to the portions of variance that the developed structure could explain, while Q^2 reveals whether the model has predictive relevance [81,104]. Table 6 list the determination coefficients and predictive validity scores for the developed model.

The structural model explains only 4.7 % of the target variable's variance (Behaviour) according to R^2, which can be classified as having a small effect below 13 % [83]. The model possesses predictive relevance regarding Behaviour, although 0.03 means a weak effect [82]. In parallel, Behaviour had the lowest Q^2 among each latent variable (Table 6), and Intention had the highest. Another study using hierarchical regression found that factors included in TPB did not effectively predict whether people would engage in safe food-handling practices. In the aforementioned study, only 3–12 % of the variance was explained [108] in contrast to previous research, where a stronger association was observed [109]. However, in the case of the Intention construct, Knowledge, Attitude, Subjective norms, and Perceived behavioural control might represent 45 % of the variance, which is considered a large effect. The variables used in the present study and the model built from them were more convincing in predicting the Intention factor than Behaviour factor, which is comparable to other studies [77,78,108].

Apparently, there is a gap between Intention and Behaviour, that is, between the behavioural intention and actual behaviour to follow safe food handling practices – in this case, to use separate chopping boards for different products. Due to the so-called intention-behavioural gap, only 50 % of intentions are usually translated into actual practices [79]. In this case, only approx. 10 % of the intentions lead to behaviours, which suggests that (together with the study by Mullan et al., 2015 [108]) there are situations, in which TPB is not the best choice. There are several barriers to following food safety guidelines and performing appropriate practices for consumers: beliefs and perceptions (e.g. safe practices took up too much time and effort, not considering food handling as a common source of illnesses, no one got sick previously etc.), laziness, lack of easy-to-follow instructions and consequently inconvenience, personal preferences (e.g. taste of raw eggs or meat) are all hindering factors even if consumers intend to handle food safely [72]. Another possible explanation is a lack of suitable household conditions for the application of appropriate practices. The kitchen is an essential site for preventing the transmission of foodborne illnesses because it is the entry point for food preparation, distribution, and storage of the foods [97,110].

According to the developed model regarding Lao consumers, extending knowledge, improving attitudes, and the perception of control should boost food safety behaviours. The results of the related variables on the Likert scale suggest that knowledge is the best point for the intervention. Fortunately, the attitudes and intentions of the respondents were positive towards receiving food safety information and guidance on safe practices.

3.3. Considering the results in the development of risk communication strategies

Nevertheless, it is important to note that while food safety knowledge can influence consumers' intentions significantly, it does not guarantee that these intentions will always turn into actual risk avoiding behaviour [68]. Factors such as convenience, time constraints, and ingrained habits can hinder the proper execution of food safety practices [111]. Cultural factors, including the widespread consumption of raw, undercooked, and fermented meat, must also be considered [44]. Past behaviours and habits, although significant predictors of future behaviours, are not conscious actions and do not require intentions; thus, they do not depend on motivation [108]. Therefore, safe practices picked up during childhood via education (especially practical education and personal experiences), when ingrained faulty behaviours do not yet exist, are more efficient in preventing foodborne illnesses in the long term [55,89]. However, the participants of this study believed that Lao students get a lot of information about food safety in schools; a survey highlighted that their knowledge of hygienic practices is insufficient [88]. Hence, developing a national food safety education programme should be included in the agenda. In the case of adults, continued efforts to raise awareness and promote food safety knowledge through risk communication, along with interventions to facilitate and encourage the adoption of safe practices, are essential for improving overall food safety at the consumer level.

Where resources and options for safe food preparation and storage are limited to a significant part of society, especially in rural areas, it is crucial to develop context-specific risk communication methods to increase food safety knowledge and improve food safety

Table 5
Characterization of the connections between the latent constructs of the TPB model and the size of the effects.

Path	Path Coefficients	t-score	p value	f^2
Attitude – Intention	0.254	5.073	0.000	0.080
Intention – Behaviour	0.024	0.364	0.716	0.000
Knowledge – Attitude	0.251	3.858	0.000	0.067
Knowledge – Behaviour	0.008	0.122	0.903	0.000
Knowledge – Perceived behavioural control	0.297	4.620	0.000	0.097
Perceived behavioural control – Behaviour	0.200	3.269	0.001	0.025
Perceived behavioural control – Intention	0.445	7.844	0.000	0.224
Subjective norms – Intention	0.090	1.642	0.101	0.009

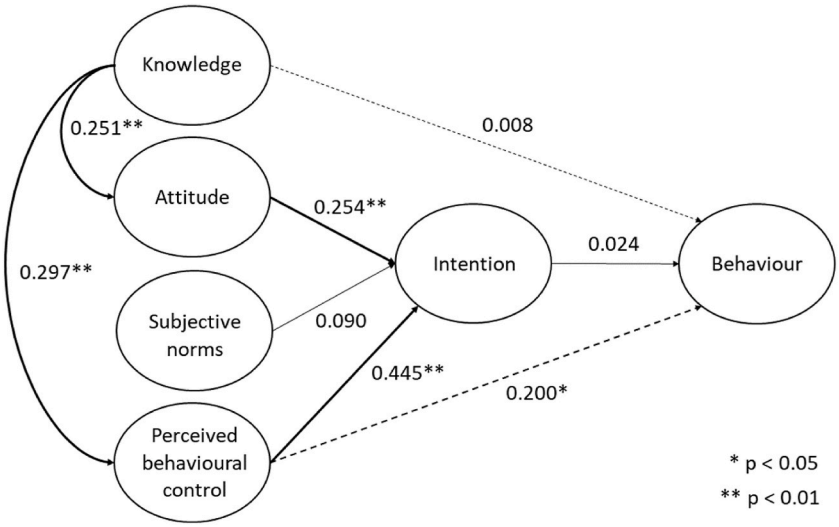

Fig. 7. The strength of the relationships between the latent variables within the TPB model, presented by the path coefficients (the thickness of the arrows shows the significance of the connection).

Table 6
Determination coefficients (R^2 and adjusted R^2) and predictive validity (Q^2) of the latent variables of the TPB model.

Latent variables	R^2	Adjusted R^2	Q^2
Attitude	0.063	0.061	0.041
Behaviour	0.047	0.042	0.030
Intention	0.450	0.447	0.278
Perceived behavioural control	0.088	0.086	0.071

practices. Besides common forms of risk communication, such as mass media campaigns, dissemination of visual materials (posters, leaflets), development of mobile phone applications, creating videos targeting specific behaviours, and more direct and communal approaches (e.g., school or community-based programs, engaging resident volunteers to reach households etc.) could be combined with training for farmers, food marketers, and street vendors [112]. The latter is crucial because many Laotian food consumers participate in food production. Therefore, in addition to the most critical points of home food preparation (necessity and technique of proper hand washing, refrigerated storage, heat treatment, and methods to prevent cross-contamination), the messages must also cover the rules of animal husbandry, plant cultivation, and food processing.

In addition, further in-depth research is needed on the topic, and the results should contribute to the improvement of the conditions of a healthy food supply chain by complying with appropriate standards and following Good Manufacturing Practices carried out by producers and processors of raw materials. Also, government bodies must utilize results of the research by developing and enforcing laws and regulations that serve food safety.

4. Conclusions

The study revealed that most Lao consumers are aware of the most essential food safety rules, although some gaps have been identified (e.g., the concept of risk prevention, and cooled storage etc.). The developed model based on the extended Theory of Planned

Behaviour highlighted that Knowledge and Perceived behavioural control elements positively influence food safety behaviours, such as using separate chopping boards for raw and ready-to-eat foods. Laotian people intend to follow food safety guidelines, and a considerable proportion of households also ensure suitable environments for safe practices; however, the participants did not consider themselves to have enough knowledge.

Consumer risk perception and risk management preparedness are expected to play a crucial role in Laos's future food policies. Considering the high prevalence of self-sustaining farming and proliferation of commercial agriculture a general understanding of food safety risks and risk mitigation must be significantly improved. The gaps identified in this study could be covered by food safety risk communication in the case of adults and the development of general education in the case of children. For both solutions, the authors recommended governmental interventions that could lead to more efficient, safe, and sustainable Lao agriculture. For these initiatives, the relevant public offices (Ministry of Agriculture and Fisheries, Ministry of Health, and province-level offices) accumulate all the necessary knowledge and proficiency, but these competences must be channelled to the general public through the already well-organised education system and to the everyday practices of Lao farmers and food processors through efficient risk communication practices.

4.1. Limitations of the investigation

While this study presents a generally positive picture, an important limitation is that: the sample collection was limited to Vientiane Capital, which is the most developed part of the country. Replication of this study in rural areas of Laos could deliver significantly different results. To mitigate this possible bias, the sample collection method aimed to recruit respondents with diverse demographic backgrounds.

5. Ethics and consent

Ethical compliance with the research methodology was verified by the Research and Innovation Committee of the University of Veterinary Medicine Budapest (approval number: 2023/10/17/1, date: October 17, 2023). Verbal informed consent was obtained from the respondents before they participated in the survey.

6. Data availability statement

Data will be made available on request.

CRediT authorship contribution statement

Gyula Kasza: Writing – original draft, Formal analysis, Conceptualization. **Tekla Izsó:** Writing – original draft, Visualization, Formal analysis. **Atilla Kunszabó:** Writing – review & editing, Investigation. **Dávid Szakos:** Writing – review & editing, Investigation. **István Lénárt:** Writing – review & editing, Project administration. **Emese Bozánné Békefi:** Writing – review & editing. **Khamphouth Vongxay:** Writing – review & editing, Investigation. **József Popp:** Writing – review & editing, Methodology. **Judit Oláh:** Writing – review & editing, Methodology. **Zoltán Lakner:** Writing – review & editing, Methodology. **Widya Satya Nugraha:** Writing – original draft, Visualization. **Lajos Bognár:** Supervision, Conceptualization. **Miklós Süth:** Supervision, Conceptualization.

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.heliyon.2024.e29725.

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