Food Control 158 (2024) 110253

Contents lists available at ScienceDirect

Food Control

journal homepage: www.elsevier.com/locate/foodcont

Consumers' raw poultry washing practices: A cross-sectional and observational study in eight Southeast Asian countries

Jan Mei Soon-Sinclair [a,*], Thanh Mai Ha [b,c], Mark Raguindin Limon [d], Iwan Vanany [e], Pornthipa Ongkunaruk [f], Pisidh Voe [g], Sayvisene Boulom [h], Fue Yang [h], Ikarastika Rahayu Abdul Wahab [i], Ruhil Hayati Hamdan [j], Mohd Hafiz Jamaludin [i,k], Cong Duan Dao [l]

[a] School of Health, Social Work and Sport, University of Central Lancashire, Preston, PR1 2HE, UK
[b] Department of Economics, Swedish University of Agricultural Sciences, Box 7013, 750 07, Uppsala, Sweden
[c] Faculty of Economics and Rural Development, Vietnam National University of Agriculture, Gia Lam District, Hanoi, Viet Nam
[d] Technical-Vocational and Livelihood Education Department, College of Teacher Education, Mariano Marcos State University, Laoag City, Ilocos Norte, 2900, Philippines
[e] Department of Industrial and Systems Engineering, Institut Teknologi Sepuluh Nopember, Surabaya, 60111, Indonesia
[f] Department of Industrial Engineering, Faculty of Engineering, Kasetsart University, Bangkok, 10900, Thailand
[g] Faculty of Agriculture and Food Processing, National Meanchey University, Sisophon, 010807, Cambodia
[h] Faculty of Agriculture, National University of Laos, Lao PDR
[i] Faculty of Agro-Based Industry, Universiti Malaysia Kelantan, 17600, Jeli, Kelantan, Malaysia
[j] Faculty of Veterinary Medicine, Universiti Malaysia Kelantan, 16100, Kota Bharu, Kelantan, Malaysia
[k] Faculty of Agriculture, Sultan Sharif Ali Islamic University, Sinaut Campus, TB1741, Brunei
[l] Faculty of Veterinary Medicine, Vietnam National University of Agriculture, Gia Lam District, Hanoi, Viet Nam

ARTICLE INFO

Keywords:
Cross contamination
Food safety
Hand hygiene
Raw poultry
Supermarket
Traditional market
wet market

ABSTRACT

Consumers are recommended not to wash raw poultry before cooking since this practice increases risks of cross contamination with foodborne pathogens. However previous studies had identified that consumers were unaware of this incorrect behaviour. This study aims to assess consumers' self-reported and observed raw poultry washing practices in Southeast Asian (SEA) countries. A mixed method design was employed, with data collected via a cross-sectional survey across eight SEA countries, observational studies and semi-structured interviews conducted in Indonesia and Malaysia. Ninety-six percent (n = 2009) of surveyed participants reported that they washed raw poultry at home. Participants from Laos and Philippines, older, married and low-income participants reported washing raw poultry more frequently. The main reasons for washing raw poultry were to remove dirt, slime, blood or feathers and the act of washing makes them feel safer. Participants from Cambodia (OR = 2.855, $p < 0.001$), Indonesia (OR = 3.208, $p < 0.001$), Laos (OR = 3.012, $p < 0.05$), Malaysia (OR = 2.003, $p < 0.05$) and Thailand (OR = 2.148, $p < 0.001$) were 2.00–3.21 times more confident about not washing raw poultry upon understanding the rationale that washing does not reduce microbial load. Participants who purchased from supermarkets (OR = 1.785, $p < 0.05$) were significantly more confident about not washing raw poultry compared to other sources of raw poultry. Our observation study identified various cross contamination pathways including lack of hand hygiene practices, inadequate cleaning and sanitation procedures, and cross contamination of raw poultry and washed water to surrounding areas. Semi-structured interviews revealed that participants preferred to wash raw poultry due to the lack of cleanliness of raw poultry purchased from traditional markets and the act is ingrained in their cultural practice. Due to consumers' preference for freshly slaughtered poultry and perceived cleanliness of raw poultry purchased from traditional markets, hand hygiene practices during and after handling raw poultry and cleaning of kitchen sinks and surrounding areas with soap should be emphasised. Targeted food safety messages and educational campaigns suited to local cultural differences should be conducted. This study presents the first empirical findings on consumers' raw poultry washing practices in eight SEA countries. Practical implications and further recommendations are provided.

* Corresponding author.
E-mail address: jmsoon-sinclair@uclan.ac.uk (J.M. Soon-Sinclair).

https://doi.org/10.1016/j.foodcont.2023.110253
Received 24 August 2023; Received in revised form 21 November 2023; Accepted 8 December 2023
Available online 14 December 2023

1. Introduction

Poultry consumption contributes to food security and nutrition in developing countries including most nations in Southeast Asia (SEA) (Mottet & Tempio, 2017). This region includes Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam. Five of the key emerging markets within the region including Indonesia, Malaysia, the Philippines, Thailand and Vietnam are projected to increase poultry production and consumption in the next decade due to increased income, population growth, and increasing urbanisation (OECD, 2023; USDA, 2019). Live poultry and poultry products are often sold in traditional retail outlets such as wet markets and local butchers in the region. Poultry especially chicken posed a threat to human health due to risk of foodborne illnesses and because of its role in antimicrobial resistance (Lambraki et al., 2023). Studies from SEA region had isolated foodborne pathogens such as *Salmonella* spp. and *Campylobacter* spp. from retail chickens sold in Cambodia (Rortana et al., 2021), Indonesia (Yulistiani & Praseptiangga, 2019), Laos (Inthavong et al., 2022), Malaysia (Nidaullah et al., 2017), Thailand (Wangroongsarb et al., 2021), Vietnam (Nhung et al., 2018) and the Philippines (Santos, Widmer, & Rivera, 2020). According to Havelaar et al. (2015), SEA is one of the regions with the highest foodborne disease burden affecting between 690 and 710 Disability Adjusted Life Years (DALYs) per 100,000 population.

This highlights the importance of food safety practices in the poultry supply chain, including at-home food handling techniques. One of such food safety practices is not washing raw poultry at home (FSA, 2020; Health Canada, 2019; USDA, 2022). Previous studies had identified that washing raw poultry at home (prior to cooking) were common. For example, 73.5% (n = 1340) of US consumers (Vatral, Gilman, & Quinlan, 2022) and 64% (n = 333) of consumers in Canada (Young, Sekercioglu, & Meldrum, 2020) reported washing or rinsing raw poultry before cooking. Twenty nine percent (n = 56) of US (Mazengia, Fisk, Liao, Huang, & Meschke, 2015) and 20% (n = 100) UK consumers (Evans & Redmond, 2018) were observed washing raw poultry. It is recommended that raw poultry and meat should not be washed before preparation to reduce the risk of foodborne illnesses due to cross contamination (FSA, 2020; Health Canada, 2019; USDA, 2022). Washing or rinsing raw poultry do not reduce microbial load. Instead, the action would spread microorganisms up to 70 cm during washing (Everis & Betts, 2003). There is a growing body of literature that studied the spread of microorganisms in domestic kitchens associated with consumer's handling practices of raw poultry (Cardoso, Ferreira, Truninger, Maia, & Teixeira, 2021; Møretrø et al., 2021; Shumaker et al., 2022). There is evidence from Asia documenting 46% (n = 101) of consumers from South Korea (Koppel, Suwonsichon, Chitra, Lee, & Edgar Chambers, 2014) to 99.5% (n = 200) of consumers in Egypt (Habib et al., 2020) who reported washing raw poultry during preparation. However, few studies have investigated this practice in Southeast Asia (Koppel et al., 2014; Soon, Wahab, Hamdan, & Jamaludin, 2020). There is also an absence of research that utilises a mixed method approach such as cross-sectional study, observations and semi-structured interviews to investigate consumers' raw poultry washing practices in the region. Mixed method approach provides a richer understanding of participants' beliefs and practices about food safety. It is also possible to reveal potential discrepancies between their beliefs, self-reported practices and observed food safety practices (da Cunha, de Rosso, Pereira, & Stedefeldt, 2019; Meysenburg, Albrecht, Litchfield, & Ritter-Gooder, 2014). As each single method has their benefits and limitations, thus the triangulation with data from survey, observation of raw poultry washing practices and semi-structured interviews will improve the reliability of data (Creswell & Creswell, 2017; Her, Seo, Choi, Pool, & Ilic, 2019). The aim of this study was to assess consumers' self-reported and observed behaviour of raw poultry washing practices. Moreover, the study also aims to determine if a food safety message or intervention information would improve consumers' perceived confidence to not wash raw poultry. Interventions such as educational campaigns had been reported by Henley, Gleason, and Quinlan (2016) and Partnership for Food Safety Education (2022) but studies had revealed that a high number of consumers were still unaware of the correct behaviour. As far as we know, no previous research has investigated the use of intervention information to not wash raw poultry among consumers in Southeast Asia. Socio-demographic factors play a role in modulating consumers' food safety practices, thus this study utilises ordinal logistic regression to determine the relations between socio-demographic factors and raw poultry washing practices. Based on a mix of data collection methods to assess consumers' practices in 8 out of 10 SEA countries, the study provides an important insight into SEA consumers' behaviour in washing raw poultry and can make recommendations tailored to local context.

2. Methodology

A cross-sectional survey on consumers' raw poultry washing practices before cooking was conducted in eight Southeast Asian countries (Brunei, Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, the Philippines, Thailand and Vietnam). This was followed by observational studies and semi-structured interviews in Indonesia and Malaysia. While the survey captured self-reported behaviour in washing raw poultry, the observational study revealed the actual behaviour. Self-reported data in behavioural and health care research is prone to response bias (Rosenman, Tennekoon, & Hill, 2011), which is the difference between the behaviour reported by participants and their actual behaviour due to perceived social-desirability, for example. Thus, in this study, observational method was used to validate and confirm the survey results. Furthermore, consumers have many reasons or beliefs towards not washing raw poultry (Vatral et al., 2022). Semi-structured interviews (qualitative approach) were employed as a complement to the survey method (quantitative approach) to explore in-depth such reasons from a consumer's perspective. In these regards, the validity of the study' results can be enhanced. The study was reviewed and approved by the UCLan HEALTH Ethics Committee (Reference No. 456).

2.1. Questionnaire development

The survey questionnaire was designed based on previous studies on food safety risk assessment, consumers' perception and handling of raw poultry at home (Katiyo, de Kock, Coorey, & Buys, 2019; Kosa, Cates, Bradley, Edgar Chambers, & Godwin, 2015; Myintzaw, Moran, & Jaiswal, 2020; Vatral et al., 2022). The questionnaire was divided into four sections: (i) demographics (10 questions); (ii) raw poultry washing practices (7 questions); (iii) knowledge (5 questions); and (iv) food safety message and confidence in not washing raw poultry practice (1 question). The food safety message serves as an intervention information of safe poultry washing. The demographics section asked participants about their gender, age, marital status, income level and if they had experienced food poisoning. Section 2 elicited raw poultry washing practices. Examples of questions in Section 2 include 'Where do you or your household members buy raw poultry most frequently?', 'Do you wash the raw poultry before cooking?' and 'If yes/no, could you explain why?'. Additionally, participants were asked to answer the following hypothetical scenario: "Assuming that the raw poultry is slaughtered according to food safety standards, would you wash raw poultry?" This variable, hereafter called "assumption of habit strength" indirectly captures the extent to which washing raw poultry is automatic or persistent. A positive response implies a stronger habit since regardless of the safety conditions of poultry, respondents are likely to maintain their current habit (i.e., washing raw poultry). In contrast, a negative response suggests that respondents have the intention to change or move away from the current habit due to improved food safety conditions. The negative response therefore reflects a lower level of persistency in respondents' habit of washing raw poultry.

In the knowledge section, participants were provided with 'Yes', 'No' and 'Uncertain' options. This section measures participants' knowledge of food safety practices such as 'Raw poultry can make me sick if not cooked adequately' and 'Raw poultry that looks clean does not transfer harmful bacteria to other foods or kitchen surfaces.' Questions that were answered correctly were scored 1 point and incorrect or uncertain answers were awarded 0 point. The total knowledge score equals = 5 points. The purpose of section 4 was to capture participants' perceived confidence in not washing raw poultry. To do so, a message based on food safety and health organisations' recommendations (FSA, 2020; Health Canada, 2019; USDA, 2022) was provided to them: '*Washing raw* poultry *at home does not remove germs. By washing raw* poultry*, you can spread germs in the food preparation area. It is unnecessary to wash raw* poultry *that has been slaughtered according to food safety standards since the germs will be destroyed when it is cooked adequately.*' After reading the message, participants were asked 'How confident are you to stop washing raw poultry after reading the message above?' Responses were on a 5-point Likert scale ranging from 1 (Not confident at all) to 5 (Very confident). It has been documented that the lack of knowledge is among the causes of incorrect handling of raw poultry and thus innovative food safety education interventions can enhance consumers' awareness and promote behavioural change (Henley et al., 2016). Given the scope of this study, we used the simple educational message above to address the knowledge gap among surveyed participants and to examine their responses to this educational message; that is their level of confidence in not washing raw poultry after being equipped with food safety information. According to Kraft, Rise, Sutton, and Roysamb (2005), perceived confidence was identified as one of the variables of perceived behavioural control (in addition to perceived control and perceived difficulty) in the Theory of Planned Behaviour. In this case, such confidence level can be regarded as a proxy of behavioural intention towards not washing raw poultry, as perceived confidence in adopting a behaviour is positively associated with intention to perform it, as proposed by Theory of Planned Behaviour (Ajzen, 2011).

Pilot surveys were conducted with 15 participants from Indonesia and 17 from Thailand. Test-retest reliability was used to examine the stability of scores of perceived confidences over two weeks period. Pearson correlation test was 0.693 ($p < 0.05$) indicating moderate reliability. Questionnaire was translated from English into Khmer, Bahasa Indonesia, Laotian, Bahasa Melayu, Filipino, Thai and Vietnamese and back translated into English. English questionnaire was used in Brunei. All questionnaires were uploaded onto onlinesurvey. ac.uk and pre-tested to ensure the logic and sequence of questions were correct. The eligibility criteria include 18 years or older, prepare raw poultry at home and are current residents in their respective countries. The online surveys were shared widely using social media in each country and snowball sampling approach was used to recruit participants. The questionnaire is available in Supplementary Material 1.

2.2. Observation and semi-structured interviews

Observation and interview guide were adapted from Evans and Redmond (2018), Gilman, Henley, and Quinlan (2022) and Moretro et al., (2021). Participants in Indonesia and Malaysia who self-reported that they prepared raw poultry at home in the online survey were invited to participate in the observation study. The eligibility critera were age ≥18 years and prepare raw poultry at home. Two research assistants well versed in food safety were trained in observation and interviewing techniques. A video clip on washing of raw poultry was shown to both research assistants and they completed the checklist. Results were reviewed and discordant notifications were discussed (Sax et al., 2009). The intra-class coefficient was calculated to determine the inter-rater reliability (ICC). ICC value of 0.73 was achieved indicating moderate reliability (Koo & Li, 2016). Appointments were made with eight participants (four from each country) to visit their home, preferably at a time when participants prepared a poultry dish. Participants were provided with an explanation of the study and opportunity to ask questions and consent were obtained. Participants were told that the purpose of the study was to explore how consumers prepared their poultry dish and were instructed to prepare the dish as they normally would. Participants were observed from the point when they started handling the raw poultry, preparation and washing of raw poultry. Potential routes of cross contamination and hand hygiene practices were noted. Semi-structured interviews were conducted after the observations to provide deeper insights into why participants washed raw poultry before cooking. Interviews lasted between 15 and 20 min. Participants were then informed of the study's purpose and participants had the option to opt out of the study.

2.3. Data analysis

Normality was assessed using Shapiro-Wilk test. Descriptive statistics were conducted to provide a general picture of participants' raw poultry washing practices. Fisher's exact chi-squared test was performed to identify the association between demographic variables and washing raw poultry practices. Spearman's rho was conducted to assess correlation between washing raw poultry behaviour and total knowledge and between washing raw poultry behaviour and assumption of habit strength. Kruskal Wallis was employed to test the possible difference in perceived confidence in not washing raw poultry across the studied countries. Ordered logistic regression was carried out to determine if socio-demographic factors and responses to a hypothetical scenario on washing practice (assumption of habit strength) affect participants' perceived confidence in not washing raw poultry. Given the ordinal nature of this dependent variable, ordered logistic regression was employed. Independent variables were assumption of habit strength and demographic characteristics including country, gender, age, marital status, education level, employment, income level, number of children and/or elderly household members, the most frequent purchasing place of raw poultry, and experience of food poisoning. Sensitivity analysis was performed to determine how sensitive the results were to exclusion of countries with small sample sizes i.e., less than 100 responses (Model 1) and countries with less than 200 responses (Model 2). P-value <0.05 was considered statistically significant. Semi-structured interviews were transcribed, translated into English and thematically analysed according to Braun and Clarke (2006) and Pilamala Rosales, Linnemann, and Luning (2023).

3. Results

A total of 2009 responses were eligible for data analyses. Table 1 shows the demographic profiles of the respondents from eight Southeast Asian countries. The majority of participants were females, employed, highly educated, married and lived in urban areas.

4. Self-reported practices and knowledge

More than 45% of participants purchased raw poultry products from traditional or wet markets. Ninety-six percent of participants reported that they washed raw poultry at home before cooking. Several of the main reasons for this washing practice were to remove dirt, slime, blood or feather and the act of washing makes them feel safer. There is also a general misunderstanding that washing raw poultry helps to remove germs. Participants mostly learnt the practice from their family members or through their own experiences. Salt was the most preferred ingredient used to wash raw poultry. It is interesting to note that the number of participants who would not wash raw poultry increased from 4.0% to 16.9% if they perceived that the product has been slaughtered according to food safety standards. More than 65% of the participants scored 4 points and above in the knowledge section. Participants were highly knowledgeable in the correct handwashing techniques and understood the implications of inadequate cooking or using the same

Table 1
Demographic characteristics of participants (n = 2009).

Demographics	Variables	Frequency (%)
Country	Laos	32 (1.6)
	Brunei	60 (3.0)
	Cambodia	99 (4.9)
	Malaysia	142 (7.1)
	Vietnam	302 (15.0)
	Thailand	379 (18.9)
	Indonesia	495 (24.6)
	Philippines	500 (24.9)
Gender	Male	632 (31.5)
	Female	1377 (68.5)
Age	18–29	938 (46.7)
	30–39	533 (26.5)
	40–49	368 (18.3)
	50–59	132 (6.6)
	60 and above	38 (1.9)
Education	Primary	7 (0.3)
	Secondary	77 (3.8)
	Tertiary	1925 (95.8)
Employment	Self-employed	219 (10.9)
	Employed	1453 (72.3)
	Unemployed/ Retired	82 (4.1)
	Student	255 (12.7)
Marital status	Single	605 (30.1)
	Married	1366 (68.0)
	Divorced	26 (1.3)
	Widowed	12 (0.6)
Residence	Urban	976 (48.6)
	Sub-urban	805 (40.1)
	Rural	228 (11.3)
Income level	Low	784 (39.0)
	Medium	425 (21.2)
	High	800 (39.8)
The presence of children less than 12 years old in the household	Yes	943 (46.9)
	No	1066 (53.1)
The presence of elderly (aged 65 years or above) in the household	Yes	633 (31.5)
	No	1376 (68.5)
Having household members, who have experienced food poisoning after eating poultry dishes prepared at home	Yes	267 (13.3)
	No	1742 (86.7)

chopping board for raw poultry and cooked food. However, almost half of the participants were unaware of the indicators of adequately cooked poultry. Spearman's rho revealed low but significant correlation co-efficients between washing raw poultry behaviour with total knowledge and assumption of habit strength. (Table 2).

There was significant association between country, age, marital status, residence, income level and source of raw poultry with washing raw poultry practice. Participants from Laos and Philippines, those aged 50 years and above, being married, low income and lived in sub-urban areas self-reported washing raw poultry more frequently. A higher % of participants who purchased raw poultry from farms, butchers and wet markets reported washing raw poultry (Table 3).

Fig. 1 shows participants' level of confidence in not washing raw poultry by country. All boxplots ranged between low score (1: Not confident all all) to high score (4.00: Confident). Cambodia, Indonesia and Laos had a median of 3. Kruskal Wallis test revealed significant difference between Philippines and the rest of the countries. Besides Brunei, Vietnam showed significant difference in their level of confidence compared to other countries (Table 4).

All socio-demographics and assumption of habit strength (response to a hypothetical scenario on raw poultry washing practice) were used as independent variables in the ordered logistic regression. The Philippines data were excluded from the regression analysis since the response to the item measuring perceived confidence (dependent variable) were

Table 2
Raw poultry washing practices (n = 2009).

Raw poultry washing practices	Items	Frequency (%)
Where do you or your household members buy raw poultry most frequently?	**Traditional or wet market**	**966 (48.1)**
	Supermarket	606 (30.2)
	Butcher	240 (11.9)
	Mobile hawker	98 (4.9)
	Farm	20 (1.0)
	Others	79 (3.9)
Do you wash the raw poultry bought from the place you mentioned above before cooking?	Yes	1929 (96.0)
	No	80 (4.0)
Assuming that the raw poultry you bought has been processed according to food safety standards, are you going to wash the poultry at home before cooking?	Yes	1670 (83.1)
	No	339 (16.9)
Participants were able to select more than one options in the questions below.		
If yes, could you explain why?	To remove blood or feather	1301 (64.8)
	To remove germs	1163 (57.9)
	To remove dirt or slime	**1317 (65.6)**
	To remove odour	1076 (53.6)
	To remove preservatives	585 (29.1)
	It is my habit	805 (40.1)
	I feel safer	1170 (58.2)
	I do not feel confident with the cleanliness of the poultry processing area	954 (47.5)
	Others	129 (6.4)
If yes, where did you learn to wash raw poultry at home before cooking?	**Family and friends**	**1431 (71.2)**
	Television	195 (9.7)
	Social media	316 (15.7)
	School/college/university	161 (8.0)
	Cookbook	162 (8.1)
	From own experience	994 (49.5)
	Others	87 (4.3)
If yes, do you use any of the following to wash raw poultry at home?	**Salt**	**1194 (59.4)**
	Lime juice or vinegar	590 (29.4)
	Ginger/other herbs	271 (13.5)
	Baking soda	76 (3.8)
	Hot water	485 (24.1)
	Others	497 (24.7)
If you do not wash raw poultry at home before cooking, could you explain why?	I was taught not to wash raw poultry before cooking	20 (1.0)
	To prevent cross contamination in the kitchen	**46 (2.3)**
	To save water	1 (0.1)
	To save time	7 (0.4)
	Others	20 (1.0)
Knowledge	**Correct answers**	**Number of correct responses (%)**
Raw poultry can make me sick if not cooked adequately.	True	1691 (84.2)
Raw poultry that looks clean does not transfer harmful bacteria to other foods or kitchen surfaces.	False	1223 (60.9)

(*continued on next page*)

Table 2 (*continued*)

Raw poultry washing practices	Items	Frequency (%)
Poultry is cooked properly when the juice is clear and not pink.	True	1028 (51.2)
The same chopping board can be used for both raw poultry and cooked food.	False	1616 (80.4)
Hands should be washed with soap and water after handling raw poultry.	True	1923 (95.7)
Knowledge scores	**Total correct answers**	**Frequencies (%)**
	0	13 (0.6)
	1	39 (1.9)
	2	142 (7.1)
	3	475 (23.6)
	4	967 (48.1)
	5	373 (18.6)
Correlation		**Spearman's rho**
Washing raw poultry behaviour and total knowledge		0.05*
Washing raw poultry behaviour and assumption[a]		0.32**

a: Response to a hypothetical scenario on raw poultry washing practice. *$p < 0.05$; **$p < 0.001$.

consistent for all respondents. The likelihood ratio chi square test [$\chi^2(30) = 291.865$, $p < 0.001$] indicated a significant improvement in fit compared with the null (no predictors) model. The likelihood ratio chi square tests were significant for country (Cambodia, Indonesia, Laos, Malaysia and Thailand), source of raw poultry, and assumption of habit strength. Specific country effects were determined in the ordered logistic regression. Cambodia (OR = 2.855, $p < 0.001$), Indonesia (OR = 3.208, $p < 0.001$), Laos (OR = 3.012, $p < 0.05$), Malaysia (OR = 2.003, $p < 0.05$) and Thailand (OR = 2.148, $p < 0.001$) were significantly more confident than Vietnam (Vietnam is coded as the reference value) in not washing raw poultry after reading the food safety message. Negative coefficient values were associated with less confidence about not washing raw poultry. For example, households with young children or elderly members were less confident about not washing raw poultry before cooking. Participants who purchased from supermarkets (OR = 1.785, $p < 0.05$) were significantly more confident about not washing raw poultry compared to other sources (other sources are coded as the reference value). If participants perceived that the raw poultry has been slaughtered accordingly and met the food safety standards, they were also significantly more confident about not washing raw poultry (OR = 4.007 $p < 0.001$) (Table 4).

The findings from sensitivity analysis i.e., Model 1 (Supplementary Table 2) and Model 2 (Supplementary Table 3) were compared with the full model. Results were largely consistent with the main results presented in Table 4.

5. Observation

Raw poultry washing and handwashing practices of eight participants from Indonesia and Malaysia were observed. All of them rinsed or washed raw poultry before cooking. The time spent washing and preparing raw poultry ranged from 21 s to 20.6 min. All participants rinsed or washed raw poultry in their kitchen sinks equipped with tap water. The washing procedures ranged from simple rinsing under the tap to soaking and rubbing each individual pieces of chopped raw poultry with flour and salt and rinsed several times (Table 5). Besides washing raw poultry, multiple cross contamination actions were observed during the practice. This includes inadequate hand hygiene practices before or after handling raw poultry. The observed behaviour did not match the knowledge of the participants in the survey where more than 95% of the participants agreed that hands should be washed with soap and water after handling raw poultry. In the observed study, participants did not wash their hands before handling raw poultry or before using utensils or touching ingredients such as flour and salt. Other cross contaminating actions were also revealed. For instance, participants did not wash utensils and sink with soap and water after handling raw poultry. In some cases, utensils that were cleaned with soap and water were cross contaminated with raw poultry trimmings in the sink. There were also instances where contaminated washed water was splashed onto other kitchen surfaces and into soap dish.

Semi-structured interviews were conducted with all participants. Two main themes ('Cleanliness, safety and source of raw poultry' and 'Maintain *status quo* of washing raw poultry') emerged from the thematic analysis.

6. Cleanliness, safety and source of raw poultry

All participants revealed that washing or rinsing raw poultry makes them feel cleaner and safer. Most participants learnt the act of washing raw poultry from their mother or grandmother. Participant 2 learnt the practice from healthcare professional whilst P6 learnt from YouTube. Some participants used flour, salt and lime 'to reduce germs' and as safety precautions. The ingredients were also added to reduce the smell of raw poultry.

> *'We must wash it before cooking, then we can eat it in a proper way. It also felt safer and cleaner.'* P8, Malaysia

All participants purchased raw poultry from wet markets. Based on their observation, they were not confident of the hygiene and cleanliness of poultry sellers at their local markets.

> *'I've seen dirty raw chicken and there were still sand on them.'* P3, Indonesia

> *'I feel unsafe as the raw poultry came from the wet market. They do not have a proper way of handling raw chicken and the surrounding is dirty.'* P7, Malaysia

7. Maintain *status quo* of washing raw poultry

Participants were informed about the message not to wash raw poultry and explanation was given why one should not wash raw poultry before cooking. None of the participants were aware of the food safety message. When participants were asked if they would be willing to change their current washing practices, two participants from Indonesia reported yes. This qualitative finding further supported the survey data where participants from Indonesia were more confident about modifying their practice of washing raw poultry after reading and understanding the food safety message. The rest of the surveyed participants reported that they would continue with the practice due to their perception of cleanliness, culture and faith. Three participants from Malaysia also revealed that no action needs to be taken by healthcare authorities or poultry industry whilst participants from Indonesia were more receptive of change.

> *'If raw poultry should not be washed, consumers should be made aware.'* P2, Indonesia

> *'I would still wash raw poultry even now that I am aware of it. It is my culture, and I am used to it. There is no need for any campaigns or plans to encourage consumers not to wash raw poultry'* P5, Malaysia

8. Discussion

The findings indicate a significant number of consumers wash raw poultry before cooking. Older consumers, those who were married, on low-income and who purchased raw poultry from farms, butchers or wet markets were significantly associated with washing raw poultry. The results are consistent with Vatral et al. (2022) who identified that older adults, consumers with lower annual income and those from ethnic

Table 3
Chi-square association between sociodemographic variables and washing raw poultry practices (n = 2009).

Demographics	Variables	Yes Frequency (%)	No Frequency (%)	Chi-square test		Fisher's exact test	df	Cramer's V
				X^2	*p*	*p*		
Country				**59.59**	**<0.001**	**<0.001**	7	0.17**
	Brunei	58 (96.7)	2 (3.3)					
	Cambodia	94 (94.9)	5 (5.1)					
	Indonesia	474 (95.8)	21 (4.2)					
	Laos	32 (100.0)	0					
	Malaysia	138 (97.2)	4 (2.8)					
	Philippines	500 (100.0)	0					
	Thailand	341 (90.0)	38 (10.0)					
	Vietnam	292 (96.7)	10 (3.3)					
Gender				0.61	0.464	0.464	1	0.02
	Male	610 (96.5)	22 (3.5)					
	Female	1319 (95.8)	58 (4.2)					
Age				**10.81**	**0.032**	**0.028**	4	0.07
	18–29	906 (96.6)	32 (3.4)					
	30–39	511 (95.9)	22 (4.1)					
	40–49	344 (93.5)	24 (6.5)					
	50–59	131 (99.2)	1 (0.8)					
	60 and above	37 (97.4)	1 (2.6)					
Education				3.31	0.200	0.241	2	0.04
	Primary	7 (100)	0					
	Secondary	71 (92.2)	6 (7.8)					
	Tertiary	1851 (96.2)	74 (3.8)					
Marital status				**32.06**	**<0.001**	**<0.001**	3	0.13**
	Single	563 (93.1)	42 (6.9)					
	Married	1333 (97.6)	33 (2.4)					
	Divorced	22 (84.6)	4 (15.4)					
	Widowed	11 (91.7)	1 (8.3)					
Residence				**12.82**	**0.002**	**0.002**	2	0.08**
	Urban	923 (94.6)	53 (5.4)					
	Sub-urban	788 (97.9)	17 (2.1)					
	Rural	218 (95.6)	10 (4.4)					
Employment				3.44	0.319	0.256	3	0.04
	Self-employed	207 (94.5)	12 (5.5)					
	Employed	1402 (96.5)	51 (3.5)					
	Unemployed/Retired	77 (93.9)	5 (6.1)					
	Student	243 (95.3)	12 (4.7)					
Income level				**12.81**	**0.002**	**0.001**	2	0.08*
	Low	768 (98.0)	16 (2.0)					
	Medium	404 (95.1)	21 (4.9)					
	High	757 (94.6)	43 (5.4)					
Children				2.24	0.139	0.139	1	0.03
	Yes	912 (96.7)	31 (3.3)					
	No	1017 (95.4)	49 (4.6)					
Elders				0.62	0.464	0.464	1	0.02
	Yes	611 (96.5)	22 (3.5)					
	No	1318 (95.8)	58 (4.2)					
Food poisoning				0.05	0.870	1.000	1	0.01
	Yes	257 (96.3)	10 (3.7)					
	No	1672 (96.0)	70 (4.0)					
Source of raw poultry				**31.17**	**<0.001**	**<0.001**	5	0.13**
	Traditional/wet market	943 (97.6)	23 (2.4)					
	Supermarket	563 (92.9)	43 (7.1)					
	Butcher	236 (98.3)	4 (1.7)					
	Mobile hawker	95 (96.9)	3 (3.1)					
	Farm	20 (100.0)	0					
	Others	72 (91.1)	7 (8.9)					

*$p < 0.05$; **$p < 0.001$.

minority groups such as Asians were more likely to wash raw poultry. Previous studies in Asia found that 46% (n = 101) consumers from South Korea, 75% (n = 133) consumers in India, 48% (n = 100) from Thailand (Koppel et al., 2014), 83% (n = 787) consumers in Malaysia (Soon et al., 2020), 99.5% (n = 200) in Egypt and 97.2% (n = 250) in Iraq (Habib et al., 2020) reported washing raw poultry during preparation.

According to Vatral et al. (2022), many consumers wash raw poultry because they were not aware of the correct behaviour. Vatral et al. (2022) study was conducted in the United States, where U.S. Department of Agriculture (USDA, 2022) has recommended that consumers do not wash raw poultry. However, in SEA countries, there is no such recommendation or official food safety message that consumers should not wash raw poultry before cooking. Our study revealed that several factors play a role on why consumers wash raw poultry before cooking. The perceived cleanliness, safety and incorrect knowledge that washing helps to remove germs were known to affect consumers' raw poultry washing practices. All the interviewed participants revealed that they washed raw poultry as the act makes them feel cleaner and safer. This could potentially be linked to the origins of the purchased raw poultry. In this study, the source of raw poultry was found to be significantly associated with washing raw poultry, especially when purchased directly from farms, butchers or wet markets. For example, all the participants who were observed, purchased freshly slaughtered poultry from local wet markets.

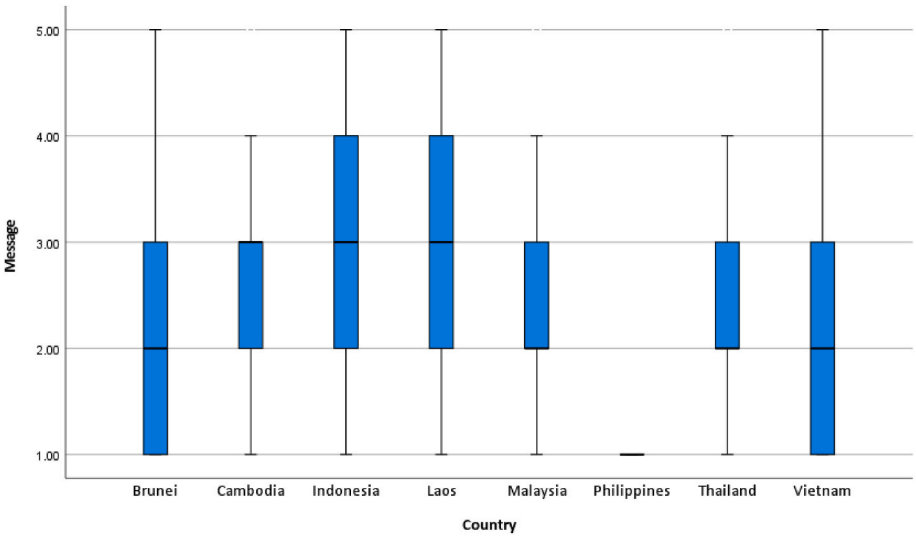

Fig. 1. Self-reported confidence among eight Southeast Asian countries on not washing raw poultry after reading a food safety message (n = 2009). Message = *Washing raw* poultry *at home does not remove germs. By washing raw* poultry, *you can spread germs in the food preparation area. It is unnecessary to wash raw* poultry *that has been processed according to food safety standards since the germs will be destroyed when it is cooked adequately.*' After reading the message, participants were asked 'How confident are you to stop washing raw poultry after reading the message above?' Responses are on 5-point Likert scale ranging from 1 (Not confident at all) to 5 (Very confident).

Live poultry are often purchased from farm and consumers would slaughter the poultry at home, and this requires washing to remove blood, faeces and feather. It is possible that some butchers and wet markets sell both live and slaughtered poultry (Naguib et al., 2021). Slaughtering and chopping of raw poultry products are often done upon receiving purchase orders from customers. Asian consumers tend to perceive the freshness of newly slaughtered poultry meat to be better than chilled or frozen poultry (Cui et al., 2022; Indrawan, Christy, & Hogeveen, 2021). The hygienic practices at butcher shops and wet markets are not sufficient due to inadequate hygiene, improper disposal of faeces and blood, improper disposal of carcasses, improper storage of live and slaughtered carcasses, overcrowding of live poultry and inadequate handwashing facilities (Aiyar & Pingali, 2020; Patchanee et al., 2016; Soon & Abdul Wahab, 2021). These factors may be a cause for concern and trigger consumers to wash raw poultry at home. This was evident during the observation of participants' washing and rinsing of raw poultry at home, where some participants would remove feathers and innards from bird cavities during washing. Similarly, our results were supported by the regression findings where participants who purchased from supermarkets were more confident in not washing raw poultry. Poultry and meat products sold in supermarkets in SEA are required to meet retailers' food safety standards and are often pre-packaged and sold under refrigeration (Minami et al., 2010). Studies had also detected lower levels of *Salmonella* spp. in supermarket meat and poultry products compared to wet markets (Minami et al., 2010; Shafini, Son, Mahyudin, Rukayadi, & Zainazor, 2017; Thung et al., 2016).

There is also a misperception about using ingredients such as salt or lime juice to reduce microbial contamination. Studies had found that consumers use vinegar, lemon, flour, salt, lime and soap when they wash raw poultry due to beliefs that these ingredients would remove microorganisms from raw poultry (Gilman et al., 2022; Habib et al., 2020; Vatral et al., 2022; Vatral & Quinlan, 2021). Washing raw poultry with acidic solutions such as diluted lemon, lime juice or vinegar were found to be ineffective (Henley, Launchi, & Quinlan, 2018). Though using essential oils derived from herbs, organic acid salts and acids used in combination with modified atmosphere packaging was found effective in controlling microbial load (Heir et al., 2022; Karam, Roustom, Abiad, El-Obeid, & Savvaidis, 2019), the different amount, contact time of added ingredients during washing and storage conditions used by consumers make it highly difficult to evaluate their effectiveness (Habib et al., 2020). It is posited that ingredients such as flour and lime were added during the washing or soaking process to reduce raw poultry smell and participants were driven to use such ingredients for organoleptic purposes rather than safety. Similarly, Habib et al. (2020) demonstrated that participants added additional ingredients to mask unwanted smell and reduce sliminess of raw poultry.

Various cross contamination pathways were identified during the observation. One of such contamination was not washing hands whilst handling raw poultry and then touching ingredients such as flour and salt with unwashed hands. Alves, Santos-Ferreira, Magalhães, Ferreira, and Teixeira (2022) and Santos-Ferreira et al. (2021) identified cooking salt as an indirect cross contamination route for foodborne pathogens from contaminated chicken to ready-to-eat salads via unwashed hands. Other contamination pathways observed during the washing procedure could lead to contamination with foodborne pathogens on kitchen surfaces such as the sink, chopping board, kitchen cloth and refrigerator door handle as demonstrated by Cardoso et al. (2021) and Evans and Redmond (2018).

Our study's survey indicates that only a small share of participants (17%) may change their behaviour if the raw poultry were slaughtered according to food safety standards. This was supported by our ordered logistic regression findings where participants who felt that the raw poultry has been slaughtered accordingly and met food safety standards, they were also significantly more confident about not washing raw poultry. Meanwhile, 15.3% of participants were quite or very confident about not washing raw poultry after reading the food safety message. In contrast, Vatral et al. (2022) found that consumers in USA were more likely to change their behaviour after being presented with a message explaining why washing raw poultry is not safe. In their study, more than 80% of the participants reported somewhat to very confident that they would change their behaviour. Our study's semi-structured interviews further demonstrated that the practice of washing raw poultry was heavily ingrained in the daily lives, cultures and social norms of consumers in SEA. This might be one of reasons for the difference between our results and Vatral et al. (2022). Given the social and cultural embeddedness of the practice in SEA, it would be difficult to change consumer behaviour without further education and understanding of the barriers faced. It is highly challenging to recommend to consumers not to wash raw poultry in countries where the source and preparation

Table 4
Ordered logistic regression predicting consumers' level of confidence on not washing raw poultry after reading a food safety message (n = 1484).

Items	B(SE)	Odds ratio	95% CI
Country[a]			
Brunei	0.06 (0.305)	1.062	[0.584–1.928]
Cambodia	1.049 (0.253)**	2.855	[1.738–4.689]
Indonesia	1.166 (0.171)**	3.208	[2.293–4.488]
Laos	1.102 (0.378)*	3.012	[1.435–6.321]
Malaysia	0.694 (0.215)*	2.003	[1.314–3.052]
Thailand	0.764 (0.188)**	2.148	[1.487–3.101]
Vietnam	0	1	
Gender			
Male	0.123 (0.106)	1.131	[0.919–1.393]
Female	0	1	
Age			
18–29	0.580 (0.377)	1.787	[0.853–3.743]
30–39	0.494 (0.364)	1.639	[0.802–3.347]
40–49	0.257 (0.367)	1.293	[0.630–2.654]
50–59	−0.076 (0.382)	0.927	[0.439–1.959]
60 and above	0	1	
Education[b]			
Secondary	0.101 (0.231)	1.106	[0.703–1.741]
Tertiary	0	1	
Employment			
Self-employed	0.074 (0.217)	1.077	[0.703–1.648]
Employed	0.190 (0.185)	1.209	[0.842–1.736]
Unemployed/retired	0.307 (0.279)	1.360	[0.786–2.352]
Student	0	1	
Marital status			
Single	−0.396 (0.592)	0.673	[0.211–2.148]
Married	−0.577 (0.581)	0.562	[0.180–1.755]
Divorced	0.065 (0.680)	1.067	[0.282–4.43]
Widowed	0	1	
Residence			
Urban	−0.177 (0.155)	0.838	[0.618–1.135]
Sub-urban	0.035 (0.167)	1.036	[0.746–1.438]
Rural	0	1	
Income level			
Low	−0.136 (0.178)	0.873	[0.616–1.238]
Medium	−0.034 (0.128)	0.967	[0.753–1.241]
High	0	1	
Children[c]			
Yes	−0.106 (0.117)	0.900	[0.715–1.132]
No	0	1	
Elders[d]			
Yes	−0.103 (0.101)	0.902	[0.741–1.099]
No	0	1	
Where did you purchase raw poultry from?[e]			
Traditional/wet market	0.270 (0.254)	1.310	[0.796–2.154]
Supermarket	0.579 (0.272)*	1.785	[1.047–3.042]
Butcher	0.192 (0.314)	1.211	[0.655–2.241]
Mobile hawker	0.484 (0.308)	1.622	[0.887–2.967]
Others	0	1	
Food poisoning			
Yes	−0.045 (0.149)	0.956	[0.714–1.280]
No	0	1	
Assumption of habit strength[f]			
No	1.388 (0.124)**	4.007	[3.142–5.110]
Yes	0	1	

[a]Data from the Philippines were excluded from the regression analysis since the response to the item measuring perceived confidence (dependent variable) were consistent for all respondents. [b]Data from primary educational background and [e]source of raw poultry (farm) were removed due to the small number of responses. [c]Yes/No=Living with or without children less than 12 years old. [d]Yes/No=Living with or without elders more than 65 years old. [f]Assumption of habit strength was measured using the following hypothetical scenario: Assuming that the raw poultry is slaughtered according to food safety standards, would you wash raw poultry? *$p < 0.05$; **$p < 0.001$.

method of raw poultry reduces consumers' confidence of raw poultry safety. Purchasing raw poultry from wet markets, butchers or farms are highly prevalent in Southeast Asia nations due to the strong preference for freshly slaughtered poultry. There is also less regulatory oversight in animal and food products sold at wet markets compared to larger food retailers (Lambraki et al., 2023). Raw poultry purchased from such markets would still contain feathers, blood, dirt and faeces (Soon et al., 2020) which causes consumers to wash them.

9. Practical recommendations

This study suggests the following recommendations. Participants from Laos and Indonesia were more confident about modifying their behaviour upon realising that washing raw poultry could cause cross contamination and will not reduce microorganisms. In contrast, participants from Vietnam, Brunei, and the Philippines tend to be more reluctant to change their behaviour. Thus, targeted food safety messages and educational campaigns suited to local context should be conducted. For instance, for Vietnam, Brunei, and the Philippines, messages and campaigns should include very innovative communication tools and should be inclusive and regular to induce behavioural change. Understanding the opportunities and barriers to not washing raw poultry would facilitate our understanding of domestic food safety practices. Risk assessments of microbial burden of raw poultry from different sources such as traditional markets or supermarkets and understanding cross contamination pathways during washing and handling of raw poultry would provide valuable data to identify control and preventive measures. Future studies could combine observational study with microbial sampling. Due to the challenges associated with raw poultry products purchased from traditional markets and the lack of confidence among consumers, in this case, a more effective food safety message would be to encourage good hand hygiene practices during and after handling raw poultry and to wash kitchen sink and preparation area with soap and water.

10. Limitations

There are several limitations in the study. There were limited number of participants from Laos, Cambodia, and Brunei. Selection bias might occur since participants who are interested in the study are more likely to participate in the survey. The observations were conducted amongst a small group of participants in two countries due to limited resources. All raw poultry products used in the observation study were purchased by consumers from traditional markets and were more likely to be contaminated with blood, feathers and faeces. During the observation, participants are more likely to be influenced by Hawthorn effect due to the presence of an observer. Cultural differences, socioeconomic factors, access to education and food safety information are highly variable between the countries and the findings from this study should not be generalised.

11. Conclusion

This study illustrates the first empirical findings on consumers' raw poultry washing practices in eight SEA countries. Most participants reported that they washed raw poultry at home before cooking. One of the main reasons for washing raw poultry were to remove dirt, slime, blood and feathers. Participants learnt the act of washing raw poultry at home and reported using salt to wash raw poultry. More specifically, based on surveyed data, the study revealed the association between sociodemographic characteristics and raw poultry washing practice. All participants were observed to rinse or soak raw poultry resulting in multiple cross contamination pathways. Via observation method, cross contamination pathways of washing raw poultry practice include lack of hand hygiene practices, inadequate cleaning and sanitation procedures and splashing of washed water to surrounding areas were observed.

Table 5
Observation of participants' raw poultry washing and hand hygiene practices.

Participants (P)	Profile	Did participants wash their hands before handling raw poultry?	Wash/Rinse procedures (Time spent rinsing/washing/ preparing raw poultry)	Did participants use other ingredients to wash raw poultry?	Did participants wash their hands after handling raw poultry?	Did participants wash the sink and utensils after handling raw poultry?
Indonesia						
P1	Female, 41, married, 3 children	Washed and rubbed hands with soap and rinsed (29 s)	Washed, removed feathers from wings and cloaca and rinsed poultry (1:65 min)	No	Washed and rubbed hands with soap and rinsed (24 s)	Did not wash sink
P2	Male, 33, single	Rinsed hands under tap (3 s)	Rinsed whole poultry, cut and rinsed the inside cavity (2:58 min)	No	Washed and rubbed hands with soap and rinsed (21 s)	Rinsed sink with tap water
P3	Female, 46, married, 2 children	Did not wash hands	Rinsed, cut, removed feathers and innards were pulled from cavity. Lime juice were added and soaked for 10 min (3:27 min)	Lime juice	Did not wash hands	Rinsed sink with tap water
P4	Female, 28, single	Did not wash hands	Rinsed whole poultry and stored in plastic bag (21 s)	No	Did not wash hands	Rinsed sink with tap water
Malaysia						
P5	Female, 35, widowed, 4 children	Did not wash hands	Cut, rinsed, and innards were removed, feather and fat were trimmed. Poultry was soaked with cornflour and salt and rubbed. (9:63 min)	2 teaspoons of cornflour and salt	Rinsed hands (3 s)	Rinsed colander and basin with tap water Rinsed sink with tap water
P6	Male, 32, married, 2 children	Rinsed hands under tap (2 s)	Poultry was chopped, rinsed and skin and fat were trimmed (20:6 min)	No	Rinsed dominant hand (1 s)	Washed chopping board, knives, scissor and basin with soap and rinsed. Sink was rinsed with water
P7	Female, 57, married, 7 children	Did not wash hands	Poultry was chopped, skin and fat were trimmed. Chopped poultry was rinsed four times. Salt was added after the 1st rinse (8:55 min)	2 small handful of salt were added	Rinsed hands (2 s)	Rinsed, scrubbed and washed chopping board with soap (but only one side of the chopping board was washed with soap). Knife blade was washed with soap and rinsed (but only blade was washed with soap). Basins were washed with soap but replaced in the sink containing poultry trimmings/waste.
P8	Female, 64, married, 7 children	Did not wash hands	Rinsed, cut, fat and skin were trimmed, and innards removed. Flour and salt were added, soaked, rubbed and poultry was rinsed twice.	Flour and salt	Handwashed with soap but during washing, participant cleared the sink drainage containing poultry trimmings and washed water,	Knife was rinsed with water only. Colander and basins were washed with soap and rinsed but placed in the sink which still contains poultry trimmings. Did not clean sink.

Semi-structured interviews further provided a deeper understanding of the reasons behind not washing raw poultry. Participants indicated that they washed raw poultry as they perceived it to be cleaner and safer. This is partly caused by the preparation method of raw poultry purchased from traditional markets such as wet markets, butchers and farms and participants indicated less confidence in the safety and hygiene measures from such sellers. However, participants from Laos and Indonesia reported being more confident about not washing raw poultry upon understanding the rationale for not washing raw poultry. This indicates the possibility for targeted food safety messages and educational awareness suited to cultural differences in the region. Due to consumers' preference for freshly slaughtered poultry and perceived cleanliness of raw poultry purchased from traditional markets, hand hygiene practices during and after handling raw poultry and cleaning of kitchen sink and surrounding areas with soap should be emphasised.

CRediT authorship contribution statement

Jan Mei Soon-Sinclair: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Supervision, Validation, Writing – original draft, Writing – review & editing. **Thanh Mai Ha:** Data curation, Formal analysis, Investigation, Methodology, 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:** Conceptualization, Investigation, Methodology, Writing – review & editing.

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.

Data availability

The data that has been used is confidential.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.foodcont.2023.110253.

References

Aiyar, A., & Pingali, P. (2020). Pandemics and food systems-towards a proactive food safety approach to disease prevention & management. *Food Security, 12*(4), 749–756.

Ajzen, I. (2011). The theory of planned behaviour: Reactions and reflections. *Psychology and Health, 26*(9), 1113–1127.

Alves, Â., Santos-Ferreira, N., Magalhães, R., Ferreira, V., & Teixeira, P. (2022). From chicken to salad: Cooking salt as a potential vehicle of salmonella spp. and listeria monocytogenes cross-contamination. *Food Control, 137*, Article 108959. https://doi.org/10.1016/j.foodcont.2022.108959

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101.

Cardoso, M. J., Ferreira, V., Truninger, M., Maia, R., & Teixeira, P. (2021). Cross-contamination events of campylobacter spp. in domestic kitchens associated with consumer handling practices of raw poultry. *International Journal of Food Microbiology, 338*, Article 108984. https://doi.org/10.1016/j.ijfoodmicro.2020.108984

Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.

Cui, B., Wang, L. D., Chen, X., Xu, M. Y., Ke, J., & Tian, Y. (2022). Chicken meat taste preferences, perceived risk of human infection with avian influenza virus, and self-reported chicken meat consumption in China. *Preventive Veterinary Medicine, 203*, Article 105658. https://doi.org/10.1016/j.prevetmed.2022.105658

da Cunha, D. T., de Rosso, V. V., Pereira, M. B., & Stedefeldt, E. (2019). The differences between observed and self-reported food safety practices: A study with food handlers using structural equation modeling. *Food Research International, 125*, Article 108637.

Evans, E. W., & Redmond, E. C. (2018). Behavioral observation and microbiological analysis of older adult consumers' cross-contamination practices in a model domestic kitchen. *Journal of Food Protection, 81*(4), 569–581.

Everis, L., & Betts, G. D. (2003). Microbiological risk factors associated with the domestic handling of meat. *Campden & Chorleywood Food Association Group*, 88.

FSA. (2020). *Cleaning: Raw meat*. Available at: https://www.food.gov.uk/safety-hygiene/cleaning#cleaning-food. (Accessed 5 October 2023).

Gilman, A., Henley, S. C., & Quinlan, J. (2022). Understanding barriers to consumers to stop washing raw poultry through in-depth interviews. *British Food Journal, 124*(11), 3411–3427.

Habib, I., Harb, A., Hansson, I., Vågsholm, I., Osama, W., Adnan, S., et al. (2020). Challenges and opportunities towards the development of risk assessment at the consumer phase in developing Countries—the case of campylobacter cross-contamination during handling of raw chicken in two middle eastern countries. *Pathogens, 9*(1), 62.

Havelaar, A. H., Kirk, M. D., Torgerson, P. R., Gibb, H. J., Hald, T., Lake, R. J., et al. (2015). World health organization global estimates and regional comparisons of the burden of foodborne disease in 2010. *PLoS Medicine, 12*(12), Article e1001923.

Health Canada. (2019). *Poultry safety*. Available at: https://www.canada.ca/en/health-canada/services/meat-poultry-fish-seafood-safety/poultry-safety.htmlAccessed05October2023.

Heir, E., Solberg, L. E., Jensen, M. R., Skaret, J., Grøvlen, M. S., & Holck, A. L. (2022). Improved microbial and sensory quality of chicken meat by treatment with lactic acid, organic acid salts and modified atmosphere packaging. *International Journal of Food Microbiology, 362*, Article 109498. https://doi.org/10.1016/j.ijfoodmicro.2021.109498

Henley, S. C., Gleason, J., & Quinlan, J. J. (2016). Don't wash your chicken!: A food safety education campaign to address a common food mishandling practice. *Food Protection Trends, 36*(1).

Henley, S. C., Launchi, N., & Quinlan, J. J. (2018). Survival of salmonella on raw poultry exposed to 10% lemon juice and vinegar washes. *Food Control, 94*, 229–232. https://doi.org/10.1016/j.foodcont.2018.06.034

Her, E., Seo, S., Choi, J., Pool, V., & Ilic, S. (2019). Assessment of food safety at university food courts using surveys, observations, and microbial testing. *Food Control, 103*, 167–174.

Indrawan, D., Christy, A., & Hogeveen, H. (2021). Improving poultry meat and sales channels to address food safety concerns: Consumers' preferences on poultry meat attributes. *British Food Journal, 123*(13), 529–546.

Inthavong, P., Chanthavong, S., Nammanininh, P., Phommachanh, P., Theppangna, W., Agunos, A., et al. (2022). Antimicrobial resistance surveillance of pigs and chickens in the Lao people's democratic republic, 2018–2021. *Antibiotics, 11*(2), 177.

Karam, L., Roustom, R., Abiad, M. G., El-Obeid, T., & Savvaidis, I. N. (2019). Combined effects of thymol, carvacrol and packaging on the shelf-life of marinated chicken. *International Journal of Food Microbiology, 291*, 42–47. https://doi.org/10.1016/j.ijfoodmicro.2018.11.008

Katiyo, W., de Kock, H. L., Coorey, R., & Buys, E. M. (2019). Assessment of safety risks associated with handling chicken as based on practices and knowledge of a group of south african consumers. *Food Control, 101*, 104–111.

Koo, T. K., & Li, M. Y. (2016). A guideline of selecting and reporting intraclass correlation coefficients for reliability research. *Journal of Chiropractic Medicine, 15*(2), 155–163. https://doi.org/10.1016/j.jcm.2016.02.012

Koppel, K., Suwonsichon, S., Chitra, U., Lee, J., & Edgar Chambers. (2014). E.No title. Eggs and poultry purchase. *Storage, and Preparation Practices of Consumers in Selected Asian Countries.Foods, 3*, 110–127.

Kosa, K. M., Cates, S. C., Bradley, S., Edgar Chambers, I. V., & Godwin, S. (2015). Consumer-reported handling of raw poultry products at home: Results from a national survey. *Journal of Food Protection, 78*(1), 180–186. https://doi.org/10.4315/0362-028X.JFP-14-231

Kraft, P., Rise, J., Sutton, S., & Roysamb, E. (2005). Perceived difficulty in the theory of planned behaviour: Perceived behavioural control or affective attitude? *British Journal of Social Psychology, 44*, 479–496.

Lambraki, I. A., Chadag, M. V., Cousins, M., Graells, T., Léger, A., Henriksson, P. J. G., et al. (2023). Factors impacting antimicrobial resistance in the south east asian food system and potential places to intervene: A participatory, one health study. *Frontiers in Microbiology, 13*, Article 992507.

Mazengia, E., Fisk, C., Liao, G., Huang, H., & Meschke, J. (2015). Direct observational study of the risk of cross-contamination during raw poultry handling: Practices in private homes. *Food Protection Trends, 35*(1).

Meysenburg, R., Albrecht, J. A., Litchfield, R., & Ritter-Gooder, P. K. (2014). Food safety knowledge, practices and beliefs of primary food preparers in families with young children: A mixed methods study. *Appetite, 73*, 121–131.

Minami, A., Chaicumpa, W., Chongsa-Nguan, M., Samosornsuk, S., Monden, S., Takeshi, K., et al. (2010). Prevalence of foodborne pathogens in open markets and supermarkets in Thailand. *Food Control, 21*(3), 221–226. https://doi.org/10.1016/j.foodcont.2009.05.011

Møretrø, T., Nguyen-The, C., Didier, P., Maître, I., Izsó, T., Kasza, G., et al. (2021). Consumer practices and prevalence of campylobacter, salmonella and norovirus in kitchens from six european countries. *International Journal of Food Microbiology, 347*, Article 109172. https://doi.org/10.1016/j.ijfoodmicro.2021.109172

Mottet, A., & Tempio, G. (2017). Global poultry production: Current state and future outlook and challenges. *World's Poultry Science Journal, 73*(2), 245–256.

Myintzaw, P., Moran, F., & Jaiswal, A. K. (2020). Campylobacteriosis, consumer's risk perception, and knowledge associated with domestic poultry handling in Ireland. *Journal of Food Safety, 40*(4), Article e12799.

Naguib, M. M., Li, R., Ling, J., Grace, D., Nguyen-Viet, H., & Lindahl, J. F. (2021). Live and wet markets: Food access versus the risk of disease emergence. *Trends in Microbiology, 29*(7), 573–581. https://doi.org/10.1016/j.tim.2021.02.007

Nhung, N. T., Van, N. T. B., Van Cuong, N., Duong, T. T. Q., Nhat, T. T., Hang, T. T. T., et al. (2018). Antimicrobial residues and resistance against critically important antimicrobials in non-typhoidal salmonella from meat sold at wet markets and supermarkets in vietnam. *International Journal of Food Microbiology, 266*, 301–309.

Nidaullah, H., Abirami, N., Shamila-Syuhada, A. K., Chuah, L.-O., Nurul, H., … Rusul. (2017). Prevalence of Salmonella in poultry processing environments in wet markets in Penang and Perlis, Malaysia. *Veterinary World, 10*(3), 286–292.

OECD. (2023). *OECD-FAO agricultural outlook 2021-2030*. Paris: OECD Publishing. https://doi.org/10.1787/19428846-en

Partnership for Food Safety Education. (2022). *Don't wash your chicken!*. Available at: https://www.fightbac.org/dwyc/. (Accessed 6 October 2023).

Patchanee, P., Tansiricharoenkul, K., Buawiratlert, T., Wiratsudakul, A., Angchokchatchawal, K., Yamsakul, P., et al. (2016). Salmonella in pork retail outlets and dissemination of its pulsotypes through pig production chain in chiang mai and surrounding areas, Thailand. *Preventive Veterinary Medicine, 130*, 99–105. https://doi.org/10.1016/j.prevetmed.2016.06.013

Pilamala Rosales, A., Linnemann, A. R., & Luning, P. A. (2023). Food safety knowledge, self-reported hygiene practices, and street food vendors' perceptions of current hygiene facilities and services - an ecuadorean case. *Food Control, 144*, Article 109377. https://doi.org/10.1016/j.foodcont.2022.109377

Rortana, C., Nguyen-Viet, H., Tum, S., Unger, F., Boqvist, S., Dang-Xuan, S., et al. (2021). Prevalence of salmonella spp. and staphylococcus aureus in chicken meat and pork from cambodian markets. *Pathogens, 10*(5), 556.

Rosenman, R., Tennekoon, V., & Hill, L. G. (2011). Measuring bias in self-reported data. *International Journal of Behavioural and Healthcare Research, 2*(4), 320–332.

Santos-Ferreira, N., Alves, Â., Cardoso, M. J., Langsrud, S., Malheiro, A. R., Fernandes, R., et al. (2021). Cross-contamination of lettuce with campylobacter spp. via cooking salt during handling raw poultry. *PLoS One, 16*(5), Article e0250980.

Santos, P. D. M., Widmer, K. W., & Rivera, W. L. (2020). PCR-based detection and serovar identification of salmonella in retail meat collected from wet markets in metro manila, Philippines. *PLoS One, 15*(9), Article e0239457.

Sax, H., Allegranzi, B., Chraïti, M., Boyce, J., Larson, E., & Pittet, D. (2009). The world health organization hand hygiene observation method. *American Journal of Infection Control, 37*(10), 827–834. https://doi.org/10.1016/j.ajic.2009.07.003

Shafini, A. B., Son, R., Mahyudin, N. A., Rukayadi, Y., & Zainazor, T. T. (2017). Prevalence of salmonella spp. in chicken and beef from retail outlets in Malaysia. *International Food Research Journal, 24*(1), 437.

Shumaker, E. T., Kirchner, M., Cates, S. C., Shelley, L., Goulter, R., Goodson, L., et al. (2022). Observational study of the impact of a food safety intervention on consumer poultry washing. *Journal of Food Protection, 85*(4), 615–625. https://doi.org/10.4315/JFP-21-397

Soon, J. M., & Abdul Wahab, I. R. (2021). On-site hygiene and biosecurity assessment: A new tool to assess live bird stalls in wet markets. *Food Control, 127*, Article 108108. https://doi.org/10.1016/j.foodcont.2021.108108

Soon, J. M., Wahab, I. R. A., Hamdan, R. H., & Jamaludin, M. H. (2020). Structural equation modelling of food safety knowledge, attitude and practices among consumers in Malaysia. *PLoS One, 15*(7), Article e0235870.

Thung, T. Y., Mahyudin, N. A., Basri, D. F., Wan Mohamed Radzi, C. W. J., Nakaguchi, Y., Nishibuchi, M., et al. (2016). Prevalence and antibiotic resistance of salmonella enteritidis and salmonella typhimurium in raw chicken meat at retail markets in Malaysia. *Poultry Science, 95*(8), 1888–1893. https://doi.org/10.3382/ps/pew144

USDA. (2019). *Southeast Asia's growing meat demand and its implications for feedstuffs imports*. Available at: https://www.ers.usda.gov/amber-waves/2019/april/southeast-asia-s-growing-meat-demand-and-its-implications-for-feedstuffs-imports/. (Accessed 5 October 2023).

USDA. (2022). *Washing food: Does it promote food safety?*. Available at: https://www.fsis.usda.gov/food-safety/safe-food-handling-and-preparation/food-safety-basics/washing-food-does-it-promote-food. (Accessed 5 October 2023).

Vatral, C. D., Gilman, A. D., & Quinlan, J. J. (2022). Consumer awareness of the message not to wash raw poultry, current practices, and barriers to following that message. *Journal of Food Protection, 85*(6), 930–937.

Vatral, C. D., & Quinlan, J. J. (2021). Identification of barriers to consumers adopting the practice of not washing raw poultry. *Food Control, 123*, Article 107682. https://doi.org/10.1016/j.foodcont.2020.107682

Wangroongsarb, P., Cheunban, N., Jittaprasatsin, C., Kamthalang, T., Saipradit, N., Chaichana, P., et al. (2021). Prevalence and antimicrobial susceptibility of campylobacter isolated from retail chickens in Thailand. *International Journal of Food Microbiology, 339*, Article 109017.

Young, I., Sekercioglu, F., & Meldrum, R. (2020). Determinants of food thermometer use and poultry washing among canadian consumers. *Journal of Food Protection, 83*(11), 1900–1908.

Yulistiani, R., & Praseptiangga, D. (2019). Contamination level and prevalence of foodborne pathogen enterobacteriaceae in broiler and backyard chicken meats sold at traditional markets in surabaya, Indonesia. *Malaysian Applied Biology, 48*(3), 95–103.