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Food safety knowledge, needed and trusted information of pork consumers in different retail types in Northern Vietnam

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Introduction: Food safety is an important public health concern globally. Risk communication is one of crucial element to manage food safety. While current food safety studies have focused on contamination of hazards or risk factors, limited research exists on consumer concerns, knowledge and perception about the actual risk food poses to their health. This study aimed to assess and compare the knowledge and perceptions regarding food safety, and the information needed and trusted by pork consumers in Northern Vietnam.

Methods: A total of 225 consumers recruited from three different market types: modern urban, traditional urban and traditional rural, were interviewed using a questionnaire between November to December 2019.

Results: The majority of participants (81.8%) were female and consumers interviewed at modern urban retail were younger than those interviewed at traditional retail settings ($p < 0.01$). Sixty-five percent of participants across the three retail types agreed that microbes were the most common hazards which can make them sick, but the adverse health effect due to chemical hazards was ranked higher than that of biological hazards. Most participants often received food safety information that was about animal diseases (such as African swine fever most recently), chemical contamination and the unknown origin of food rather than about food poisoning and measures to prevent it. Food safety messages from television and professional experts were the most trusted sources and consumer preference was for information about the origin of food (traceability) and how to choose safe food. Participants were willing to receive food safety information daily to weekly. A lack of perception and awareness about animal welfare related to pig farming or slaughtering was reported by most respondents (84.3%).

Discussion: These findings provide insight on Vietnamese consumer knowledge gaps, information demand and communication channels for food safety, so that risk communicators and managers can implement better food safety awareness campaigns and communication to consumers.

KEYWORDS

risk communication, food safety, mass media, consumers, Vietnam

Introduction

Food safety is an important public health concern globally. The World Health Organization (WHO) estimated that over 600 million foodborne illness cases were recorded in 2010, leading to losses such as nearly 420,000 deaths and 33 million DALYs (Disability Adjusted Life Years). As foodborne illness is contributing to the global disease burden, particularly for young children and for people living in low-income subregions of the world (World Health Organization, 2015), action to improve food safety from farm to fork across all food commodities and all production systems is needed. A joint FAO/WHO Food Standards Program emphasized the importance of the risk analysis framework, in which risk communication is one of the crucial elements to manage food safety. Risk communication promotes the interactive exchange of information about risks among risk assessors, managers or policymakers, the media, interested groups and the community or consumers. Close interaction and timely communication about food safety risks help to improve consumer knowledge of food safety, the belief and trust in the safety of the food supply and the food management system and the quality of food for human consumption (Codex Alimentarius Commission, 2019). In addition, food safety communication campaigns (e.g., World food safety day) and messages (e.g., WHO 5 keys to Food Safety), plus regular training and certification help to increase the knowledge of food producers, and thus support actors to comply with suggested food safety practices (Cohen et al., 2001; Roberts, 2008; Kassa et al., 2010).

In Vietnam, food retail markets can be classified into traditional and modern retail channels. Traditional retail channels include traditional markets and wet markets, where many types of food are sold and at a permanent location in close proximity to residential areas (Nga, 2014). Modern retail markets can be divided into several types, including supermarkets, convenience stores and boutique food shops, which are equipped with better infrastructure to store and display food to sell and predominantly located in urban areas. The food retail landscape in Vietnam is largely dominated by traditional retail due to market accessibility, availability, convenience, package-size flexibility and competitive prices, especially for fresh produce and dried food (Lapar and Toan, 2010; USDA, 2020). In spite of such advantages, traditional markets and wet markets often lack mechanisms for food safety control, such as assessment of food quality and product traceability (Nga, 2015; Dang-Xuan et al., 2016). In contrast, modern retail channels with an extensive store network, committed to providing high-quality products with known origin source are gradually gaining the trust of customers, especially middle-income consumers in big cities (Unger, 2020).

Nowadays, consumer perception is greatly influenced by mass media (television, radio, newspapers, Facebook, Twitter). In Vietnam, pork constitutes nearly 70% of total meat

consumption and this percentage has been rising steadily, linked to population growth, improved living standards and a shift in diet favoring animal-based proteins (Ruengjirachuporn, 2017; OECD, 2022). However, media reports about swine disease outbreaks have impacted pork consumption in Vietnam. In 2019, the African swine fever outbreak in Vietnam, which rapidly spread and devastated pig farms across almost all provinces of the country over 5 months (DAH, 2019), resulted in a dramatic decrease in pork consumption (USDA, 2019; Nguyen-Thi, 2021). This reduction was due in part to misinformation about the health risk posed to people such that people were scared of disease transmission from sick pigs to themselves, along with the doubling of the pork price due to the reduced supply of pigs (Chau, 2020; Nguyen-Thi, 2021). Further, information on health risks associated with meat of unknown origin, contaminated meat and poor-quality meat that appear frequently in the mass media, has raised consumer concern about the quality and safety of pork. Despite these adverse impacts, as yet risk communication on food safety issues has not been integrated into the risk-based food safety management system in Vietnam (The World Bank, 2016; Nguyen-Viet et al., 2017).

While food safety research has focused on potential risk factors, limited research exists on consumer concern and consumer knowledge and perception about the risk food poses to human health. Microbial pathogens are reported to be responsible for the great majority of foodborne diseases (Havelaar et al., 2015). This is in the line with recent findings from Ngo et al. (2021) for Northern Vietnam, in which a high *Salmonella* contamination in pork has been found across all retail types, included traditional retails, modern retails, canteen and street food services. However recent studies in Vietnam indicated that people are more concerned about chemical rather than microbial hazards (Nguyen-Viet et al., 2017; Ha et al., 2019). A food safety report from the General Statistics Office of Vietnam revealed that within 10 years from 2010 to 2020, the proportion of food poisoning cases (i.e., cases of illness due to eating contaminated food) found to involve chemical hazards was 4.2%, which was notably less than the 38.7% caused by biological hazards (38.7%) (GSO, 2020). This mismatch between Vietnamese consumer perception and actual causes of illness indicates that accurate information is not being conveyed effectively to the public. If not managed appropriately, even accurate information on food safety risks can result in changes to consumer behavior that have unintended adverse consequences for both human nutrition and producer livelihoods (Hoffmann et al., 2019). Therefore, this study aimed to assess and compare the knowledge and perceptions regarding pork safety and risk communication of consumers at urban and rural traditional retail outlets, and modern retail outlets in Northern Vietnam. A better understanding of consumers' knowledge and perception will inform the government, policymakers and food safety risk communicators about the information consumers want and the

avenues to convey it leading to more targeted and effective communication strategies.

Materials and methods

Ethical approval

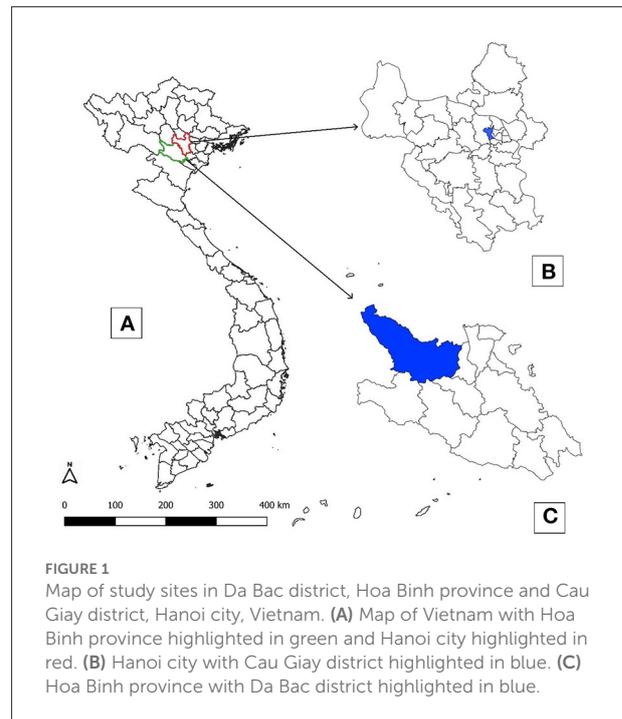
The Institutional Review Board of Hanoi University of Public Health reviewed and approved the methods for this survey (Decision number: 110/2018/YTCC-HD3). Consumers over 18 years old were briefed on the purpose of the survey and asked to give written informed consent if they agreed to participate. Participants were also informed that their answers would remain anonymous, they could withdraw at any time, and that the information collected would be kept confidential. As an incentive, each participant was given the gift of a cloth apron (valued at \$9USD) upon completing the questionnaire.

Study design and area

This cross-sectional study was conducted from November to December 2019 in Cau Giay district, Hanoi and Da Bac district, Hoa Binh province, which represented urban and rural areas of Northern Vietnam, respectively (Figure 1). Cau Giay district, one of the 12 urban districts among the 30 districts in Hanoi, is where over 293,000 people reside with a population density of 23,516 people/km², and an average annual income per person in 2019 of 102 million VND (approximate 4,430 \$US) (Hanoi Portal, 2019). It was selected as it is a built-up central area in the capital city of Hanoi which whilst still largely dominated by traditional retail, has an established and increasing number of supermarkets and convenience stores (USDA, 2017, 2019). In contrast, Da Bac district, one of 10 districts in Hoa Binh province, is a rural district where over 55,000 people reside with the population density of 80 people/km² and an average annual income per person in 2019 of 59.58 million VND (approximate 2,503 \$US). Traditional markets are the only retail option in Da Bac district (Hoa Binh statistic office, 2019).

Sample size and target groups

The sample size for this survey was calculated for a two-independent proportions comparison using a 95% confidence level and 80% power with an assumed difference of 25% in consumer food safety knowledge among the three retail types (rural and urban traditional markets and urban modern markets). With the inclusion of a target group of consumers per market (cluster), the sample size calculation was adjusted using the intra-cluster coefficient of 0.1 and equal proportions



among the three retail types. Thus, the minimum number of consumers required for interviews in each group was 72. Ten to fifteen markets each for urban traditional and for urban modern in Cau Giay district and five markets for rural traditional in Da Bac district were convenience sampled from the respective sampling frame that listed all markets by retail type in each study area. On average, five consumers per urban market and fifteen consumers per rural market were interviewed in the study. The actual number of consumers interviewed from rural traditional, urban traditional and urban modern retails was 76, 76, and 73, respectively.

Questionnaire and data collection

A structured questionnaire was first developed in English and then translated into Vietnamese by experienced, bilingual research team members. The questionnaire was pretested with five consumers in Gia Lam district, Hanoi and subsequently the wording of questions was refined to clarify meaning. The questionnaire consisted of 25 questions across four sections: (i) general demographic information, (ii) food and pork safety knowledge and perception (iii) information that the consumer wants to know about food and pork safety, and (iv) concern about animal and pig welfare. It was administered during a face-to-face interview that took approximately 20 min to complete. The interviews were conducted in Vietnamese. All interviewers attended a training session prior to administration of the questionnaire in the field.

Participants were selected through convenience sampling by directly approaching potential consumers who were observed purchasing pork. These consumers were politely approached by a research team member, given a brief explanation of the research and invited to participate in an interview. For consumers that were eligible and willing to participate in the survey, the interview was then conducted on the spot either within the market or outside the market entrance.

Data management and analysis

Data was collected using Kobotoolbox (version 1.27.3-3, www.koboToolbox.org), then extracted into spreadsheet sheets (Microsoft Corporation, 2018) and cleaned before analysis. Data analysis was performed using R3.4.4 (R Core Team, 2018). Descriptive statistics were used such as percentages for categorical data and means, standard deviations and ranges for quantitative data. Chi-square or Fisher exact tests (where appropriate) were used to compare frequencies between groups. Multiple groups comparisons were done for ranking questions by using Kruskal-Wallis test. For significant results from Kruskal-Wallis test, *post-hoc* analysis (kruskalmc function) was conducted to identify significant difference between tested groups using “pgrimess” package in R. Statistically significance was set at $p \leq 0.05$.

Results

Demographic information of respondents

There were 225 participants in this survey, including 76 from rural traditional markets, 76 from urban traditional markets, and 73 from urban modern markets (Table 1). Participants were evenly distributed across five age categories except for consumers from modern urban markets that were younger than consumers from other groups ($p < 0.01$). In all market types, female participants made up the majority. A larger percentage of male participants were interviewed in the modern urban markets compared to traditional urban markets ($p < 0.01$). Most participants had at least a high school level of education, with a higher percentage of participants with college/university education in the modern urban group than the others ($p < 0.01$). The mean distance of the markets from the participant’s residence was 2.9 km. Consumers from rural markets often travel further than consumers in urban areas (ANOVA, $p < 0.01$).

Consumer’s knowledge of pork safety hazards and constraints

Microbes were identified as the most common hazard that can make consumers sick related to eating pork or pork products, followed by chemical hazards and physical hazards

TABLE 1 General information on 225 pork consumers interviewed at three retail types in Northern Vietnam in 2019.

Information	Modern urban		Traditional urban		Traditional rural		Total	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Age group (<i>n</i> = 223)								
18–25	21	29.6 ^a	3	3.9 ^b	0	0.0 ^b	24	10.8
26–35	30	42.3 ^a	12	15.8 ^b	14	18.4 ^b	56	25.1
36–45	11	15.5 ^a	11	14.5 ^a	19	25.0 ^a	41	18.4
46–55	3	4.2 ^a	20	26.3 ^b	19	25.0 ^b	42	18.8
≥56	6	8.5 ^a	30	39.5 ^b	24	31.6 ^b	60	26.9
Gender (<i>n</i> = 225)								
Male	23	31.5 ^a	5	6.6 ^b	13	17.1 ^{a,b}	41	18.2
Female	50	68.5 ^a	71	93.4 ^b	63	82.9 ^{a,b}	184	81.8
Education (<i>n</i> = 225)								
Primary school or less	0	0.0 ^a	6	7.9 ^b	8	10.5 ^b	14	6.2
Secondary school	3	4.1 ^a	23	30.3 ^b	30	39.5 ^b	56	24.9
High school	26	35.6 ^a	35	46.1 ^a	33	43.4 ^a	94	41.8
Colleges/university or higher	44	60.3 ^a	12	15.8 ^b	5	6.6 ^b	61	27.1
Distance to market (<i>n</i> = 201)*								
	<i>Mean ± SD</i>							
	2.0 ^b	3.3	1.7 ^b	4.6	5.1 ^a	3.3	2.9	6.1

^{a,b}Difference superscripts indicate statistically significance at $p < 0.01$, * using t-test. SD, standard deviation.

TABLE 2 Perception of hazards associated with pork, main problems with access to buying pork and its reasons reported by pork consumers at three retail types in Northern Vietnam in 2019.

	Modern urban		Traditional urban		Traditional rural		Overall	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Hazards associated with pork (<i>n</i> = 225)								
Microbes	49	67.1	48	63.2	49	64.5	146	52.2
Chemical	36	49.3	31	40.8	28	36.8	95	33.8
Physical	4	5.5	2	2.6	3	3.9	9	3.2
Don't know	8	11.0 ^{ab}	16	21.1 ^a	5	6.6 ^b	29	10.4
Difficulty accessing pork to buy during last month (<i>n</i> = 224)								
Yes	45	61.6 ^a	62	81.6 ^b	59	77.6 ^{ab}	166	73.8
No	27	37.0	14	18.4	17	22.4	58	25.8
Missing	1	1.4	0	0	0	0	1	0.4
Main problem with access to buying pork (<i>n</i> = 166)								
High price	42	93.3	59	95.2	49	83.1	150	90.4
Concern about disease in pigs	3	6.7	2	3.2	9	15.3	14	8.4
No pork in market	0	0.0	1	1.6	0	0.0	1	0.6
Market where pork is sold is too far from home	0	0.0	0	0.0	1	1.7	1	0.6
Reasons for the main problem (<i>n</i> = 166)								
African Swine Fever (ASF)/Pig diseases	32	71.1	48	77.4	37	62.7	117	70.5
Low income	7	15.6	14	22.6	15	25.4	36	21.7
Increase in export to China	10	22.2 ^a	9	14.5 ^{ab}	3	5.1 ^b	22	13.3
Lack of pork retailers	6	13.3 ^a	2	3.2 ^{ab}	1	1.7 ^b	9	5.4
Insufficient pigs/pork supply to meet demand	3	6.7	2	3.2	4	6.8	9	5.4
Other (specify)	0	0.0	2	3.2	1	1.7	3	1.8
Don't know	4	8.9	9	14.5	2	3.4	15	9.0

^{ab}Difference in proportion between groups statistically significant at $p < 0.05$ when superscripts differ.

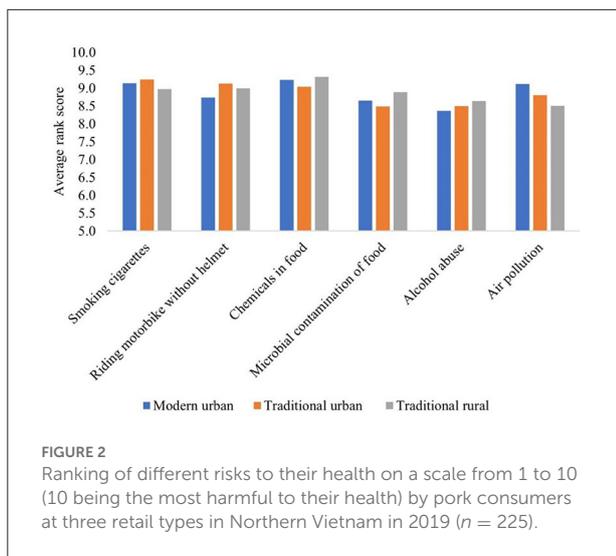
(Table 2). There was no significant difference of these hazards among the 3 retail types. However, more of the participants from the traditional urban markets did not know what type of hazard could cause illness related to eating pork than at the traditional rural markets with 21.1 and 6.6%, respectively ($p < 0.01$).

Regarding the question asking respondents whether they had any difficulty accessing pork to buy during the last month, 73.8% (166/225) of them reported that they had, with a higher proportion reporting difficulty from the traditional urban market (81.6%, 62/76) than traditional rural (77.6%, 59/76) and modern urban markets (61.6%, 45/73) ($p < 0.01$). Among the listed difficult problems with accessing pork, high price was the most reported one (150/166, 90.4%), and this percentage was similar among all market types. Another reported problem was the concern of consumers about disease in the pigs (8.4%, 14/166, Table 2). Respondents then were asked for the most common reason leading to the high price problem. It is revealed that the African swine fever (ASF) outbreak was the most frequently reported reason (117/166, 70.5%), followed by reduced/low income (21.7%), and an increase in pig export to China (13.3%). Lack of pork retailers and increase in pig export to China were mentioned more by consumers from modern markets than traditional rural ones ($p < 0.05$, Table 2).

In addition to inquiring if pork had been difficult to access, consumers were asked if they were worried about the safety of eating the pork that they purchased in the last month. To which, 71.1% (160/225) of consumers answered yes. Consumers in traditional rural markets (82.9%, 63/76) were more likely to worry about the safety of purchased pork than those in modern urban markets (58.9%, 43/73) ($p < 0.01$).

Consumer's knowledge and attitude on food safety risk and trust of different retail types

Consumers were asked to rank different risks, included smoking cigarette, riding motorbike without helmet, chemicals in food, microbial contamination in food, alcohol abuse and air pollution, which are common factors in the Vietnamese context to compare their perception about the risks to their health (on a scale from 1-being less, to 10-being the most harmful to their health). Overall, microbial contamination of food and alcohol abuse were of less concern compared to chemicals in foods and smoking cigarettes by all groups ($p < 0.05$), with no significant



difference between retail types (Figure 2). Consumers were also asked to rank issues that worry them about eating pork or pork products from the most to the least source of worry. Pig diseases/ASF was in first rank, followed by reports of people getting sick from eating pork, media reports about unsafe pork product processing, and media footage of the killing of pigs to control disease, respectively. This rank order was the same across the 3 retail types, though notably consumers at traditional rural markets were more likely to worry about reports of people getting sick from eating pork than those at traditional urban markets ($p < 0.05$, data not shown).

More than 80% of respondents indicated that they consider whether food is safe or not when deciding where to buy pork. Consumers had more trust in the safety of pork sourced from their own pigs, from pigs raised by neighbor/known people and from modern retail outlets such as supermarkets, boutique shops and convenience stores. Mobile vendor and street/wet markets were the least trusted, being significantly lower than all other sources ($p < 0.01$) (Figure 3). There was no difference in trust levels of consumers at the 3 retail types for pork sourced from their own pigs and from pigs raised by neighbor/known people. Traditional rural consumers trusted less in the safety of pork in convenience stores and more in supermarkets compared with other groups ($p < 0.01$, chi square). Modern urban consumers trusted less in traditional markets and street/wet markets, and more in boutique shops compared with other groups ($p < 0.01$). Traditional urban consumers trusted more in street/wet markets ($p < 0.05$).

Content and consumer demand of food safety information

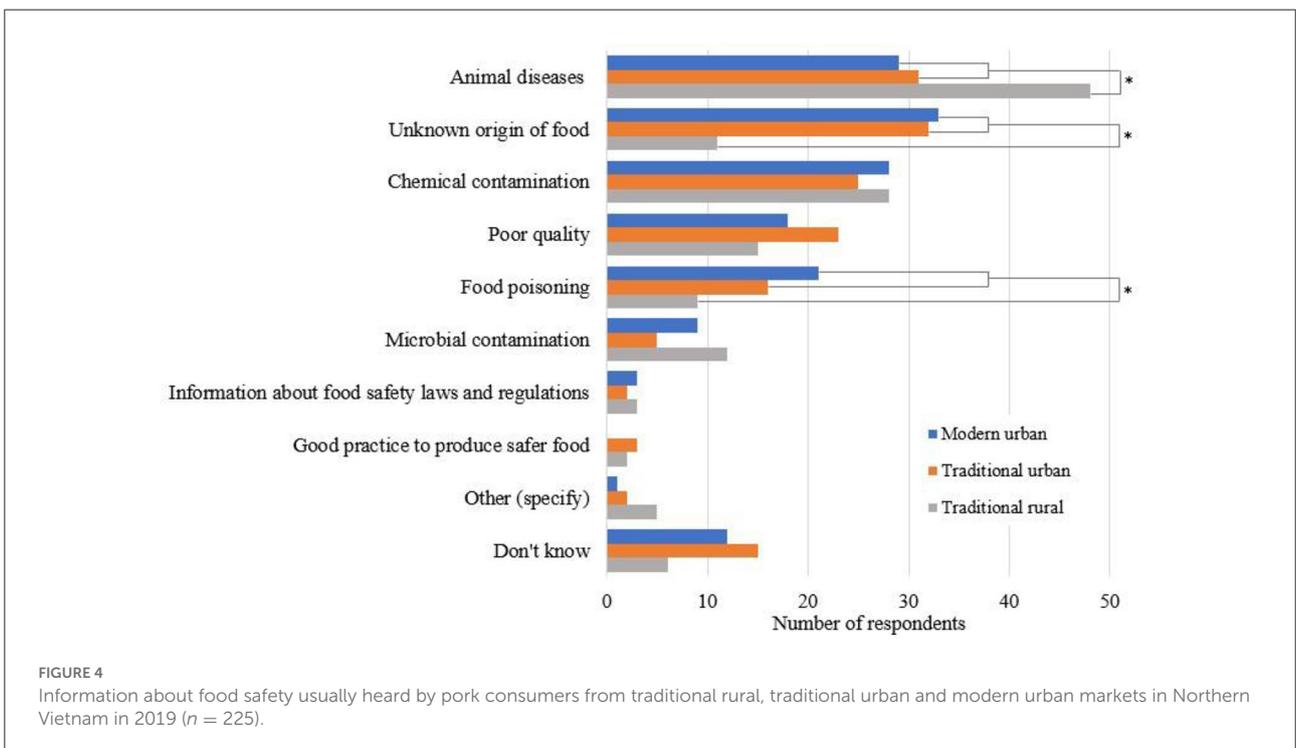
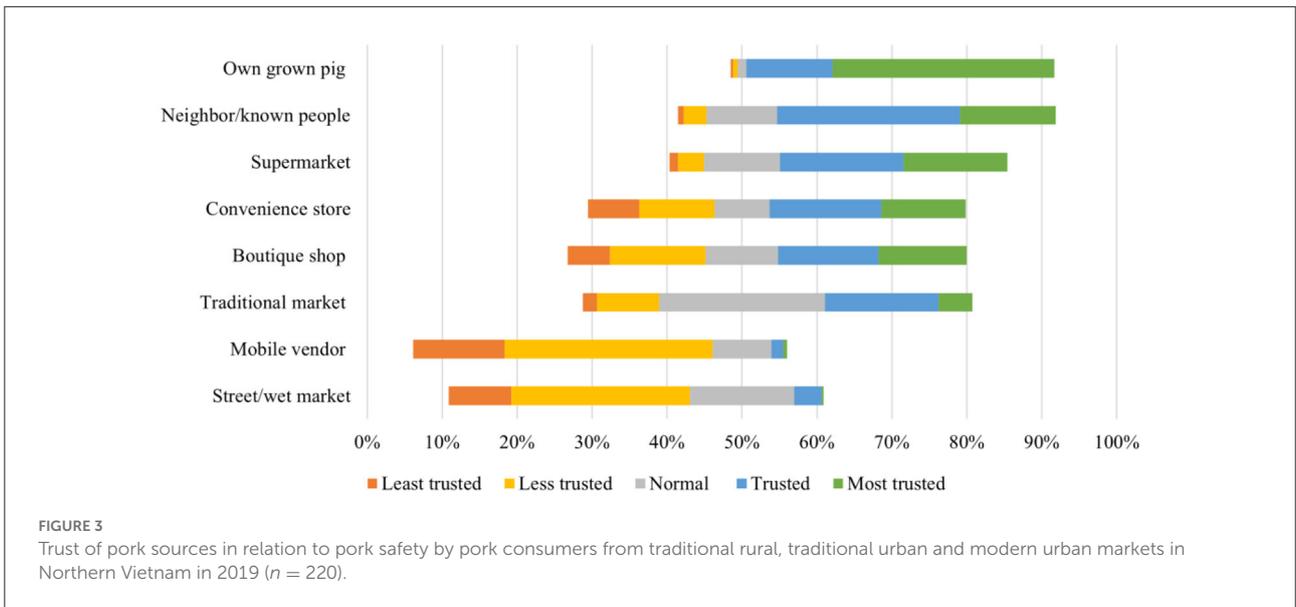
The food safety information that most participants reported usually hearing about was animal diseases (such as ASF

most recently), and this was reported by a significantly higher proportion of consumers at the traditional rural markets ($p < 0.01$). Chemical contamination and unknown origin of food were the second and third most common types of information received by participants (Figure 4). A significantly lower percentage of consumers in traditional rural markets reported hearing about unknown origin of food and food poisoning compared to urban consumers ($p < 0.01$). The survey found that when going to buy pork, consumers were interested to have information provided about the specific farm of origin, production/expired dates and the region that pig came from. The other information such as cooperative of pig producers, pig raised with/without antibiotic, breed and age of pig, and slaughterhouse where the pig was slaughtered were of less interest. Traditional rural consumers were more interested in information about the region that pig came from, type of feed fed to pig, age of pig and slaughterhouse where the pig was slaughtered. Modern urban consumers were more interested in production/expired date information.

When consumers were asked what information they would like to know about food safety in general, the two most common responses were the origin of food (food traceability information) and how to choose safe food, being reported respectively by 61.6 and 45.2% of modern urban consumers, 44.7 and 32.9% by traditional urban consumers, and 39.5 and 44.7% by traditional rural consumers.

Trust of source on food safety information by consumers

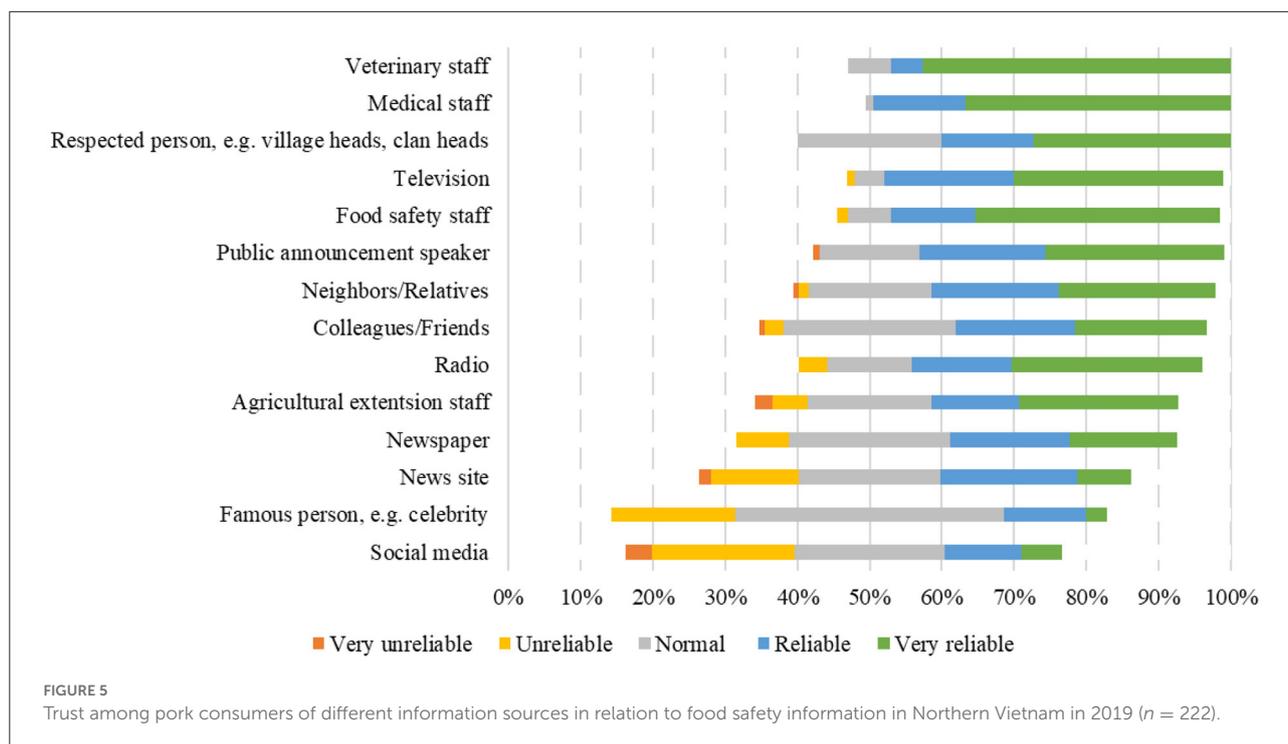
In general, professionals (medical staff, veterinarian, food safety staff) and television were the most trusted sources for information on food safety while social media and famous person were the least reliable (Figure 5), being similar among consumers across the 3 retail types. From a list of channel options by which to receive food safety information, the two most common options chosen by consumers from all three groups were television and mobile phone, with 75 and 31.1% respectively. The third most common option chosen by urban consumers (both modern and traditional ones) was online newspaper (41.1 and 21.1%), while consumers from traditional rural markets prefer community meetings for the distribution of information (19.7%). The option of community meetings was less mentioned by modern urban consumers than other groups (chi square, $p < 0.01$). Compared to the other two groups, modern urban consumers mentioned more about the options of receiving food safety information through phone and news sites, and much less about the option of community meetings (chi square, $p < 0.01$). On the other hand, traditional urban consumers reported a higher preference to receive information via radio (22.4%)



than the modern urban and traditional rural groups (1.4 and 3.9%, respectively) (chi square, $p < 0.01$). Consumers were then asked how often they would like to receive food safety information and across both the urban and rural markets, consumers said that they would like to receive food safety information daily or weekly, with 67.1 and 23.1% respectively.

Perception of consumer about animal welfare

The survey found that 84.3% (188/223) of participants had not heard of the term “animal welfare.” Of the 35 participants that had heard the term, more than half (51.4%) were modern urban consumers, 25.7% were traditional urban and 22.9% were



traditional rural (statistically different between modern urban and traditional rural consumers, $p < 0.05$). When participants were asked how pigs should be kept on the farm, the majority agreed that pigs should be kept in good hygienic conditions (175/218, 72.5%). In addition, 27.6% (62/218) thought the pigs should have enough space to move around and exhibit natural behavior such as nesting behavior for pregnant sows before giving birth (43/218, 19.1%). Less people were concerned that pigs be able to run around (17/218, 7.8%), of which the number was significantly higher among consumers from traditional rural markets ($p < 0.01$). A small portion of consumers reported that pigs only need space to lay down (12/218, 5.5%).

In relation to slaughter, 43.7% (97/222) of participants said that they did not know how pigs should be slaughtered in terms of animal welfare. However, 34.2% of respondents said that pigs should be slaughtered with the least amount of suffering possible and for 40.2% (89/221) less suffering during slaughter was thought to improve the quality of pork, with this stated by a significantly higher proportion of consumers from traditional rural markets ($p = 0.01$, data not shown).

Discussion

In general, consumers were concerned about the quality and safety of food, especially pork in this study. Similarly, a survey of food shoppers in rural and urban areas of Hanoi found that 95% of respondents expressed concern about the safety of food

(Ha et al., 2021). These findings are further evidence of the growing public concern about food safety in Vietnam, indicated in previous studies (Nguyen-Viet et al., 2017; Unger, 2020).

However, there were gaps in knowledge and perception of consumers regarding pork safety and these varied between retail types. Microbial contamination was identified as the most common hazard that can make consumers sick, but participants were less concerned about the health impact to consumers of microbial hazards compared to chemicals in food and/or smoking cigarettes. This finding aligns with previous literature in both developed countries and Vietnam (Kher, 2013; Ha et al., 2019). It can be explained at least in part by the fact that gastrointestinal illness is common, everyone experiences it at some time, and most episodes resolve quickly without hospitalization, thus it is highly under reported (American Society for Microbiology, 2002). On the other hand, chemical hazards are less common but attract more media attention due to more serious health consequences (such as cancer) (Kher, 2013; Nguyen-Viet et al., 2017). In contrast to public perception, a recent study that assessed chemicals in 190 fresh pork samples (pooled in 18 samples) in two provinces of Vietnam found that arsenic, lead and cadmium were lower than the allowable level (Tuyet-Hanh et al., 2017), while another study collected 671 pork samples from different retail channels in Northern Vietnam found 58.1% of pork samples was contaminated with *Salmonella* and only 6.2% pork samples fulfilled the Vietnamese standard requirement for total bacteria count (Ngo et al., 2021). In addition, according to the food safety report from

General Statistics Office of Vietnam, from 2010 to 2020, the cause of foodborne outbreaks related to microbial and chemical hazards recorded were 38.7 and 4.2%, respectively (GSO, 2020). Therefore, more concrete evidence of chemical contamination and its health effect would be helpful to confirm the safety of pork in Vietnam. Such evidence could be used to shift consumers' focus to microbial contamination.

Additionally, significantly more of the participants from the traditional urban markets were unsure of what might make them sick in regard to eating pork than those from the traditional rural markets. A recent study found that urban consumers tend to have greater risk perceptions compared to consumers from rural areas because urban consumers were more aware of food safety concerns (Ha et al., 2021). As knowledge of potential food hazards are generally lower in areas where levels of educational attainment are low and we would generally expect that due to the rural-urban gap, rural populations would have lower levels of education (Hoffmann et al., 2019). The levels of educational attainment among participants were fairly equal between traditional urban and traditional rural markets. In this case, the higher perception among rural consumers compared to urban consumers could depend on more frequent dissemination of pork safety information at traditional rural markets. As a result, consumers in traditional rural markets were more worried about the safety of purchased pork and reports of people getting sick from eating pork.

The survey found that almost all participants had found it difficult to access pork in the last month (November-December 2019). The problem of accessing pork to buy was reported more by consumers at the traditional urban markets, which are supplied by smallholder farms, the sector in which most ASF outbreaks occurred due to a lack of capacity and biosecurity resources to prevent the disease (USDA, 2019). Government imposed restriction on the movement of live pigs and pig carcasses between provinces limited the source of pork for consumers in urban areas (MARD, 2018). These results were expected as following the 2019 ASF outbreak in Vietnam more than 5.9 million pigs were either culled or died from the disease despite significant government efforts to control the disease (Ngoc Que, 2020). Furthermore, during this time, the demand for live pig export from Vietnam to China increased (Bui and Gilleski, 2020). The higher demand and lack of pigs in the supply chain led to a substantial price increase for pork, and this is reflected by 90.4% of consumers in this survey reporting high prices as the main reason for difficulty with the purchase of pork.

Our findings indicated that pig diseases/ASF was a top concern of consumers when eating pork or pork products, concern likely influenced by mass media reporting about ASF which included in some instances disgusting images of culled pigs (no inspection, no control of carcass/infected pigs). From early in the ASF outbreak, many consumers changed their consumption behaviors and diets to select chicken, beef or fish instead of pork, although no evidence of human health risk

from ASF was reported (USDA, 2019). In the present study, information about getting sick from eating pork was also ranked as a second concern by respondents. The vast majority of consumers also stated that they were worried about the safety of the pork that they were able to purchase in the last month. Once fears settled and risk in relation to ASF was clearly clarified, the demand for pork rose again, however many consumers still remain hesitant to re-introduce pork to their diets (USDA, 2019; Nguyen-Thi, 2021).

Risk communication allows authorities and experts to listen to and address people's concerns and needs so that the advice they provide is relevant, trusted and acceptable. Microbial contamination can be prevented and addressed by the application of sanitary measures throughout the production chain. This study suggested a need for proper and timely knowledge translation from experts to consumers with strong support from the authorities, in order to avoid misdirection of perceptions about risks that various hazards in food pose to consumers' health. This survey revealed consumer demand for information on food safety and pork safety specifically, and the most suitable communication channels and time interval by which to provide this. Food safety information points demanded by all groups included the origin of food (food traceability information) and how to choose safe food. Knowing consumer preference for pork labeling and traceability information gives insight into what value consumers place on certain areas of food safety and may aid in the formation of better risk communication strategies. Across both consumer groups, the majority rated pigs they raised themselves as their most trusted source of pork, followed by neighbor/known person producing pig or pork product. These results agree with previous literature which found that consumers felt more assured of the safety of pork that they themselves had produced or pork that had been produced by someone they personally knew and trusted (Ha et al., 2019). It was also consistent with their demands on pork safety information about the specific farm of origin, region that pig came from, and type of feeds given to pigs.

It is confirmed that the traditional media avenues of television and professionals working for the government are more trusted than social media. Rural consumers indicated that talking in the community/discussion with groups was a preferred way to receive information, a preference that likely reflects in part the differences in social constructs between urban and rural communities. In addition, although internet tools (e.g., social media, online newspaper) were quite popular, serious consideration is needed before application due to differences in their use by age group and geographic location. Although the way consumers would like to receive information varies greatly between the market types, the preference for frequency of information dissemination was consistent. Most consumers would like to receive information about food safety every day. This high demand emphasizes the strength of consumer concern about food safety, which may in part arise from

the substantial negative information about hazards related to food in the media which makes consumers perceive food-related risks to be more severe than other health-related issues (Nguyen-Viet et al., 2017).

Animal welfare which ensures animals' quality of life (both physical and psychological state) is an increasing concern worldwide [National Health and Medical Research Council, 2013]. Among consumers in developed countries, there is a high demand for animal products with declaration of animal welfare status (European Commission, 2005; Bozzo, 2019) but consumers from developing countries are as yet less engaged. It is important to gauge what the consumer understanding of animal welfare is and whether or not they care about it as consumer demand for better animal welfare could cause changes to the ways in which animals are managed in Asia, as it has in Europe for example (Sinclair et al., 2019). Pig management and slaughter are important not only from an animal welfare perspective, but also from a food safety perspective. In the present study, while few participants had heard of animal welfare, 72.5% of interview consumers stated that the pigs should be kept in good hygienic conditions, and 27.6% thought that pigs should have enough space to move around and lie down in their pens, and that pigs should be slaughtered with the least possible suffering. This perspective provides evidence of concern about pig welfare among consumers although they lack knowledge about the concept of animal welfare, and formalization of these concerns could be used to help demand changes in pig management practices along the pork value chain. A greater concern for pig welfare among rural consumers than urban consumers may be due to a more experience with the management and slaughter of livestock among rural consumers than urban consumers. Recent animal husbandry and veterinary laws of Vietnam have included consideration of animal welfare with the aim moving forward to align the development of the livestock sector and consumer's demand (National Assembly, 2015; National Assembly, 2018). Therefore, stronger future consumer demand in relation to animal welfare may lead to changes in pig management and slaughter practices in Vietnam.

This study had some limitations. First, the questionnaire was kept as short and concise as possible to maximize questionnaire completion. This meant other topics related to food safety, trusted information sources and animal welfare were not able to be covered, and as such further studies are needed. Second, it was obvious that some consumers, particularly consumers at the urban markets, were in a hurry and wanted to rush through the survey toward the end. This could have reduced the accuracy of the results and may partly explain the higher proportion of "don't know" responses from urban consumers compared to rural consumers. Lastly, there was fewer male participants as females are mainly responsible for purchasing food from markets. Therefore, the survey results may not reflect food safety knowledge and perceptions among Vietnamese men who eat pork.

Conclusions

This study assessed the food safety knowledge, needed and trusted information regarding pork and risk communication of consumers in Northern Vietnam. It highlighted some food safety knowledge gaps between current research findings and consumer knowledge. Our study has also identified differences among traditional and modern markets in regard to the information consumers would like to know about their pork and how to best get that information to them. But more importantly, this study showed that all consumers had strong concerns about the safety of the pork they eat. Promoting risk communication helps to develop law enforcement and disseminate scientific information to the community, build trust and let people have enough accurate information to choose, use and control food safely and profitably. This study informs researchers and policymakers about channels by which to reach target consumers, so that risk communicators and managers can implement better food safety awareness campaigns and communicate more effectively to consumers. Suggested educational materials to address gaps for consumers could be flyers, brochures, and posters provided by professionals working for the government in community meetings; radio broadcasts; or food safety channels in TV shows, depending on consumers' characteristics either modern or traditional, urban or rural settings.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by the Institutional Review Board of Hanoi University of Public Health Decision number: 110/2018/YTCC-HD3. The patients/participants provided their written informed consent to participate in this study.

Author contributions

J-AT, FU, SD-X, and HN-V conceptualized and designed the study. TT-H, SL, JD, LN-T, and HN conducted the field work, translated the raw data, performed the data processing, and validation. TT-H, SD-X, and J-AT analyzed the data and prepared the draft manuscript. J-AT, HN-V, FU, SL, JD, LN-T, and HN reviewed and edited the manuscript. All authors have read and approved the final manuscript.

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