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Consumer egg washing and handling practices in Southeast Asia: a mixed-method study

Jan Mei Soon-Sinclair [a,*], Iwan Vanany [b], Pornthipa Ongkunaruk [c], Theingi Myint [d], Pisidh Voe [e], Chanthy Huot [f], Mark Raguindin Limon [g], Sayvisene Boulom [h], Fue Yang [h], Ikarastika Rahayu Abdul Wahab [i], Cong Duan Dao [j], Tareq Osaili [k,l,m], Thanh Mai Ha [n,o]

[a] School of Health, Social Work and Sport, University of Lancashire, Preston, PR1 2HE, UK
[b] Department of Industrial and Systems Engineering, Institut Teknologi Sepuluh Nopember, Surabaya, 60111, Indonesia
[c] Department of Industrial Engineering, Faculty of Engineering, Kasetsart University, Bangkok, 10900, Thailand
[d] Department of Agricultural Economics, Yezin Agricultural University, Nay Pyi Taw, Myanmar
[e] National Meanchey University, NR5, Sisophon, Cambodia
[f] Faculty of Agronomy, Royal University of Agriculture, Phnom Penh, Cambodia
[g] Technical-Vocational and Livelihood Education Department, College of Teacher Education, Mariano Marcos State University, Ilocos Norte, Laoag City, 2900, Philippines
[h] Faculty of Agriculture, National University of Laos, Laos
[i] Faculty of Agro-Based Industry, Universiti Malaysia Kelantan, Jeli, Kelantan, 17600, Malaysia
[j] The Unit for Multilingualism, Uppsala Council, Sweden
[k] Department of Clinical Nutrition and Dietetics, College of Health Sciences, University of Sharjah, P.O. Box 27272, Sharjah, United Arab Emirates
[l] Research Institute of Medical & Health Sciences, University of Sharjah, P.O. Box 27272, Sharjah, United Arab Emirates
[m] Department of Nutrition and Food Technology, Faculty of Agriculture, Jordan University of Science and Technology, P.O. Box 3030, Irbid, 22110, Jordan
[n] Department of Economics, Swedish University of Agricultural Sciences, Box 7013, Uppsala, 750 07, Sweden
[o] Faculty of Economics and Management, Vietnam National University of Agriculture, Gia Lam district, Hanoi, Viet Nam

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ABSTRACT

Egg washing at home is generally discouraged in some regions because it can damage the egg's natural protective cuticle and increase the risk of bacterial penetration. However, little is known about how consumers in Southeast Asia wash and handle eggs in domestic settings. This study aims to investigate egg washing and handling practices among consumers using a mixed-method approach. A cross-sectional online survey was conducted with consumers from Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Thailand, and Vietnam. This was followed by 24 domestic kitchen observations and semi-structured interviews in Malaysia, Indonesia, and Thailand. Quantitative data were analysed using descriptive statistics, chi-square tests, Kruskal-Wallis tests, and logistic regression. Qualitative data were analysed thematically. The majority of participants reported washing eggs before cooking. More than half of those who washed eggs indicated that they would still wash eggs even when they appeared visually clean. Eggs were commonly rinsed under tap water, often to remove dirt, faeces, slime, or feathers. Respondents from Cambodia, Indonesia, Malaysia, Myanmar, the Philippines and those with greater perceived risk of *Salmonella* contamination in eggs were more confident in following the message. Observations revealed appropriate handwashing after handling or cracking eggs was rare and cross-contact opportunities were frequently observed. Semi-structured interview findings showed that egg washing was closely linked to perceived beliefs about cleanliness and safety, habitual practice, and uncertainty about how eggs had been handled before purchase. Some participants also described wiping as an alternative cleaning strategy, while informal information sources appeared to influence views on egg washing. Practical guidance should emphasise

* Corresponding author.
E-mail addresses: jmsoon-sinclair@lancashire.ac.uk (J.M. Soon-Sinclair), vanany@ie.its.ac.id (I. Vanany), pornthipa.o@ku.ac.th (P. Ongkunaruk), dr.theingimyint@yau.edu.mm (T. Myint), voe.pisidh@moeys.gov.kh (P. Voe), huotchanthy@rua.edu.kh (C. Huot), mark_limon149@yahoo.com (M.R. Limon), sayvisene.b@nuol.edu.la (S. Boulom), f.yang@nuol.edu.la (F. Yang), ikarastika@umk.edu.my (I.R.A. Wahab), cong.dao@uppsala.se (C.D. Dao), tosaili@sharjah.ac.ae (T. Osaili), thi.thanh.mai.ha@slu.se (T.M. Ha).

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washing only visibly dirty eggs, cooking them immediately after washing, handwashing hands with soap and water after handling or cracking eggs and preventing cross-contamination during preparation.

1. Introduction

Salmonellosis is a global public health concern and contributes to foodborne gastrointestinal illnesses (WHO, 2026). Southeast Asia (SEA) region has the second highest foodborne disease burden per population (after Africa). According to the World Health Organization (WHO) Southeast Asia region (WHO, 2026), the region experiences more than 150 million foodborne illness cases and 175,000 deaths annually, with non-typhoidal *Salmonella* identified as one of the major diarrhoeal pathogens contributing to this burden. The global incidence of invasive non-typhoidal *Salmonella* (iNTS) in 2021 was estimated at 509,976 cases. In SEA, the reported incidence was 17,080 cases and contributed to 12.66 disability adjusted life years (DALYs) (He et al., 2025). *Salmonella* is commonly associated with egg and egg-derived products. Eggs are prone to contamination through vertical transmission, contamination the during laying process and exposure to the surrounding laying environment (Liu et al., 2023). One of the methods to reduce *Salmonella* contamination in SEA region at household level is to cook eggs thoroughly to 71°C ensuring that both yolk and white are firm, refrigerating eggs, avoiding leaving egg dishes at room temperature, discarding cracked eggs and preventing cross contamination during handling (Cardoso et al., 2021; US FDA, 2024). Cross-contamination preventive measures include keeping raw eggs and their content separate from foods that will not be cooked (US FDA, 2024) and handwashing with soap and water after handling or cracking eggs (Kosa et al., 2015). These preventive behaviours are particularly important in Southeast Asia where warm and humid environmental conditions can facilitate rapid microbial proliferation, thereby increasing the risk of contamination and foodborne illness. This is especially significant given that eggs are a key source of dietary protein in the region (Morris et al., 2018) and are widely sold through both formal and informal retail channels.

In the United States and Canada, table eggs are commercially washed and refrigerated, and consumers are advised not to wash them again before storage (CFIA, 2019; Guyonnet, 2023; US FSIS, 2024). In contrast, eggs in the United Kingdom and European Union are not routinely washed commercially to prevent damage to the eggshell (Commission Regulation EC No. 589/2008). Meanwhile, national regulations that set out commercial egg washing standards or guidance associated with domestic egg washing in Southeast Asia remains limited. The Philippine National Standard on Code of Hygienic Practice for Table Eggs states that egg washing should be carried out under carefully controlled conditions to minimise shell damage and contamination, eggs should not be soaked before or during washing and water used for washing should be potable (BAFS, 2017). Based on De Castro-Naagas (2026), egg washing practices however varied among farms in the Philippines with most avoiding washing due to concerns about rapid egg spoilage. Based on FAO Marketing of Eggs guidance, eggs are often not consistently washed in the region to avoid spoilage (FAO, 1961). National standards often refer to the Codex Code of Hygienic Practice for Eggs and Egg Products (CAC, 1976)which permits and regulates egg washing where national authorities allow it, that is, where washing is permitted, it should be carried out under carefully controlled condition to minimise shell damage and prevent contamination of egg contents.

Although egg washing could reduce visible dirt and surface microbial load, it could increase contamination and cause rapid deterioration if not carried out appropriately. Unwashed eggs maintain the natural bloom where the cuticle forms a natural protective layer. Washing eggs before storage could lead to moisture on surface of eggshell which facilitates movement of microorganisms across the shell and increases risk of contamination (Kulshreshtha et al., 2024). Similarly, washing was found to reduce cuticle coverage (Liu et al., 2016), thus leaving pores less protected and making it easier for microbes to penetrate the shell. In another study, Gole et al. (2014) compared washed and unwashed eggs and found *Salmonella* Typhimurium penetrated washed eggs at a higher rate than unwashed eggs.

For these reasons, routine egg washing at household level before storage is discouraged to avoid damaging the cuticle which may increase bacterial penetration (Al-Natour et al., 2012). To date, there is one study from SEA reporting that 45% (n = 100) of respondents in Thailand always wash eggs and poultry (Koppel et al., 2015), with additional studies from developed regions reporting egg washing practices such as in the USA (Kosa et al., 2015), Australia (Whiley et al., 2017), and across different European countries (Cardoso et al., 2021). Since raw poultry washing is very common in SEA (Soon-Sinclair et al., 2024), we hypothesised that this practice extends to egg washing among consumers in the region. This is likely due to the origins of eggs which are often sold from formal and informal retail settings including farm, wet market, supermarket or street vendors where cleanliness and storage conditions vary (Junqueira et al., 2022; Koppel et al., 2014). Additionally, lightly cooked or runny eggs are commonly consumed in parts of the region (Omar et al., 2018; Sriruengsuk & Siriwong, 2018), which increases the risk of foodborne illnesses. To date, there is very limited evidence on consumers' egg washing and handling practices, whether they wash visually clean eggs, how they handle eggs in the kitchen, and what beliefs shape these behaviours. There is also limited observational evidence on whether self-reported practices, such as handwashing after handling eggs, reflect actual behaviour in domestic settings. Therefore, this study aims to investigate egg washing and handling practices among consumers in Southeast Asia using a mixed method approach including quantitative survey, domestic kitchen observations and semi-structured interviews.

2. Methodology

2.1. Study design

This study used a mixed-method design including a cross-sectional online survey, domestic kitchen observations, and semi-structured interviews. The survey was conducted across eight Southeast Asian countries to investigate consumers' egg handling, storage, and washing practices. The observations and interviews were conducted in Malaysia, Indonesia, and Thailand to provide further insights into how eggs are handled in domestic kitchens and to explore participants' reasons for washing or not washing shell eggs.

2.2. Questionnaire development

The questionnaire was designed based on previous studies on shell egg consumption and handling practices at the home (Cardoso et al., 2021; Koppel et al., 2015; Kosa et al., 2015). Selected design elements relating to habitual behaviour or proxy measure were based on Soon-Sinclair et al. (2024). The questionnaire was divided into four sections: (i) demographics (7 questions); (ii) egg safety knowledge (5 questions); (iii) egg handling and consumption practices (16 questions); and (iv) food safety messaging and confidence in not washing shell eggs (1 question). The food safety message was included as an educational message to assess participants' confidence in following the recommendation not to wash visibly clean eggs. The demographic section collected information on gender, age, education, employment, country of residence, food poisoning experience in the previous 12 months, and whether participants lived with potentially vulnerable household members, including pregnant individuals, older adults, and children

under 5 years of age. The knowledge section measures participants' knowledge of egg safety practices such as 'Egg dishes can make me sick if not cooked thoroughy' and 'Eggs should be wiped with dry paper towel or brush' with response options of 'Yes', 'No' or 'Unsure'. Correct responses were awarded 1 point, while incorrect and uncertain answers were scored 0, giving a total possible knowledge score of 0 to 4. Under the knowledge section, participants were also asked about the perceived likelihood of *Salmonella* in eggs ranging from not at all likely (1) to extremely likely (5). In Section III, questions include source of eggs, whether eggs were refrigerated at point of purchase, home storage location and egg inspection during purchasing. Participants were also asked whether they wash shell eggs before cooking and how they washed them. In this section, participants were also asked to answer the following hypothetical scenario: 'Assuming that the shell egg is clean, will you wash it before storing/keeping it?' This variable, hereafter called "proxy measure" indirectly captures the extent to which washing shell egg is automatic or persistent. A positive response implies a stronger habit since regardless of the cleanliness of shell egg, respondents are likely to maintain their current habit (i.e., washing shell egg). In the final section, the questionnaire provided the following food safety message: '*Do not wash eggs at home. Washing can remove the egg's natural protective layer and let bacteria in. Before storing, just wipe or dry-clean eggs. Only wash eggs if they are dirty and you will cook them right away*'. After the message, participants were asked to rank their confidence level: 'After reading the message above, how confident are you to stop washing shell eggs that have been processed according to food safety standard and looks visually clean?'

A pilot survey was conducted with 20 participants from Indonesia. The questionnaire showed acceptable internal consistency, with a Cronbach's alpha of 0.74. Questionnaire was translated from English into Burmese, Khmer, Bahasa Indonesia, Laotian, Bahasa Melayu, Filipino, Thai and Vietnamese and back translated into English. All versions were uploaded to onlinesurvey. ac.uk and pre-tested to ensure the logic and sequence of questions were correct. Eligibility criteria were age 18 years or older, current residence in one of the participating countries, and involvement in preparing or cooking eggs at home. Participants were screened using the question: "Do you prepare or cook eggs at home?" Only those who answered "Yes" were eligible to proceed. The survey was distributed through social media platforms in each country using convenience and snowball sampling. The full questionnaire is provided in Supplementary Material 1.

2.3. Observation and semi-structured interviews

Domestic kitchen observations and semi-structured interviews were conducted in Malaysia, Indonesia, and Thailand. These countries were selected since they represented different levels of egg washing prevalence observed in the survey, with relatively high, intermediate and low prevalence respectively. The observation and semi-structured interview guide were adapted from Soon-Sinclair et al. (2024), Maughan et al. (2016) and Maengia et al. (2015). Participants were recruited using purposive sampling through the local networks of the research team in the participating countries. Participants were eligible if they were aged 18 years or older, handled or cooked egg dishes at home, were willing to allow researchers to observe their egg handling and cooking practices in their home, participated in a brief interview, and provided written informed consent. A total of 24 participants were recruited, with eight participants from each of the three countries. Three research assistants well versed in food safety were trained in observation and interviewing techniques. Appointments were made with participants for a time when they were preparing an egg dish at home. Participants were provided with an explanation of the study and opportunity to ask questions after which consent were obtained. They were informed that the purpose of the study was to explore how consumers prepare egg dishes and were instructed to prepare the dish as they normally would. They were also informed that participation was voluntary, that they could decline to answer any questions or stop the observation at any time without consequence, and that written informed consent would be obtained before data collection commenced. To minimise changes in participants' usual food handling behaviours during the observation, the specific focus on hygiene practices when handling raw eggs was not disclosed before the observation. Participants were observed from the point at which they began handling shell eggs until the completion of cooking. Potential routes of cross contamination and hand hygiene practices were noted, including egg handling (e.g., washing or wiping eggs), handwashing after handling raw eggs or eggshells, handling and disposal of eggshells, and behaviours that could result in the transfer of contamination to food, utensils or food contact surfaces. After the completion of the observations, participants were debriefed about the study's purpose which was to assess hygiene practices during egg handling and cooking at home. Participants were then given the opportunity to ask questions and to withdraw from the study if they wished. For those who wished to continue, semi-structured interviews were conducted with participants' permission. Semi-structured interviews were audio-recorded after the observations to provide deeper insights into why participants washed or did not wash shell eggs before cooking (Supplementary Material 2).

2.4. Data analysis

Descriptive statistics were used to determine frequencies and percentages of categorical variables. Chi-square tests were applied to examine associations between selected demographic variables and self-reported washing of shell eggs before cooking. A logistic regression model was used to examine factors associated with participants' confidence in not washing visually clean shell eggs after reading the food safety message. The dependent variable was measured with the question: 'How confident are you to stop washing shell eggs that have been processed according to food safety standard and looks visually clean?' Responses were recorded in a 5-point likert scale from 1 (Not confident at all), 2 (Not confident), 3(A little confident), 4(Quite confident) to 5 (Very confident). Since the responses are ordinal, ordered logit regression is appropriate if the proportional odds assumption is satisfied. This assumption was assessed using the Test of Parallel Lines. The test was statistically significant ($p < 0.05$), indicating violation of the proportional odds assumption. Although a generalised ordered logit model could be suitable, its interpretation is less straightforward, especially when the dependent variable has many categories (5 categories in this study). For ease of interpretation, the dependent variable was recoded into a binary variable and estimated using a logistic regression model as the main model. Given the exploratory nature of the study, binary logistic regression was performed to identify factors associated with participants' confidence in not washing visually clean shell eggs after reading the food safety message. All socio-demographics, total knowledge, perceived likelihood of *Salmonella* in eggs, proxy measure of habitual egg washing behaviour and source of shell eggs were used as independent variables in the logistic regression model. To assess the sensitivity of the findings, we estimated a generalised ordered logit model as an alternative and examined the consistency of results across model specifications. For the logit model, confidence = 0 if the response was *"Not confident at all"* or *"Not confident,"* and confidence = 1 for the remaining responses (*"A little confident," "Quite confident,"* or *"Very confident"*).

Normality test was conducted and Kolmogorov-Smirnov was 0.201 ($p < 0.001$), thus Kruskal-Wallis test was carried out to determine if countries' confidence in not washing shell eggs differed significantly. All statistical analyses were carried out using IBM SPSS 31.0. P-value <0.05 was considered statistically significant.

2.4.1. Thematic analysis

Semi-structured interviews were transcribed, translated into English and analysed using thematic analysis following the six-phase approach described by Braun and Clarke (2006, 2022). Eight semi-structured

interviews per country enabled us to achieve data saturation where no new themes were identified. This aligns with Guest et al. (2006) where between 6 and 12 interviews would enable data saturation, particularly if the study topic is niche (Hennink & Kaiser, 2022). Transcripts were read repeatedly to ensure familiarisation with the data. Initial codes were generated inductively from the interview transcripts and subsequently organised into potential themes describing participants' reasons for washing or not washing shell eggs. Coding was undertaken by the first author, with emerging codes and themes discussed among the research team until consensus was reached. The observational data were reviewed, and the frequency of observed practices summarised descriptively to complement the findings from the survey and semi-structured interviews.

2.5. Ethical approval

Informed consents were obtained from all participants. The study was reviewed and approved by the University of Lancashire HEALTH Ethics Committee (Reference No. 01307).

3. Results

A total of 2422 valid responses were received. Participants were recruited from eight Southeast Asian countries, with the largest proportions from Myanmar (14.5%), Thailand (14.3%), Malaysia (14.2%), and Indonesia (13.8%) (Table 1).

Table 2 summarises participants' egg safety knowledge. Overall, knowledge levels were mixed. While the majority of participants correctly identified that hands should be washed with soap and water after handling shell eggs (82.1%), only 33.3% correctly recognized that egg dishes can make them sick if not cooked thoroughly. A total of 39.7% of participants achieved a knowledge score of 3 or 4 out of 4, while 60.4% scored 0–2, indicating room for improvement in basic egg safety knowledge.

Table 1
Demographic characteristics of participants (n = 2422).

Items	Frequencies (%)
Country	
Cambodia	326 (13.5)
Indonesia	334 (13.8)
Laos	123 (5.1)
Malaysia	343 (14.2)
Myanmar	351 (14.5)
Philippines	292 (12.1)
Thailand	346 (14.3)
Vietnam	307 (12.7)
Gender	
Male	849 (35.1)
Female	1573 (64.9)
Age	
18 – 29	1122 (46.3)
30 – 39	524 (21.6)
40 – 49	405 (16.7)
50 and above	371 (15.3)
Education	
Primary or Secondary	341 (14.1)
Tertiary	2081 (85.9)
Employment	
Self-employed	241 (10.0)
Employed	1163 (48.0)
Unemployed/Retired	205 (8.5)
Student	813 (33.6)
Living with pregnant individual(s)	
Yes	106 (4.4)
No	2316 (95.6)
Living with individuals over the age of 65	
Yes	926 (38.2)
No	1496 (61.8)
Living with children under the age of 5	
Yes	640 (26.4)
No	1782 (73.6)
*Food poisoning in the past*12 months	
Yes	488 (20.1)
No	1934 (79.9)

Table 2
Egg safety knowledge (n = 2422).

Statements	Frequencies (%)		
	True	False	Unsure
Egg dishes can make me sick if not cooked thoroughly	[a]**807 (33.3)**	853 (35.2)	762 (31.5)
Cracked eggs should be discarded	**1316 (54.3)**	545 (22.5)	561 (23.2)
Eggs should not be wiped with dry paper towel or brush	625 (25.8)	**1162 (48.0)**	635 (26.2)
Hands should be washed with soap and water after handling shell eggs	**1988 (82.1)**	196 (8.1)	238 (9.8)
Total knowledge score			
0	143 (5.9)		
1	513 (21.2)		
2	806 (33.3)		
3	692 (28.6)		
4	268 (11.1)		
How likely do you think that shell eggs carry Salmonella (a type of food poisoning bacteria)?			
a) Not at all likely	132 (5.5)		
b) Slightly likely	409 (16.9)		
c) Moderately likely	538 (22.2)		
d) Very likely	433 (17.9)		
e) Extremely likely	176 (7.3)		
f) Not sure	734 (30.3)		

[a] Bold indicates correct answers.

Table 3 presents participants' self-reported egg handling and consumption practices. Eggs were commonly purchased from supermarkets (28.0%) and public/wet markets (26.5%). More than 50% of participants reported that eggs were not refrigerated at the point of purchase (51.4%), while 62.8% reported storing eggs in the refrigerator at home. Majority of participants stated that they inspected eggs at the time of purchase (81.7%) and checked for visible cleanliness before cooking (89.9%). Nearly half (47.6%) preferred eggs with a runny consistency and the level of 'doneness' was assessed by time (28.2%), appearance (25.4%) and yolk consistency (20.5%). A small proportion also reported using smell as an indicator of doneness. Smell is not a reliable indicator of microbiological safety or adequate cooking; rather, this response represents a sensory cue used by some participants to judge egg doneness. In relation to leftovers, only 19.9% reported refrigerating egg dishes within 2 h after the meal, while 38.8% either left egg dishes on the kitchen table until the next meal or refrigerated them after more than 2 h. Two-thirds (66.4%) reported washing shell eggs before cooking, mainly by rinsing under tap water (53.9%) and using a sponge or scouring pad (30.0%). The main reasons cited for washing were to remove faeces (46.3%), dirt or slime (44%) and feathers (20.3%). Among participants who reported washing eggs before cooking, 59.3% (n = 1608) stated that they would still wash eggs even if the eggs appeared visually clean (Table 4).

Table 5 shows the chi-square associations and summary of differences in egg washing practices across sociodemographic groups. Country, gender, education, employment and source of eggs showed statistically significant associations with self-reported egg washing. Participants from Malaysia and Cambodia were more likely to report washing shell eggs. Females, those with secondary or lower education, and participants who were self-employed, unemployed/retired, or students were more likely to report washing shell eggs. Egg washing was also more likely among participants who sourced eggs from grocery stores, their own backyard, or other sources.

Fig. 1 shows participants' confidence in not washing shell eggs after reading the food safety message "*Do not wash eggs at home. Washing can remove the egg's natural protective layer and let bacteria in. Before storing,*

Table 3
Egg handling and consumption practices (n = 2422).

Questions	Frequencies (%)
Where do you purchase/get shell eggs from most frequently?	
a) Supermarket	679 (28.0)
b) Wet/public market	643 (26.5)
c) Roadside stall	305 (12.6)
d) Grocery store	491 (20.3)
e) Other (e.g., farm, own backyard)	304 (12.6)
When you purchased the eggs, were they refrigerated?	
Yes	1176 (48.6)
No	1246 (51.4)
Did you inspect the eggs at time of purchasing?	
Yes	1979 (81.7)
No	443 (18.3)
Where do you store the eggs at home?	
a) Kitchen counter/shelf	742 (30.6)
b) Cupboard	82 (3.4)
c) Refrigerator	1522 (62.8)
d) Floor	18 (0.7)
e) Other	58 (2.4)
Do you store the eggs in their original carton/tray?	
a) Yes	984 (40.6)
b) No	1438 (59.4)
Do you normally check that the eggs look visibly clean before cooking?	
a) Yes	2177 (89.9)
b) No	245 (10.1)
What would you do if you found that one of the eggs is broken in the egg container or box?	
a) Discard the broken egg	1435 (59.2)
b) Cook the broken egg immediately	827 (34.1)
c) Leave them in room temperature and cook later	33 (1.4)
d) Store in the refrigerator	72 (3.0)
e) Other	55 (2.3)
How do you handle the egg shell after cracking the egg?	
a) Discard immediately	1674 (69.1)
b) Save for gardening	653 (27.0)
c) Other	95 (3.9)
Do you prefer runny consistency in your prepared eggs?	
a) Yes	1152 (47.6)
b) No	1270 (52.4)
[a]How do you determine if the egg items are cooked?	
a) Appearance	615 (25.4)
b) Colour	178 (7.3)
c) Yolk consistency	497 (20.5)
d) Amount of liquid in egg	64 (2.6)
e) Smell	31 (1.3)
f) Texture	213 (8.8)
g) Taste	38 (1.6)
h) Time	683 (28.2)
i) Thermometer	13 (0.5)
j) Other	90 (3.7)
What do you do with leftover egg dishes?	
a) Store them in refrigerator within 2 h after the meal	481 (19.9)
b) Store them in refrigerator more than 2 h after the meal	247 (10.2)
c) Leave them on kitchen table until next meal	692 (28.6)
d) Discard them	403 (16.6)
e) Feed them to my pets	391 (16.1)
f) Other	208 (8.6)

[a] Participants were asked to select a single indicator that they commonly use to determine whether egg dishes are sufficiently cooked. The question was not restricted to a specific egg dish (e.g., boiled, fried or scrambled eggs).

Table 4
Egg washing practices (n = 2422).

Questions	Frequencies (%)
Do you wash eggs before cooking?	
Yes	1608 (66.4)
No	814 (33.6)
Assuming that the eggs you bought look visibly clean, are you going to wash the eggs at home before storage?	
Yes	953 (59.3)
No	655 (40.7)
[a]How do you clean eggs before using them?	
a) Rinse under tap water	1306 (53.9)
b) Wipe with kitchen roll/cloth	268 (11.1)
c) Wash with dishwashing liquid	140 (5.8)
d) Sponge/scouring pad	259 (30.0)
e) Wipe with antibacterial wipes/disinfectant	58 (2.4)
f) Other	73 (3.0)
[a]Why do you wash the eggs?	
a) To remove faeces	1122 (46.3)
b) To remove feathers	492 (20.3)
c) To remove dirt or slime	1065 (44.0)
d) To remove odour	341 (14.1)
e) Other	146 (6.0)
How often do you wash your hands with soap and water after handling raw eggs?	
Never	95 (3.9)
Rarely	215 (8.9)
Sometimes	456 (18.8)
Often	663 (27.4)
Always	993 (41.0)

[a] Participants could choose more than one option.

just wipe or dry-clean eggs. Only wash eggs if they are dirty and you will cook them right away'. A Kruskal–Wallis test indicated a statistically significant difference in confidence across countries, $\chi^2(7) = 181.284$, $p < 0.001$. Indonesia had the highest median confidence score (median = 5.0). Similar to several other countries, the interquartile range (Q1-Q3) extended from approximately 3 to 5, indicating some variability in reported confidence levels ranging from moderate to very high. Post hoc pairwise comparisons showed that participants from Indonesia were significantly more confident than participants from the other countries. Full pairwise comparison results are presented in Supplementary Material 3.

A logistic regression analysis was conducted among participants who reported washing eggs before cooking (n = 1608) to examine factors associated with the likelihood of expressing confidence in not washing visually clean eggs after reading the message (Table 5). The likelihood ratio of chi square test [$\chi^2(32) = 130.69$, $p < 0.001$] indicated a significant improvement in fit compared with the null (no predictors) model. The Wald chi square tests were significant for country, gender, the presence of elderly in the household, proxy measure of habitual egg washing behaviour and perceived likelihood of *Salmonella* in eggs. Negative coefficients indicate lower likelihood and lower odds of expressing confidence about not washing shell eggs. In comparison to Vietnam, participants from Cambodia (OR = 5.025), Indonesia (OR = 3.659), Malaysia (OR = 2.287), Myanmar (OR = 2.700) and the Philippines (OR = 4.260) are more likely to express the confidence in not washing visually clean eggs after reading the message. Male respondents had lower odds of expressing confidence than females. Respondents at the age of 50 or higher are less likely to indicate the confidence, as compared to the youngest group (18-19 years old). Participants living with elderly individuals had higher odds of expressing confidence than those who did not. People who habitually wash visibly clean eggs had substantially lower odds of expressing confidence in the message. In general, participants who perceived *Salmonella* as more likely had higher odds of expressing confidence in not washing visually clean shell eggs (Table 6). A sensitivity analysis was further conducted to compare the results of the logit model and generalised ordered logit model which uses the original dependent variable (5 categories). The results of the two model specifications are broadly consistent, with country, habitual egg-washing behaviour, and perceived likelihood of Salmonella in eggs are important predictors of the confidence in not washing eggs. This is evidence that the main findings are not driven solely by the binary coding of the confidence variable (Supplementary Material 4).

3.1. Observation

Domestic kitchen observations were conducted with 24 participants from Malaysia, Indonesia, and Thailand (eight participants per country). Egg washing was commonly observed in Malaysia (7/8 participants) and Indonesia (5/8 participants), but less frequently in Thailand (2/8

Table 5
Chi-square association between sociodemographic variables and washing shell egg practices (n = 2422).

Demographics	Variables	Yes Frequency (%)	No Frequency (%)	Chi-square test		Fisher's exact test	df	Cramer's V
				X^2	p	p		
Country				**412.99**	**<0.001**	**nc**	**7**	**0.41****
	Cambodia	278 (85.3)	48 (14.7)					
	Indonesia	174 (52.1)	160 (47.9)					
	Laos	58 (47.2)	65 (52.8)					
	Malaysia	330 (96.2)	13 (3.8)					
	Myanmar	230 (65.5)	121 (34.5)					
	Philippines	212 (72.6)	80 (27.4)					
	Thailand	116 (33.5)	230 (66.5)					
	Vietnam	210 (68.4)	97 (31.6)					
Gender				**13.44**	**<0.001**	**<0.001**	**1**	**0.074****
	Male	523 (61.6)	326 (38.4)					
	Female	1085 (69.0)	488 (31.0)					
Age				7.71	0.052	nc	3	0.056
	18 – 29	773 (68.9)	349 (31.1)					
	30 – 39	337 (64.3)	187 (35.7)					
	40 – 49	251 (62.0)	154 (38.0)					
	50 and above	247 (66.6)	124 (33.4)					
Education				**18.32**	**<0.001**	**<0.001**	**1**	**0.087****
	Primary or Secondary	261 (76.5)	80 (23.5)					
	Tertiary	1347 (64.7)	734 (35.3)					
Employment				**39.71**	**<0.001**	**nc**	**3**	**0.128****
	Self-employed	173 (71.8)	68 (28.2)					
	Employed	699 (60.1)	464 (39.9)					
	Unemployed/Retired	147 (71.7)	58 (28.3)					
	Student	589 (72.4)	224 (27.6)					
Living with pregnant individual(s)				1.28	0.258	0.293	1	0.023
	Yes	65 (61.3)	41 (38.7)					
	No	1543 (66.6)	773 (33.4)					
				0.11	0.738	0.757	1	0.007
Living with people over the age of 65	Yes	611 (66.0)	315 (34.0)					
	No	997 (66.6)	499 (33.4)					
Living with children under the age of 5				0.479	0.489	0.495	1	0.014
	Yes	432 (67.5)	208 (32.5)					
	No	1176 (66.0)	606 (34.0)					
Food poisoning incidents				0.19	0.667	0.707	1	0.009
	Yes	328 (67.2)	160 (32.8)					
	No	1280 (66.2)	654 (33.8)					
Source of shell eggs				**21.89**	**0.001**	**nc**	**6**	**0.095****
	Supermarket	448 (66.0)	231 (34.0)					
	Wet/public market	397 (61.7)	246 (38.3)					
	Roadside stall	210 (68.9)	95 (31.1)					
	Farm	62 (56.4)	48 (43.6)					
	Grocery store	346 (70.5)	145 (29.5)					
	Own backyard	87 (75.7)	28 (24.3)					
	Other	58 (73.4)	21 (26.6)					

**p < 0.001; nc = not computed.

participants). Eggs were typically rinsed individually or collectively under running water, with washing lasting approximately 2 to 20 s. The water used was ambient temperature tap water, which is typical in households in the participating countries. In some cases, participants used additional materials or tools, including scourers, dishwashing liquid, fingernails, paper towels, or tea towels (Table 7). Handwashing with soap and water after handling or cracking eggs was observed in one participant (T7), while the rest of the participants either did not wash their hands, rinsed briefly with water only, or wiped their hands with a cloth or paper towel. Cross-contact opportunities were frequently observed including touching food contact and non-food contact surfaces after handling eggs. Additional risky practices included transferring egg shells over cooked eggs, using dishwashing scourers to clean shell eggs, and returning minimally rinsed utensils used during egg preparation to clean storage areas (Table 7).

3.2. Qualitative findings

3.2.1. Perceived belief that eggs are safer if washed

Many participants believed that washing eggs made them cleaner and therefore safer to consume. Across the interviews, participants frequently described washing egg to remove visible dirt, faeces, feathers, slime, or other matter attached to the shell despite most eggs appearing visually clean during the observations. For many, this cleaning action was closely linked to a sense of hygiene and safety. Other reasons given for the belief included increased confidence in egg safety and the perception that washing helps prevent infection.

> 'I believe that washing eggs makes them clean and hygienic, so they are safer to consume.' Participant I6 (Indonesia, female, 43)

> 'I wash the eggs to avoid infection.' Participant M7 (Malaysia, female, 50)

3.2.2. Trust in supply chain and purchase source

Participants' decisions about whether to clean eggs were often influenced by where the eggs had been purchased and by uncertainty about how the eggs had been handled before reaching them. Eggs purchased from traditional markets, farms, or informal retail settings were more likely to be perceived as dirty or unsafe. Meanwhile, eggs from supermarkets or packed in clean and neat packaging were sometimes perceived as cleaner and thus do not require washing. Participants were worried about the egg handling practices and what they were exposed to

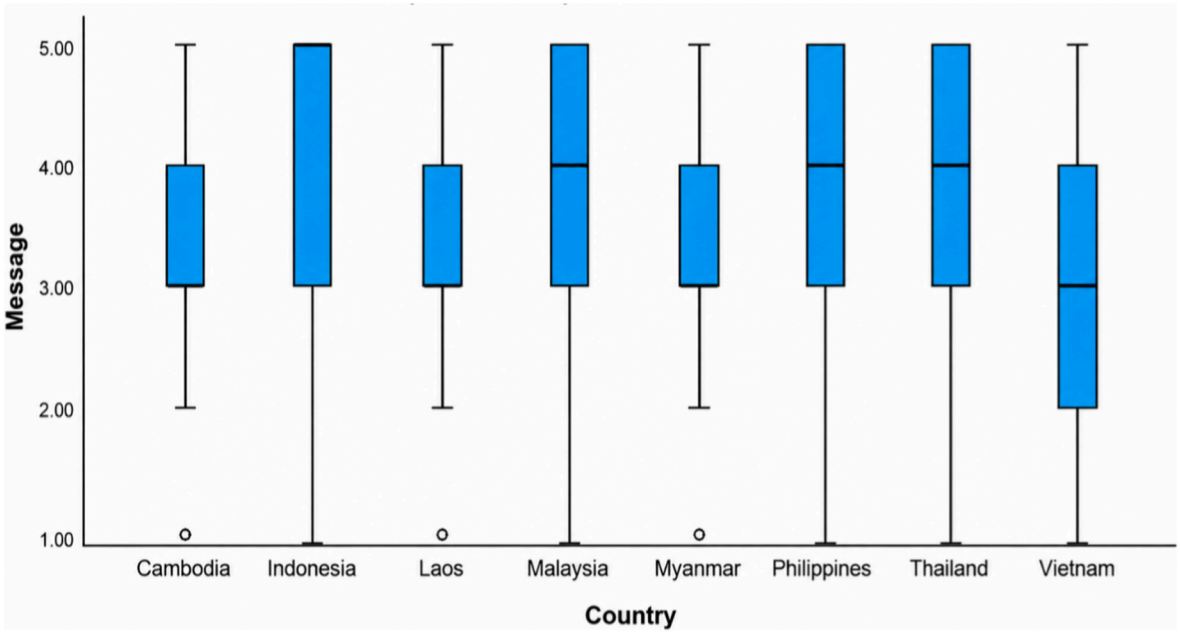

Fig. 1. Self-reported confidence in not washing shell eggs after reading the food safety message: '*Do not wash eggs at home. Washing can remove the egg's natural protective layer and let bacteria in. Before storing, just wipe or dry-clean eggs. Only wash eggs if they are dirty and you will cook them right away*'. After the message, participants were asked to rank their confidence level: 'After reading the message above, how confident are you to stop washing shell eggs that have been processed according to food safety standard and looks visually clean?' Responses are based on a 5-point likert scale from 1 (Not confident at all) to 5 (Very confident).

from farm to customers. The unknown source of egg and how it was handled increases doubt among the participants.

> 'I will still wash any kind of egg before cooking. I think the raw eggs at the shop were exposed to rats.' Participant M2 (Malaysia, female, 70)

> 'Fresh eggs from farms should be washed, as they are usually not pre-cleaned.' Participant T5 (Thailand, female, 47)

> 'What I think should be washed are sometimes the eggs I buy at traditional market, because sometimes there are still feathers, dirt or straw attached to them.' Participant I3 (Indonesia, female, 21)

3.2.3. Wiping as a distinct cleaning strategy

Wiping was identified as a distinct cleaning strategy. Participants who preferred wiping often described it as quicker, easier, and less messy than washing. Some also believed that wiping reduced the likelihood of water or bacteria entering the egg. Thai participants preferred using tissue, wet wipes or a damp cloth to clean dirty eggs rather than washing. This behaviour was also observed in one participant (Participant T8), who wiped shell eggs before placing them in the refrigerator rather than washing them.

> '*I will wipe it down, because if I wipe it, the water won't get in. But if I wash it, the water will get in, and bacteria will likely get in too.*' Participant I1 (Indonesia, female 49)

> *'I usually clean it if there is dirt or chicken droppings using a dry cloth. Wiping is the quickest way, as washing will take a long time.'* Participant I4 (Indonesia, female, 27)

> *'If egg is dirty, I will use wet tissue to wipe it before storing in the refrigerator or use.'* Participant T7 (Thailand, female, 67)

3.2.4. Role of informal information sources

Participants who did not wash eggs often referred to informal sources of information, including family members, personal or work experience, internet searches, and social media. Some participants described having learned that eggs should not be washed because washing might damage the shell's natural protective layer and increase contamination risk.

> '*My mother taught me when I was little that eggs should not be washed. My mother taught me that eggs should be wiped, not washed.*' Participant I1 (Indonesia, female, 49)

> *'I prefer to wipe rather than wash the eggs because it is convenient and clean enough to cook. Washing does make the shells look cleaner, but it would make the sink and countertop messy.'* Participant I3 (Thailand, male, 22)

> *'No, I don't believe washing eggs make it safer. I have read from an internet source that do not wash egg to prevent the contamination.'* Participant T6 (Thailand, male, 43)

Social media plays a crucial role in educating the participants. Participant read about the natural protective layer of eggs and that washing can cause bacteria to enter the egg. Participants reported seeing explanations on TikTok, while another said Instagram had reinforced her belief that washing causes bacteria to enter the egg.

> 'I have seen it on TikTok where there is an explanation about this (food safety message of not washing eggs).' Participant I2 (Indonesia, female, 20)

> 'Actually, I never used to wash them, I just wiped them. But since reading the information on Instagram, I am even more convinced that washing eggs will cause bacteria to enter.' Participant I4 (Indonesia, female, 27)

3.2.5. Resistance to change despite food safety message

Participants' responses to the message that '*washing might push bacteria through the shell*' were varied. Many reported that they had never heard this advice before and were reluctant to accept it. Participants who had previously encountered similar information, or if it aligns with prior experience appeared more open to the advice. Among participants who reported that they would still wash visually clean eggs, only two participants (Participant I3 and M7) indicated that they might consider changing their practice after hearing the message.

Table 6
Logistic regression predicting consumers' level of confidence in not washing visually clean shell eggs after reading a food safety message (n = 1608).

Variable	Coef. (SE)	Odds ratio	*Wald chi-square*	*p value*	95% CI of Coef.
Country			53.88	<0.001	
Cambodia	1.615 (0.266)**	5.025			[1.092, 2.137]
Indonesia	1.297 (0.298)**	3.659			[0.713, 1.881]
Laos	0.370 (0.352)	1.448			[-0.320, 1.061]
Malaysia	0.827 (0.254)**	2.287			[0.330, 1.324]
Myanmar	1.006 (0.269)**	2.735			[0.479, 1.533]
Philippines	1.451 (0.276)**	4.268			[0.910, 1.992]
Thailand	0.501 (0.285)	1.650			[-0.058, 1.059]
Vietnam	Reference level				
Gender					
Male	−0.325 (0.137)*	0.723	5.63	0.018	[-0.593, −0.057]
Female	Reference level				
Age			15.41	0.0015	
30-39	−0.096 (0.238)	0.908			[-0.563, 0.371]
40-49	−0.181 (0.254)	0.835			[-0.678, 0.316]
50 and above	−0.835 (0.253)**	0.434			[-1.330, −0.339]
18-19	Reference level				
Education					
Tertiary	−0.020 (0.182)	0.981	0.01	0.914	[-0.375, 0.336]
Primary or secondary	Reference level				
Employment			3.36	0.3395	
Self-employed	0.332 (0.287)	1.394			[-0.230, 0.894]
Employed	0.387 (0.227)	1.473			[-0.058, 0.832]
Unemployed/ retired	0.497 (0.319)	1.643			[-0.129, 1.123]
Student	Reference level				
Pregnant[a]					
Yes (ref. no)	0.326 (0.346)	1.385	0.89	0.346	[-0.353, 1.004]
No	Reference level				
Elderly[b]					
Yes (ref. no)	0.372 (0.139)*	1.450	7.15	0.008	[0.099, 0.644]
No	Reference level				
Children[c]					
Yes (ref. no)	−0.104 (0.153)	0.901	0.47	0.495	[-0.403, 0.195]
No	Reference level				
Total knowledge	0.012 (0.064)	1.012	0.03	0.852	[-0.114, 0.138]
Food Poisoning[d]					
Yes (ref. no)	−0.136 (0.161)	0.873	0.71	0.400	[-0.452, 0.180]
No	Reference level				
Proxy measure of habitual egg washing behaviour[e]					
Yes (ref. no)	−0.593 (0.137)**	0.552	18.68	<0.001	[-0.862, −0.324]
No	Reference level				
Perceived likelihood of *Salmonella* in eggs			26.23	0.0001	
Slightly likely	1.289 (0.286)**	3.630			[0.728, 1.850]
Moderately likely	1.021 (0.272)**	2.776			[0.488, 1.554]
Very likely	1.089 (0.283)**	2.970			[0.533, 1.644]
Extremely likely	1.604 (0.369)**	4.971			[0.881, 2.326]
I don't know	0.943 (0.254)**	2.569			[0.445, 1.442]
Not at all likely	Reference level				
Source of shell eggs			3.73	0.4436	
Wet market	0.327 (0.198)	1.387			[-0.062, 0.716]
Roadside stall	0.083 (0.255)	1.086			[-0.416, 0.582]
Grocery store	0.007 (0.198)	1.007			[-0.382, 0.396]
Other	0.246 (0.240)	1.279			[-0.224, 0.717]
Supermarket	Reference level				
_cons	−0.449 (0.406)	0.638			[-1.244, 0.345]

Wald chi-square statistics test the overall significant of each independent variable. The reported p value are the corresponding probabilities from these chi-square tests.
*p < 0.05; **p < 0.001.
[a] Yes/No=Living with or without pregnant individuals.
[b] Yes/No=Living with or without elders more than 65 years old.
[c] Yes/No=Living with or without children less than 5 years old.
[d] Experienced food poisoning in the past 12 months.
[e] Proxy measure of habitual egg washing behaviour was measured using the following hypothetical scenario: Assuming that the eggs you bought look visibly clean, are you going to wash the eggs?.

'*I have never heard of this before. I think that since the eggs are not cracked, germs are unlikely to enter. However, I would still wash the eggs before storing them to prevent anything from falling into the food during cooking.*' Participant T4 (Thailand, female, 69)

'*I don't believe it. In fact, if you don't wash them, dirt and bacteria will get into the egg white, so I still wash eggs under running water.*' Participant I8 (Indonesia, female, 23)

4. Discussion

More than half of eggs purchased were not refrigerated at point of purchase. However, the majority of participants reported storing them in the refrigerator at home. This is in line with the Koppel et al. (2014) who revealed that consumers from Thailand normally purchased unrefrigerated eggs. In Southeast Asia (SEA) eggs are often transported and sold unrefrigerated (Primer, 2015) due to the high costs of commercial cold storage. Additionally, there is limited chilling capacity especially when sold through public or wet markets, local grocery or roadside stalls or directly from farms as found in our study. Previous studies by Lublin and Sela (2008) demonstrated that *Salmonella* can multiply within eggs and reach high concentations when stored at room temperature. This is important especially within the SEA context due to the warm and humid

Table 7
Observation of participants' shell egg handling/washing and handwashing practices.

Participants	Profile	Source of eggs	Egg storage	Observed washing eggs?	Wash/Rinse procedure	Did participants use any tools to wash shell eggs?	Handwashing procedure after handling/washing shell eggs	Handwashing procedure after cracking eggs	Handwashing procedure after cooking eggs	Other cross-contact observations
Malaysia										
Participant M1	Female, 26, married with 2 children, housewife	Supermarket	Original carton on top of refrigerator	Yes	Eggs were placed in a bowl and washed with tap water. Each egg was scrubbed with a scourer and dishwashing liquid for 2 – 3 s	Scourer and dishwashing liquid	Rinsed hands for less than 3 s with running water	Did not wash hands	Rinsed hands for 2 s	After cracking and throwing the egg shells, participant touched other non-food contact surfaces
Participant M2	Female, 70, married with 6 children, retired	Wet market	Refrigerator	Yes	Eggs were washed individually and rubbed with hands under running tap water for 3 s each	No	Rinsed hands under running water for 2 s	Rinsed hands for 1 – 2 s with running water after cracking each egg	No	After handwashing (post-washing eggs), participant touched and re-washed one of the eggs again
Participant M3	Female, 67, married with 6 children, retired	Supermarket	Original carton on top of oven	Yes	Eggs were washed individually and rubbed with hands under tap water for 2-3 s each	No	Rinsed hands under running water for 3 s	Rinsed hands for 1 s with running water	No	
Participant M4	Female, 61, widowed with 5 children, seamstress and caterer	Supermarket	Refrigerator	Yes	Eggs were washed individually and rubbed with hands under running tap water for 13 s	No, eggs were dried with paper towel	Did not wash hands	Did not wash hands	Did not wash hands	Participant touched other food and non-food contact surfaces
Participant M5	Female, 23, married, housewife	Supermarket	Original tray on counter top	No	Did not wash eggs	No	Did not wash hands	Did not wash hands	Rinsed hands for 2 s while rinsing plate that was used to hold shell eggs/egg shell	Plate used to hold shell eggs/ egg shell were rinsed under running water for 4 s and replaced in clean utensils' shelf; Touched food and non-food contact surfaces; Pan lid was placed on top of egg tray.
Participant M6	Female, 57, married with 5 children, housewife	Grocery store		Yes	Rinse and scrubbed eggs for 20 s	Scourer and dishwashing liquid	Rinsed under tap water for 1 s	Did not wash hands	No	Cracked egg shells were transferred over cooked eggs during binning process. Touched food and non-food contact surfaces after cracking eggs;
Participant M7	Female, 50, married with 3 children, nanny	Grocery store	Plastic container near food preparation area.	Yes	Rinsed with bucket water and scrubbed for 13 s	Scourer	Did not wash hands	Did not wash hands	No	Touched food and non-food contact surfaces after cracking eggs
Participant M8	Female, 60, single, maid	Grocery store	Original tray on counter top	Yes	Rinsed under tap water and scrubbed for 5 s each	Steel scourer	Did not wash hands	Did not wash hands	No	Touched food and non-food contact surfaces after cracking eggs
Indonesia										
Participant I1	Female, 49, married with 2 children, housewife	Wet market	In a bowl on counter top	No	Did not wash eggs	Not applicable	Did not wash hands	Rinsed under tap water for 2 – 3 s	No	Touched food and non-food contact surfaces after rinsing hands

(*continued on next page*)

Table 7 (*continued*)

Participants	Profile	Source of eggs	Egg storage	Observed washing eggs?	Wash/Rinse procedure	Did participants use any tools to wash shell eggs?	Handwashing procedure after handling/washing shell eggs	Handwashing procedure after cracking eggs	Handwashing procedure after cooking eggs	Other cross-contact observations
Participant I2	Female, 20, single, university student	Supermarket	Refrigerator	No	Did not wash eggs	Not applicable	Did not wash hands	Rinsed one hand for 2 s	No	Cracked eggs with both hands but only rinsed one hand. Touched food and non-food contact surfaces
Participant I3	Female, 21, single, university student	Supermarket	Refrigerator	Yes	Rinsed egg for 4 s	No	Did not wash hands	Rinsed hands for 1 s	No	Cracked egg with fork, rinsed hands and replaced unwashed fork to clean utensils' shelf. Touched food and non-food contact surfaces
Participant I4	Female, 27, single, office worker	Grocery store	Refrigerator	No	Did not wash egg	Not applicable	Did not wash hands	Did not wash hands	No	Touched non-food contact surfaces
Participant I5	Female, 55, married with 3 children, housewife	Wet market/ egg agent (wholesaler)	Plastic container on counter top	Yes	Rinsed egg for 3 s	No	Did not wash hands	Wiped hands with paper towel	No	Touched ingredient (salt) and non-food contact surfaces
Participant I6	Female, 57, married with 2 children, housewife	Grocery store	Refrigerator	Yes	Rinsed egg for 5 s	No	Did not wash hands	Did not wash hands	No	Touched food and non-food contact surfaces; Used spoon to scoop ingredients and replaced spoon in clean utensils storage area
Participant I7	Female, 42, married with 4 children, housewife	Wet market	Refrigerator	Yes	Rinsed under tap water for 2 s and then wiped with tea towel	No	Did not wash hands	No (wiped right hand with tea towel)	No	Touched ingredient (salt) and non-food contact surfaces
Participant I8	Female, 23, married with two children, kindergarten teacher	Grocery store	Refrigerator	Yes	Rinsed under tap water for 2 – 3 s	No	Rinsed under tap water for 2-3 s	Did not wash hands	No	Touched ingredient (salt) and non-food contact surfaces
Thailand										
Participant T1	Female, 77, divorced, Street food vendor	Food truck	Refrigerator	No	Did not wash eggs	Not applicable	Did not wash hands	Did not wash hands	No	Touched non-food contact surfaces. Raw egg bowl was rinsed in water basin
Participant T2	Male, 27, single, farm worker	Grocery store	In original carton on counter top	No	Did not wash eggs	Not applicable	Before handling eggs, rinsed and scrubbed hands for 2 – 3 s	Did not wash hands	No	Touched non-food contact surfaces. Egg shell placed on tea towel
Participant T3	Male, 22, single, student	Wet market	Refrigerator	No	Did not wash eggs	Not applicable	Did not wash hands	Rinsed and scrubbed hands under tap water for 4 s	Rinsed and scrubbed under tap water for 2 s	Touched food and non-food contact surfaces.
Participant T4	Female, 69, divorced with 1 child, retired	Wet market	Refrigerator	No (but washed before storage)	Not observed but participant mentioned that the eggs were washed before storage	Not applicable	Did not wash hands	Rinsed under tap water for 1 – 2 s	While waiting for egg to cook, rinsed her hands for 1 – 2 s	Touched food and non-food contact surfaces.
Participant T5	Female, 47, married, factory worker	Food truck	Refrigerator	Yes	Rinsed and scrubbed with fingernail for 11 s and then wiped with paper towel	No (used fingernail)	Did not wash hands	No (wiped fingers with the same paper towel used to wipe the egg)	No	Touched food and non-food contact surfaces

(*continued on next page*)

Table 7 (*continued*)

Participants	Profile	Source of eggs	Egg storage	Observed washing eggs?	Wash/Rinse procedure	Did participants use any tools to wash shell eggs?	Handwashing procedure after handling/washing shell eggs	Handwashing procedure after cracking eggs	Handwashing procedure after cooking eggs	Other cross-contact observations
Participant T6	Male, 43, married, entrepreneur	Farm	Refrigerator	No	Did not wash eggs	Not applicable	Did not wash hands	Not applicable (prepared hard-boiled egg)	No	Peeled hard boiled eggs without handwashing
Participant T7	Female, 67, single, retired	Food truck	Refrigerator	No	Did not wash eggs	Not applicable	Did not wash hands	Washed hands with soap and tap water for 17 s	No	
Participant T8	Female, 47, married with 2 children, housewife	Supermarket	Refrigerator	No	Wiped with dry tea towel before storage	Not applicable	Did not wash hands	No	No	Touched food and non-food contact surfaces

environment in the region where warmer storage temperature may lead to increased potential of *Salmonella* multiplication in the yolk (Li et al., 2025). This is concerning given the high preference for runny yolk consistency by our study participants.

A key finding was that two-thirds of participants reported washing eggs before cooking, and almost 60% said they would still wash eggs even when they looked clean. Participants from Thailand and Laos reported lower levels of egg washing than participants from several other countries, while Malaysia showed particularly high self-reported washing prevalence. These differences may reflect variation in perceived cleanliness of eggs at purchase, market conditions, and national or local social norms around egg washing practice. The timing and method of washing are important when considering the associated food safety risks. FAO (2004) indicated that washing removes the natural protective cuticle of the eggshell and recommends that washed eggs are cooked and consumed as soon as possible rather than stored for prolonged periods. Cardoso et al. (2021) similarly reported that in some countries, washing is considered acceptable when restricted to dirty eggs and performed immediately before preparation. Washing dirty eggs immediately before cooking can reduce contamination, including *Salmonella* on the eggshell (McWhorter & Chousalkar, 2020). In our study, the use of using dishwashing sponges or scourers or rubbing eggs with hand during washing (Table 7) is of particular concern because these practices may facilitate the transfer of contamination to other kitchen surfaces and foods. Neuhaus et al. (2026) demonstrated that foodborne pathogens can persist in kitchen sponges and subsequently be transferred to other surfaces. In contrast, washing before storage may increase the risk of *Salmonella* spp. moving from the shell to the interior of the egg (Gole et al., 2014). The temperature difference between eggs and washing water may also influence microbial penetration through the eggshell (Gole et al., 2014; Messens et al., 2005). Eight of the 24 observed participants stored eggs at room temperature in the original carton or a bowl, while the remainder stored eggs under refrigeration. Thus, eggs may differ in temperature when washed with ambient temperature tap water. Washing a relatively warm egg with cooler tap water may favour microbial penetration through shell pores (Messens et al., 2005).

As shown in Table 4, 66.5% Thai participants reported they do not wash shell eggs before cooking. The Thai findings are consistent with Koppel et al. (2014) who reported that 55% (n = 100) of Thailand respondents do not always wash eggs and poultry. This may be attributed to the high grading standards in Thailand; under TAS 6702-2010, eggs must be intact and virtually free of stains (no more than 1/16 of the surface for lower grades) (TAS 6702-2010, 2010). Furthermore, the safety of the eggs is supported by the implementation of Good Agricultural Practices for Layer Farms (TAS 6909), which has transitioned from a voluntary guideline (2005) to a mandatory requirement (2019) to ensure that eggs are safe for human consumption without the need for domestic washing. Commercial farms were subjected to GAP standards (initially TAS 6909-2005, later updated to the mandatory TAS 6909-2019 (TAS 6909-2019, 2019). It is possible that consumer confidence in egg cleanliness at the point of sale contribute to the reduced perceived need for washing. However, this should be interpreted with caution as this study did not assess egg hygiene or measure retail standards at the time of purchase. Meanwhile, in other similar studies, 0.60% (n = 1504) USA respondents reported washing or rinsing eggs whereas higher proportion were reported in India (16.5%; n = 133) and Korea (11.9%; n = 101), where participants reported always washing eggs (Koppel et al., 2014; Kosa et al., 2015). In Europe and UK, cleaning dirty eggs varied between countries for example 17.7% (n = 954) in Norway, 25.8% (n = 934) in UK and 37.3% (n = 915) in Portugal (Cardoso et al., 2021).

From the observation study, 23 out of 24 participants did not wash hands with soap and water after handling or cracking eggs and proceed to touch other food and non-food contact surfaces, increasing the risk of cross-contamination. This differs from the survey findings where 41% of

survey participants reported that they always washed their hands with soap and water after handling raw eggs. The difference in self-reported and observed handwashing behaviour had been reported by previous studies. In Bai et al. (2025), the authors found the highest discrepancy between self-reported and observed handwashing behaviour compared to other food handling behaviour such as food storage, preparation, cooking and handling leftovers. This discrepancy highlights the limitations of relying solely on self-reported food safety practices and may reflect social desirability bias where participants report behaviours that are perceived as socially acceptable (Redmond & Griffith, 2003). Similarly, over-reporting of handwashing behaviour was identified by Contzen et al. (2015) who proposed that memory and recall bias may influence over-reporting. This is because handwashing is an automatic, routine behaviour where participants pay very little to no attention to the behaviour and thus participants may have found it difficult to accurately remember whether they washed their hands after cracking the eggs. Thus, their responses may reflect what they believed they usually do rather than their actual practices. Another potential explanation on why participants did not wash their hands with soap and water after handling or cracking eggs may be attributed to risk perception i.e., believing that handling or cracking shell eggs was not perceived as risky (Didier et al., 2021) or that a quick rinse was sufficient (FSA, 2026).

In a case-control study, not washing hands after handling raw eggs almost tripled the risk of *Salmonella* Enteritidis infection (Middleton et al., 2014). Egg washing in sinks as observed in our study also increases risk of cross-contamination in the sink and other kitchen surfaces (Menini et al., 2022). Other cross contact opportunities were revealed during the observation, particularly in relation to using the same dishwashing sponge to clean eggs and food-contact utensils, transferring eggshell over cooked eggs and touching both food and non-food contact surfaces. Dishwashing sponges can act as reservoirs of microorganisms where Møretrø et al. (2021) found that *Salmonella* could survive up to seven days in wet sponges. Kitchen sponges and hands also act as vehicle of microbial transmission to food and non-food contact surfaces (Osaili et al., 2020).

Indonesia reported the highest level of confidence in not washing eggs after reading the food safety message. These findings are further supported by the qualitative responses of Indonesian participants who were reported exposure to informal information channels or sources describing why eggs should not be washed. This may help explain the higher confidence observed among Indonesian participants after reading the message. For example, in Indonesia, several social media channels such as those on TikTok (viewed 496.1K times) (TikTok, 2023) and Instagram (10.9K likes) promoted food safety advice discouraging washing eggs (Instagram, 2023). Our findings were also supported by Charlesworth et al. (2023) who demonstrated the effectiveness of 30 s video intervention to promote safe egg handling. Informal communication platforms such as social media channels may serve as useful avenues to reinforce food safety messages.

Older participants (age 50 and above) were less confident in following the 'do not to wash eggs' message. It is likely that egg washing represents a long-established routine that has become habitual over time (Lally et al., 2010), thus older adults were less receptive to the food safety message. Similarly, male participants demonstrated lower confidence than females. Previous studies had consistently reported that women were more likely to engage in food safety behaviour partly because they frequently assume responsibility for household food preparation and were more risk averse to health threats including foodborne illnesses (Lewis & Dutch, 2021; Soon et al., 2022). Those who perceived *Salmonella* contamination as very or extremely likely had significantly greater odds of reporting higher confidence in not washing shell eggs after reading the food safety message. A possible explanation is that consumers who perceive eggs as risky may be more receptive to explanations about how bacteria can enter through the shell if the protective layer is damaged. This suggests that stronger perceived susceptibility or risk perception of *Salmonella* may increase consumers' receptiveness to advice against washing shell eggs. For example, perceived susceptibility was positively associated with safe food handling behaviours such as proper thawing raw meat and handling leftover while risk perceptions were associated with adequate cooking, hygiene and time-temperature control behaviours (Young et al., 2017a, Young, Thaivalappil, et al., 2017).

4.1. Why does egg washing persist despite food safety recommendations?

One of the most important findings of this study was that participants who habitually washed shell eggs were significantly less likely to express confidence in discontinuing the practice after reading the food safety message. This is further supported by the observation and qualitative findings where despite eggs looking clean (among the participant groups from Malaysia and Indonesia) participants would still wash the eggs. In the interviews, participants stated they washed eggs simply because that was what they had always done. These findings suggest that the persistence of egg washing despite food safety recommendations is potentially driven by multiple interacting factors rather than knowledge alone.

Participants who reported routinely washing visually clean eggs were significantly less confident about discontinuing the practice after reading the food safety message, suggesting that established routines may reduce receptiveness to the message. Although participants' knowledge of egg safety varied, total knowledge was not significantly associated with confidence in discontinuing egg washing after reading the food safety message. Meanwhile, habitual egg washing was identified as a significant predictor in their persistence in egg washing. This routine appeared resistant to change, even when participants were introduced to the idea that washing might push bacteria through the shell. Similar findings have been reported for other food hygiene behaviours, where repeated behaviours gradually become automatic through repetition and reduce cognitive effort (Ogutu et al., 2022). Once established, these habitual behaviours become resistant to change as the more often eggs are washed, the more 'automatic' it becomes and interventions to break this routine (i.e., to not wash egg) becomes challenging (Lally et al., 2010; Ouellette & Wood, 1998). Our finding is consistent with previous studies that have identified knowledge-behaviour gap where awareness of recommended food hygiene practices does not necessarily translate into behavioural change due to established routines, habit, perceived cleanliness and previous experience (Mullan & Wong, 2010; Redmond & Griffith, 2003; Young & Waddell, 2016).

The persistence of egg washing also appears to be reinforced by consumers' perceptions of cleanliness and food safety. Participants commonly reported washing eggs to remove visible dirt, faeces, slime and feathers, suggesting that visible contamination served as an important cue for cleaning behaviour. This was evidenced in Soon-Sinclair et al. (2024) where consumers reported that they washed raw poultry as the act of washing makes them feel cleaner and safer. Washing raw poultry and shell eggs may be heavily ingrained in SEA daily lives, cultures and the social norms of consumers in Southeast Asia.

The retail environment may further reinforce these perceptions. In the present study, approximately 72% of participants purchased eggs from informal retail settings, including wet markets, roadside stalls and backyard farms. Eggs from informal markets or retail system may not undergo the same grading and cleaning standards as eggs sold through formal supermarket supply chains (Cardoso et al., 2020), and consumers may encounter eggs with visible contamination such as dirt, faeces or feathers. Young et al. (2017a);)Young, Thaivalappil, et al. 2017 and

Soon and Abdul Wahab (2021) had reported concerns about the hygiene and microbiological quality of environment and foods sold through informal markets including farmer markets and wet markets. Thus, consumers may perceive egg washing as a necessary precaution before use. Repeated exposure to eggs with visible contamination may reinforce the habitual egg washing behaviour discussed above, such that washing becomes an automatic part of routine food preparation even when eggs appear visibly clean. Another possible explanation is that many participants may have continued washing eggs because they had performed the behaviour for years and did not get sick, thus did not perceive that washing egg is problematic (Byrd-Bredbenner et al., 2013).

Our study's findings suggest that confidence in following the food safety message was shaped more strongly by country context, habitual practice and perceived risk than by socio-demographic characteristics or knowledge level. This further suggests that domestic kitchen routines are resistant to change and knowledge alone is insufficient to increase confidence in discontinuing egg washing (Young & Waddell, 2016). Greater perceived risk of *Salmonella* contamination may therefore be an important driver of safer egg handling practices. Food safety messages that enhance understanding of contamination risk and narrated through relevant social pressures such as concern for vulnerable dependents, may increase consumers' confidence in the recommendation against washing eggs. However, increased perceived risk of *Salmonella* contamination and thus targeting food safety messages to create better understanding of the risks and through relevant social pressures such as concern for vulnerable dependents are more likely to influence consumers to change their safe food handling behaviour (Young & Waddell, 2016).

5. Practical implications

Food safety communication should explain more clearly why routine washing of eggs before storage is discouraged, particularly as some consumers may continue to wash even visually clean eggs due to lack of trust in the food supply chain. Existing food safety guidance recommend that eggs should only be washed when they are visibly dirty and washing is unavoidable, and that such eggs should be cooked immediately rather than stored. However, given that consumers may still choose to wash visually clean looking eggs, food safety messages should also reinforce appropriate handwashing with soap after handling or cracking eggs to minimise cross-contamination. Our findings also suggest that informal information channels such as social media may represent a useful platform to disseminate relevant food safety advice and recommendations.

6. Limitations

There are several limitations associated with this study. The survey was carried out online and thus may not reach those with reduced internet access. It is also prone to selection and social desirability biases as participants more interested in the topic may have been more likely to participate and to report responses perceived as desirable. Thus, the prevalence of unsafe egg washing behaviours observed in this study may represent an underestimation. This study acknowledges the small sample sizes, especially the number of participants from Laos, therefore, findings relating to Laos should be interpreted cautiously. Additionally, the coding of the dependent variable as a dummy variable might result in information lost and findings rely on self-reported responses which are subjected to recall bias. The food safety message evaluated in this study should not be interpreted as an intervention for behavioural change. Participants' responses reflected their self-reported confidence in following the recommendation after reading the message rather than actual changes in egg washing practices. Due to limited resources, the study only carried out limited observations and semi-structured interviews in selected countries only, i.e., Indonesia, Malaysia and Thailand. During the observation, participants may be influenced by Hawthorne effect due to the presence of observers and most of the observed participants were limited to females. The socioeconomic factors, social norms, cultural differences, access to education and food safety information are also highly variable between the countries thus the findings should not be generalised to all consumers or to all participating countries.

7. Conclusion

This study provides the combined first self-reported and observed egg washing and handling practices of consumers from eight Southeast Asian countries using a mixed-method approach. More than half of the eggs were not refrigerated at the point of purchase, although participants would proceed to refrigerate them at home. More than 80% of participants reported inspecting eggs at the time of purchase and before cooking. Egg washing before cooking was common, and many participants reported that they would still wash shell eggs even when they appeared visually clean. The study identified a gap between self-reported and observed handwashing practices, with only 1 of the 24 observed participants washing their hands with soap and water after handling shell eggs despite 41% of survey respondents reporting that they always performed this behaviour. Observations also showed frequent opportunities for cross-contact during egg preparation. Egg washing is influenced not only by the presence of visible foreign matter on the shell, but also by habitual practices, perceived risk, and limited trust in pre-purchase handling. Qualitative findings further showed that many participants believed washing made eggs safer, while wiping was used by some as an alternative cleaning strategy. Confidence in following the message not to wash visually clean eggs was shaped mainly by country context, habitual washing behaviour, and perceived likelihood of *Salmonella* contamination.

CRediT authorship contribution statement

Jan Mei Soon-Sinclair: Writing – review & editing, Writing – original draft, Validation, Supervision, Software, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Iwan Vanany:** Writing – review & editing, Project administration, Methodology, Investigation, Data curation. **Pornthipa Ongkunaruk:** Writing – review & editing, Project administration, Methodology, Investigation, Data curation. **Theingi Myint:** Writing – review & editing, Methodology, Investigation, Data curation. **Pisidh Voe:** Writing – review & editing, Methodology, Investigation, Data curation. **Chanthy Huot:** Writing – review & editing, Methodology, Data curation. **Mark Raguindin Limon:** Writing – review & editing, Methodology, Investigation, Data curation. **Sayvisene Boulom:** Writing – review & editing, Methodology, Investigation, Data curation. **Fue Yang:** Writing – review & editing, Investigation, Data curation. **Ikarastika Rahayu Abdul Wahab:** Writing – review & editing, Methodology, Investigation, Data curation. **Cong Duan Dao:** Writing – review & editing, Methodology, Investigation, Data curation. **Tareq Osaili:** Writing – review & editing, Investigation, Conceptualization. **Thanh Mai Ha:** Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation, Formal analysis, Data curation.

Declaration of competing interests

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.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.foodcont.2026.112578.

Data availability

Data will be made available on request.

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