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Assessment of consumer practices and awareness of *Campylobacter*-related food safety risks in chicken meat handling in Ho Chi Minh City, Vietnam

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Abstract Among 2614 respondents in Ho Chi Minh City, 61.8% were female, 49.5% were aged 18–30 years and 80.9% held a college or university degree. Chicken meat was bought at traditional markets by 80.3% of respondents, and 79.0% bought fresh chicken displayed at ambient temperature. At home, 84.1% stored chicken in a refrigerator or freezer, whereas 52.9% thawed frozen chicken at room temperature and 24.6% used a refrigerator or microwave oven. After thawing, 94.3% washed the meat before cooking. Well-done chicken was preferred by 92.8% of respondents, but 15.1% would still eat undercooked chicken; doneness was checked by cutting the meat (61.1%) or by external appearance (32.6%), and 3.1% used a food thermometer. Hands were washed both before and after handling raw chicken by 75.0% of respondents and 84.1% used soap. A cutting board and a knife were shared between raw chicken and raw vegetables in a way classified as a cross-contamination risk by 8.6% and 8.5% of respondents, respectively, and 5.1% did not separate utensils for raw and cooked meat. In the cross-contamination matrix, 76.2% reported no risky route, 13.8% one route and 0.6% all four routes (hands, cutting board, knife and utensils). *Campylobacter* spp. was recognized as a common pathogen on chicken meat by 24.6% of respondents, campylobacteriosis by 23.5%, and the possible presence of antibiotic-resistant bacteria by 42.4%. Awareness of campylobacteriosis and of antibiotic-resistant bacteria was associated with education level ($p < 0.05$). Thawing at room temperature, washing the meat after thawing, checking of doneness by external appearance and low recognition of *Campylobacter* spp. were the main gaps identified, and consumer education in Ho Chi Minh City should address these practices.

Keywords: Cross-contamination, Foodborne pathogen, Household kitchen, Poultry, Thawing

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Introduction

The chicken industry in Vietnam is growing and makes an increasingly important contribution to the food security of the country (Thi Dien *et al.*, 2023). The production and distribution networks comprise long distribution chains with numerous small-scale independent stakeholders, and live bird markets play a central role, driven by the preference of consumers for live chickens (Thi Dien *et al.*, 2023). Low biosecurity in household farms and live bird markets, mobile traders and the informal slaughter of birds were perceived by stakeholders as the main factors promoting disease risk along these networks (Thi Dien *et al.*, 2023). In a survey of fresh meat sold at wet markets and supermarkets in Vietnam, non-typhoidal *Salmonella* was isolated from 68.4% of the samples collected in Ho Chi Minh City (HCMC), and chicken samples from wet markets had the highest counts (median 3.2 log MPN/g) (Nhung *et al.*, 2018). In the same survey, antimicrobial residues were detected in 9.6% of meat samples from wet markets and 2.6% of those from supermarkets (Nhung *et al.*, 2018).

Campylobacter species are zoonotic pathogens transmitted to humans mainly through contaminated food of animal origin (El Baaboua *et al.*, 2022). Campylobacteriosis ranks among the most frequently reported foodborne illnesses in many countries, and poultry is the commodity most often associated with these illnesses, although efforts to reduce pathogen contamination on poultry have often focused on *Salmonella* (Williams *et al.*, 2021). *Salmonella*, *Campylobacter* and *Escherichia coli* are the bacteria targeted by antimicrobial interventions during poultry processing (Vaddu *et al.*, 2021). In Southeast Asia, epidemiological data on campylobacteriosis are scarce in Cambodia, Laos and Vietnam, which has been related to the limited number of laboratory facilities and the lack of surveys (Minh Nguyen, 2017). In Hanoi, *Campylobacter* spp. was detected on 41.1% of 107 fresh chicken carcasses from retail markets (Minh *et al.*, 2023) and in 38.3% of 120 chicken meat samples from traditional markets and supermarkets (Huong *et al.*, 2024). All 32 isolates characterized in the latter study were resistant to ciprofloxacin, nalidixic acid and tetracycline, and 24 of 28 *C. coli* isolates were multidrug resistant (Huong *et al.*, 2024). Among non-typhoidal *Salmonella* isolates from meat in Vietnam, resistance to quinolones (52.2%) and β-lactams (49.6%) was recorded, and isolates from chicken meat had the highest adjusted prevalence of multidrug resistance (Nhung *et al.*, 2018).

Contaminated chicken meat reaches the household kitchen, and about 40% of foodborne infections are acquired in the home (Møretrø *et al.*, 2021). Outbreak investigations and case-control studies have identified the handling of *Campylobacter*-contaminated chicken products as a risk factor for infection (Bai *et al.*, 2021). In a model kitchen, *C. jejuni* was transferred from raw chicken to

cucumber at rates of 5.32–16.28% when the knife and cutting board were reused, and to bread at 0.49% via unwashed hands (Bai *et al.*, 2021). *Campylobacter* survived for 3 h on stainless steel or wood and for up to 4.5 h on plastic surfaces (Lai *et al.*, 2023), and it persisted on 27% and 30% of the hands of chefs after washing in the restaurant and hotel kitchens examined (Lai *et al.*, 2024). In 87 households in six European countries, *Campylobacter* was found on 57% of raw chicken samples on average and on 23% of cutting boards after food preparation (Møretrø *et al.*, 2021). Using the same board and knife for vegetables after chicken without washing with detergent was common in Portugal and Romania, and rinsing chicken in the sink was common in three of the six countries (Møretrø *et al.*, 2021).

Consumer behavior has a central position in quantitative microbial risk assessment (QMRA) of poultry meat, with cross-contamination and undercooking during handling as the main concerns (Khalid *et al.*, 2020). In a farm-to-fork QMRA of *Campylobacter* in broiler chickens, the food safety practices of consumers and operations at processing plants were among the factors with the largest influence on consumer exposure (Dogan *et al.*, 2019). Consumer surveys have quantified these practices in other countries. Among 1618 Belgian respondents, 11% did not wash their hands after handling raw poultry meat, 6.7% and 8.2% used the same knife and cutting board for vegetables, respectively, and 16% would eat poultry meat that was not well cooked at a barbecue (Sampers *et al.*, 2012). Among 470 consumers in Accra, Ghana, 89.3% washed fresh chicken before cooking, and education and income were associated with the food safety practice score (Ovai *et al.*, 2022). In contrast, a prevention index of handling practices for chicken meat and eggs was not correlated with socioeconomic data or risk perception, and the thawing of chicken meat was among the procedures that determined the level of the index (Hessel *et al.*, 2019). Awareness of the risk posed by pathogens from raw chicken also differed among European countries (Møretrø *et al.*, 2021).

The studies from Vietnam cited above addressed the distribution network and contamination at retail in Hanoi and HCMC, which are the stages preceding the storage, thawing, cooking and handling of chicken meat at home. The need to enhance public awareness of food safety and foodborne diseases in Vietnam has also been emphasized (Minh *et al.*, 2023). The objectives of this study were to describe the purchase and consumption of chicken meat, the practices from storage to cooking, and hand and kitchenware hygiene among consumers in HCMC, to determine their awareness of *Campylobacter* spp., campylobacteriosis and antimicrobial-resistant bacteria, and to examine the associations between demographic factors and these practices and awareness indicators.

Materials and methods

Study design and participants

A cross-sectional descriptive study was conducted between June 2023 and June 2024 targeting adult residents of Ho Chi Minh City, Vietnam. The study aimed to evaluate consumer practices and knowledge related to chicken meat handling and microbial food safety risks. The inclusion criteria were aged 18 years or older, and actively participating in household food purchasing or preparation. A non-probability sampling strategy was employed, combining convenience sampling and snowball sampling. Initial participants were recruited in public areas (e.g., parks, supermarkets, and university campuses) and through online distribution via QR codes, email, and social media platforms. The survey teams interviewing respondents in public areas are shown in Figure 1. Participants were encouraged to share the survey with eligible acquaintances to expand the reach across multiple districts. This approach was selected due to practical limitations in conducting randomized household surveys in an urban environment and allowed broad representation across various demographic groups. Out of 2892 distributed questionnaires (including online and paper-based forms), 2614 valid responses from Ho Chi Minh City were obtained and included in the final analysis, resulting in a response rate of 90.4%. Incomplete or inconsistent responses were excluded from the dataset.



Figure 1. Pictures of the survey teams interviewing the respondents

Questionnaire development

A structured questionnaire consisting of 32 items was developed based on previous validated surveys in food safety literature (Sampers *et al.*, 2012). The questionnaire included three main sections:

Section 1: Sociodemographic characteristics (e.g., age, gender, marital status, education, income, occupation)

Section 2: Consumer behavior regarding chicken meat purchasing, storage, thawing, cooking, and cross-contamination practices

Section 3: Awareness of microbial hazards, including knowledge of *Campylobacter* spp., foodborne illness (campylobacteriosis), and antimicrobial-resistant bacteria on chicken

The questionnaire was delivered using both printed copies and an online platform (Google Forms). Participants were assured of anonymity and voluntary participation.

Risk classification

The probabilities of cross-contamination and undercooking of poultry were assessed using the coding shown in Table 1, in which risk (1) or no risk (0), as well as safe (1) or unsafe (0), were assigned to each response based on a literature review (Sampers *et al.*, 2012). Responses that fell into an intermediate risk category were also considered. For example, in question B.17, some participants reported thawing chicken using both a refrigerator and/or a microwave. According to Ovai *et al.*, thawing in a refrigerator and/or microwave is considered acceptable, whereas thawing on a countertop or kitchen table is not recommended (Ovai *et al.*, 2022). This classification aligns with established guidelines for minimizing the risk of foodborne pathogens (Dogan *et al.*, 2019). The transmission of *Campylobacter* bacteria from raw chicken to salad via cutting boards and knives was experimentally demonstrated and represented a significant route of contamination, particularly when raw chicken was found to be a high bacterial load and/or if the *Campylobacter* strain exhibits high virulence (Lai *et al.*, 2024).

Data analysis

Responses were coded and exported to Microsoft Excel 365 for initial data cleaning and subsequently analyzed using SPSS version 27.0.1.0 (IBM Inc., Chicago, USA). Categorical data were summarized as frequencies and percentages, and 95% confidence intervals (CI) of proportions were estimated by

the Wilson method. Chi-squared tests were examined associations between demographic factors (education, occupation and income) and food safety behaviors or awareness indicators. Statistical significance was set at $p < 0.05$.

Table 1. Coding of risk (R) and safety (S) for the questions on consumption (A), storage at home (B), undercooking (C) and cross-contamination (D)

Code	Question	Response options (coded value)
A13	Frequency of consuming chicken parts	Never; Rarely; Several times a month; Several times a week; Daily (not coded)
B14	Storage of chicken meat after purchase (S)	Freezer (1); Refrigerator (1); Room temperature (0)
B15	Temperature setting of the refrigerator	Medium; Coldest; Least cold (not coded)
B16	Opinion on how long chicken meat can be kept in the freezer	< 1 week; 1–4 weeks; 1–3 months; > 3 months (not coded)
B17	Place of thawing (R)	Refrigerator (0); Room temperature (1); Microwave oven (0); Immersion in water, in a plastic bag or container or directly (1)
B18	Thawing time in the refrigerator	< 6 h; 6–12 h; > 12 h (not coded)
B19	Washing meat after thawing (R)	Yes (1); No (0)
C20	Preferred doneness (R)	Well done (0); Medium (1); Raw (1)
C21	Doneness check (R)	No check (1); External appearance (1); Cutting the meat (0); Food thermometer (0)
C22	Eating chicken that is not thoroughly cooked (R)	Yes (1); No (0)
D23	Handwashing after handling raw chicken with (R)	Cold water (1); Warm water (1); Cold water and soap (0); Warm water and soap (0)
D24	Timing of handwashing when handling raw meat (R)	Before and after (0); Only before (1); Only after (1)
D25	Frequency of eating chicken with raw vegetables (R)	Never (0); Rarely (0); Sometimes (1); Often (1); Always (1)
D26	Preparing raw vegetables on a cutting board (R)	Shared cutting board, not washed (1); After the chicken had been processed (1); Separate cutting board (0); Shared cutting board, washed between uses (0)
D27	Preparing raw vegetables with a knife (R)	Shared knife, not washed (1); After the chicken had been processed (1); Separate knife (0); Shared knife, washed between uses (0)
D28	Separate utensils for raw and cooked meat (R)	Yes (0); No (1)

R: risk (1) or no risk (0); S: safe (1) or unsafe (0). Options coded as no risk (0) or safe (1) are the recommended options reported in Table 4.

Results

Sociodemographic characteristics and chicken consumption

A total of 2614 respondents in Ho Chi Minh City completed the survey (Table 2). Female respondents accounted for 61.8% and male respondents for 38.2%. Respondents aged 18–30 and 31–55 years accounted for 49.5% and 47.5%, respectively, and 3.0% were older than 55 years. A college or university degree or higher was held by 80.9% of respondents, 16.9% had completed high school and 2.2% lower secondary school. Private company employees (33.9%) and students (30.0%) were the largest occupational groups, followed by public servants (14.9%), business owners (9.0%), freelance workers (8.3%), homemakers (3.3%) and retirees (0.6%). Monthly income was 9–15 million VND for 37.7% of respondents and above 15 million VND for 21.9%, whereas 21.8% had no income.

Chicken meat was consumed weekly by 48.4% of respondents and several times a week by 31.7%; 18.5% rarely consumed chicken and 1.5% consumed it daily (Table 2). Traditional markets were the most frequently chosen place of purchase (80.3%), followed by retail shops (36.0%) and supermarkets (20.2%). Fresh chicken displayed at ambient temperature was bought by 79.0% of respondents, chilled fresh chicken by 41.7% and frozen chicken by 7.4%; these two questions allowed multiple answers (Table 2). Chicken wings and thighs were consumed at least once a week by 54.1% (n = 1415) and 49.3% (n = 1288) of respondents, respectively.

Table 2. Demographic characteristics, place of purchase, product form and frequency of chicken meat consumption of the respondents (n = 2614)

Demographic variable	Group	n	%
Gender	Male	998	38.2
	Female	1616	61.8
Age (years)	18–30	1294	49.5
	31–55	1242	47.5
	> 55	78	3.0
Education	Lower secondary school	58	2.2
	High school	442	16.9
	College, university or higher	2114	80.9
Occupation	Student	784	30.0
	Public servant	390	14.9
	Private company employee	887	33.9

Demographic variable	Group	n	%
	Business owner	236	9.0
	Freelance worker	216	8.3
	Homemaker	85	3.3
	Retired	16	0.6
Monthly income (million VND)	No income	571	21.8
	< 5	221	8.5
	5–9	265	10.1
	9–15	985	37.7
	> 15	572	21.9
Place of purchase*	Traditional market	2100	80.3
	Retail shop	941	36.0
	Supermarket	527	20.2
Product form*	Fresh, displayed at ambient temperature	2064	79.0
	Fresh, chilled	1091	41.7
	Frozen	193	7.4
Frequency of consuming chicken meat	Rarely	484	18.5
	Weekly	1264	48.4
	Several times a week	828	31.7
	Daily	38	1.5

* Multiple-response questions; percentages were calculated on all respondents and may sum to more than 100%.

Associations between demographics and food safety knowledge and behavior

Chi-squared tests were evaluated associations between demographic factors (education, occupation and income) and food safety behaviors or awareness indicators. Education level was not associated with awareness of *Campylobacter* spp. ($p > 0.05$), but was associated with awareness of campylobacteriosis ($\chi^2 = 13.10$, $p < 0.05$) and of antibiotic-resistant bacteria ($\chi^2 = 63.92$, $p < 0.05$). Occupation was associated with the cross-contamination risk via cutting board use ($\chi^2 = 87.64$, $p < 0.05$). Income was associated with awareness of *Campylobacter* spp. ($\chi^2 = 29.77$, $p < 0.05$) and with the use of a food thermometer to verify doneness ($\chi^2 = 11.63$, $p < 0.05$). The place of purchase was associated with income ($\chi^2 = 57.8$, $df = 18$, $p < 0.001$) and with education level ($\chi^2 = 78.5$, $df = 24$, $p < 0.001$).

Hygiene practices during chicken handling

Hand hygiene practices: Hands were washed both before and after handling raw chicken by 75.0% of respondents (n = 1961), 23.2% washed their

hands only after handling and 1.8% only before handling. Soap was used by 84.1% of respondents (79.2% with water at ambient temperature and 5.0% with warm water), whereas 15.9% washed their hands without soap.

Separation of equipment and utensils: Separate cutting boards, trays or utensils for raw and cooked chicken were used by 94.9% of respondents (n = 2481), whereas 5.1% (n = 133) used the same equipment.

Preparation of vegetables with chicken: A risk option for the cutting board was selected by 8.6% of respondents (n = 226): the same board for raw chicken and raw vegetables without washing between the two preparations (2.0%, n = 52) or preparation of the vegetables after the chicken had been processed (6.7%, n = 174). The corresponding proportion for the knife was 8.5% (n = 223): 1.7% (n = 45) and 6.8% (n = 178), respectively.

The combinations of cross-contamination routes via hands, cutting boards, knives and utensils are presented in Table 3. No risky route was reported by 76.2% of respondents, one route by 13.8%, two routes by 6.4%, three routes by 3.1% and all four routes by 0.6%. Among single routes, hands were the most frequent (9.9%), followed by utensils (2.1%), cutting boards (0.9%) and knives (0.9%). Among combined routes, cutting board and knife (3.0%), hands, cutting board and knife (2.1%), hands and knife (1.1%) and hands and utensils (1.0%) were the most frequent. Summed over the combinations in Table 3, irrespective of the hand and utensil routes, the risk options for both the cutting board and the knife were reported by 6.3% of respondents, for the knife only by 2.3% and for the cutting board only by 2.4%. Overall, the hand route (handwashing without soap) was reported by 15.9% of respondents.

Awareness of microbial risks

Campylobacter spp. was recognized as a common pathogen on chicken meat by 24.6% of respondents (n = 642; 95% CI: 22.9–26.2%). *Campylobacter*iosis as an illness resulting from the consumption of contaminated chicken was known to 23.5% (n = 615; 95% CI: 21.9–25.2%), and 42.4% (n = 1109; 95% CI: 40.5–44.3%) acknowledged that antibiotic-resistant bacteria could be present on chicken meat. When asked which pathogens on chicken meat concerned them (multiple answers allowed), 64.2% of respondents selected *Salmonella* spp., 48.9% *E. coli*, 24.1% *Campylobacter* spp. and 17.1% other pathogens.

Table 3. Percentage cross-contamination (risk = 1, or no risk = 0) between chicken meat preparations and kitchenware (knife or cutting board), hands or utensils used for raw and cooked meat and their combinations (n = 2614) in Ho Chi Minh city

Hands (D23)	Cutting board (D26)	Knife (D27)	Utensils (D28)	%
0	0	0	0	76.2
1	0	0	0	9.9
0	1	0	0	0.9
0	0	1	0	0.9
0	0	0	1	2.1
1	1	0	0	0.8
1	0	1	0	1.1
1	0	0	1	1.0
0	1	1	0	3.0
0	1	0	1	0.3
0	0	1	1	0.2
1	1	1	0	2.1
1	1	0	1	0.3
1	0	1	1	0.1
0	1	1	1	0.6
1	1	1	1	0.6

Recommended practices from storage to cooking

The proportions of respondents who followed the recommended option at each handling step, from storage to cooking, are presented in Table 4.

Storage: Chicken meat was stored in the refrigerator by 60.9% of respondents, in the freezer by 23.2% and at room temperature by 15.9%; thus 84.1% used cold or frozen storage. The refrigerator was set at the medium setting by 82.1% of respondents, at the coldest setting by 16.8% and at the least cold

setting by 1.1%. When asked how long chicken meat can be kept in the freezer, 26.2% of respondents answered less than one week, 29.7% 1–4 weeks, 32.8% 1–3 months and 11.3% more than three months.

Thawing methods: Thawing at room temperature was the most frequent method (52.9%); 18.6% of respondents thawed chicken in the refrigerator and 6.0% in a microwave oven, so that 24.6% used a recommended method. When asked how long thawing in the refrigerator takes, 52.4% of respondents answered less than 6 h, 42.2% 6–12 h and 5.4% more than 12 h. Thawing by immersion in water, reported by 22.5% of respondents (16.3% in a plastic bag or container and 6.2% directly in water), was classified as not recommended because water temperature and the frequency of water change were not recorded. After thawing, 94.3% of respondents washed the meat before cooking.

Table 4. Respondents following the recommended practices for chicken meat handling (n = 2614)

Practice	Recommended option	n (%)	95% CI (%)
Storage at home	Refrigerator or freezer	2198 (84.1)	82.6–85.4
Thawing method	Refrigerator or microwave oven	642 (24.6)	22.9–26.2
Washing meat after thawing	Not washing	148 (5.7)	4.8–6.6
Preferred doneness	Well done	2426 (92.8)	91.8–93.7
Doneness check	Cutting the meat to inspect or thermometer	1680 (64.3)	62.4–66.1
Eating undercooked chicken	No	2218 (84.9)	83.4–86.2
Handwashing after handling	Water and soap	2199 (84.1)	82.7–85.5
Timing of handwashing	Before and after handling	1961 (75.0)	73.3–76.6
Cutting board use	Separate board, or shared but washed	2388 (91.4)	90.2–92.4
Knife use	Separate knife, or shared but washed	2391 (91.5)	90.3–92.5
Utensils for raw and cooked meat	Separate	2481 (94.9)	94.0–95.7

Doneness verification practices: Well-done chicken was preferred by 92.8% of respondents, slightly pink meat by 4.7% and raw chicken by 2.5%; 15.1% stated that they would still eat chicken that was not thoroughly cooked. Doneness was checked by cutting the meat to inspect it (61.1%) or by external

appearance (32.6%); 3.1% used a food thermometer and 3.1% did not check doneness.

Hand hygiene and kitchenware: The recommended options for the cross-contamination questions were handwashing both before and after handling raw chicken (75.0%), handwashing with soap (84.1%), a separate or washed cutting board (91.4%), a separate or washed knife (91.5%) and separate utensils for raw and cooked meat (94.9%).

Discussion

The survey covered 2614 respondents, a larger sample than the 1618 Belgian adults surveyed with a web-based questionnaire supplemented by a printed version (Sampers *et al.*, 2012) and the 87 households in six European countries that were observed while shopping for and preparing a chicken meal (Møretrø *et al.*, 2021). However, 49.5% of the respondents were 18–30 years old and 80.9% had a college or university education. The proportions reported here therefore describe this group of respondents and should be extrapolated with caution to all consumers in Ho Chi Minh City.

Traditional markets were the place of purchase for 80.3% of respondents, and 79.0% bought fresh chicken displayed at ambient temperature. Both figures relate to storage conditions at the point of sale, a factor documented in traditional markets of other countries. In Peru, *Campylobacter* was detected in 28% (culture) and 76% (qPCR) of 90 chicken meat samples from traditional markets, with a mean count of 3.3 $\log_{10}$ CFU/g, and stalls without a refrigerator and using tap water had a higher contamination risk (Gonzales *et al.*, 2025). In a quantitative microbial risk assessment (QMRA) of the chicken meat supply chain in Burkina Faso and Ethiopia, interruption of the cold chain at the market was the main contributor to exposure (Ssemanda *et al.*, 2024). Packing freshly dressed chicken in the same bag as other groceries was also identified as a food safety gap among consumers in Accra, Ghana (Ovai *et al.*, 2022). The present study did not assess hygiene conditions at the points of sale used by the respondents, and the proportions are therefore interpreted as the purchasing behavior of the sample.

Thawing at room temperature (52.9%) was more frequent than the 34.6% recorded in Accra, Ghana (Ovai *et al.*, 2022), and 24.6% of respondents used a recommended method (refrigerator or microwave oven). Freezing does not eliminate *Campylobacter*: reductions during the freezing of poultry meat ranged from 0.5 to 3–4 $\log_{10}$ (Ovai *et al.*, 2022), and viable *Campylobacter* was still detected in frozen chicken samples in France, the United Kingdom and Hungary (Møretrø *et al.*, 2021). The proportion of respondents who would still eat

undercooked chicken (15.1%) was close to the 16% of Belgian respondents who would eat poultry meat that was not well cooked when served at a barbecue (Sampers *et al.*, 2012). In a QMRA scenario analysis in the Netherlands, thorough cooking was the household measure with the largest effect on reducing *Campylobacter* infection, followed by handwashing after handling raw chicken and replacing the cutting board (van der Vossen-Wijmenga *et al.*, 2025). In the present study, doneness was verified by cutting the meat by 61.1% of respondents and with a food thermometer by 3.1%, whereas 32.6% relied on external appearance and 3.1% did not check. Washing the meat after thawing (94.3%) was more frequent than washing fresh chicken before cooking (89.3%) in Accra, Ghana (Ovai *et al.*, 2022). Rinsing chicken in the sink was also common in three of the six European countries observed by Møretrø *et al.* (2021). Not washing the meat was the recommended option with the lowest proportion in Table 4 (5.7%). The washing method, the water flow and the cleaning of the sink and surrounding surfaces after washing were not recorded, and the contribution of this practice to cross-contamination in the kitchens of the respondents could therefore not be quantified.

The risk options for cutting board use (8.6%) and not washing hands both before and after handling raw chicken (25.0%) were self-reported behaviors. In an observational study in six European countries, *Campylobacter* was isolated from 23% and *Salmonella* from 8.7% of cutting boards after food preparation, and practices to avoid cross-contamination from chicken to kitchen surfaces and washing utensils were not established among consumers in all of these countries (Møretrø *et al.*, 2021). A quantitative experiment showed that the cutting board played a larger role than the knife in the transfer of *Campylobacter jejuni* from raw chicken to cucumber (van der Vossen-Wijmenga *et al.*, 2025). The proportions in the present study are self-reported behaviors, whereas those of Møretrø *et al.* (2021) are contamination rates on sampled surfaces. The two indicators are not directly comparable, and the 76.2% of respondents who reported no risk behavior via the four routes needs to be verified by direct observation.

Awareness of the risk from pathogens on raw chicken also differed among six European countries and was higher in Norway and the United Kingdom than in the other four countries (Møretrø *et al.*, 2021). Consumer behavior was identified as the central component of QMRA models for poultry meat (Khalid *et al.*, 2020). In the present study, the reported protective practices (94.9% separate utensils, 92.8% preference for well-done chicken and 84.1% cold or frozen storage) were more frequent than the recognition of *Campylobacter* spp. as a common pathogen on chicken meat (24.6%). The association between awareness and each practice was not tested at the individual level, and the

reported practices are therefore not interpreted as a result of knowledge about the pathogen.

The survey relied on self-reported data and non-probability sampling, and neither direct observation nor microbiological testing was included. In summary, respondents in Ho Chi Minh City reported cold or frozen storage (84.1%), a preference for well-done chicken (92.8%) and separate utensils for raw and cooked meat (94.9%), whereas thawing at room temperature (52.9%), washing the meat after thawing (94.3%), checking doneness by external appearance or not at all (35.7%) and the recognition of *Campylobacter* spp. as a pathogen on chicken meat (24.6%) were the main gaps. It is recommended that consumer food safety education in Ho Chi Minh City gives priority to thawing in the refrigerator, not washing raw chicken after thawing, verification of doneness, handwashing with soap before and after handling raw chicken, and the separation or washing of cutting boards and knives between raw chicken and raw vegetables. Self-reported practices should be verified by direct observation in future studies.

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Conflicts of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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