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ABSTRACT

BACKGROUND: Zoonoses are an increasing concern worldwide, particularly in low- and middle-income countries. People with close contact with animals are at high risk for contracting and transmitting the zoonotic diseases.

OBJECTIVES: To determine health literacy of livestock farmers toward biosecurity to prevent zoonotic diseases.

METHODS: This cross-sectional mixed-methods study was conducted in Thai Nguyen Province, Vietnam, where livestock and farming are the main occupation. The questionnaire survey was submitted to 218 farmers who have close contact with livestock. In addition, 8 farmers were invited to an in-depth interview to further explore the health literacy.

RESULTS: Half of the participants were men. The average age (standard deviation) of the participants was 49.3(11.5) years. The median years with experience in farming was 15 years. The majority (82.0%) of the participants had moderate health literacy level regarding zoonoses. Improper use of antibiotics was referred by 58.0% of participants, including antibiotic use as feeding supplements (34.0%) and the use of human antibiotics to treat sick animals (24.0%). Many participants were unaware of zoonotic prevention measures and due to this had practices such as not wearing protective equipment (60.0%), an absence of acaricides to prevent vector infestations (52.0%), an absence of disinfection measures (42.0%), low rate of rabies vaccination (54.0%), and do not quarantining sick animals (38.0%). In-depth interviews revealed great concern among farmers about a collective lack of participation from local veterinarians, health workers, and government authorities in zoonoses-prevention efforts. Statistical models showed that farm scale, ethnic groups, and perceived income were associated with the overall health literacy about zoonoses.

CONCLUSION: Comprehensive health education related to zoonotic diseases is recommended to improve overall knowledge, including routes of transmission, symptoms and consequences of diseases, and antibiotic usage. In addition, guidance should be provided to farmers on how to treat sick animals, the appropriate use of antibiotics, and waste management. Local veterinarians and health workers are important contact points and should work closely with the farmers to prevent zoonotic diseases.

KEYWORDS: Health literacy, zoonotic diseases, livestock, antibiotic use, Vietnam

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Introduction

It is estimated that 60.0% of all known infectious agents and 75.0% of emerging human pathogens are zoonotic.[1-4] Throughout recent decades, humans have experienced several epidemics or even pandemics of emerging and reemerging zoonotic diseases such as Nipah virus, High Pathogenic Avian Influenza (H5N1), Influenza A (H1N1), Severe Acute Respiratory Syndrome (SARS), and Ebola.[5] Zoonoses cause not only significant morbidity and mortality in humans and various livestock but also a significant economy loss and disturbance of global trade.[6]

Agriculture industries are growing rapidly to sustain food security due to enormous demands from global population growth. The livestock sector, in particular, is one of the fastest-growing parts in agriculture industries.[7] Upward negative pressure on natural resources, environment, and human health usually goes along with the benefits of rapid livestock sector growth.[4,8]

Humans may be infected by zoonotic agents through different routes such as inhalation, ingestion, via conjunctiva or direct contact. People with close contact to animals are at high risk of infection. The risk of zoonotic diseases has been enhanced by the increase in density of both human and animal populations and the facilitation of contacts at the human-animal interface.[4,9] Growing global trade in livestock and its products can potentially create a close contact between animals and a large human population; this could enhance epidemic and pandemic potentials of zoonoses.[7] Agricultural practice plays a major role in accelerating zoonotic pathogens to grow, spread, and eventually infect the human population.[10] Zoonotic diseases could be considered as occupation-related diseases among farmers, as these workers are frequently exposed to microorganism related to livestock.[11]

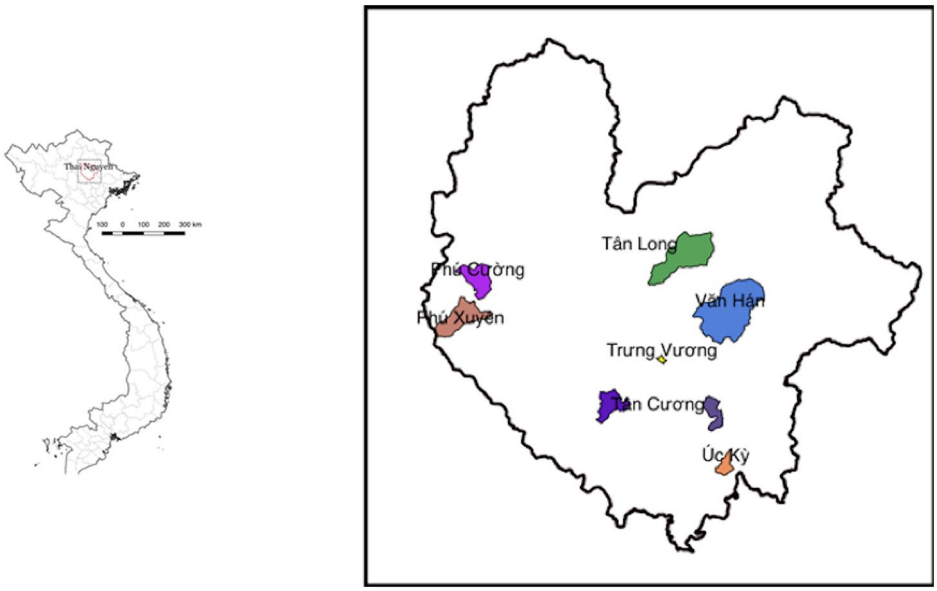

Figure 1. Study setting.

Vietnam is one of the 9 countries globally that are potential hotspots for zoonotic diseases.[12] The country has been recognized as an epicenter of emerging zoonotic diseases over the last decade. In addition, common practices of human-animal interaction in the country may facilitate the dissemination of zoonoses.[13] Vietnam has prioritized zoonotic diseases that could be potential threats to the country, according to a consensus among experts in different disciplines and organizations. The top 5 zoonotic diseases include avian influenza, rabies, *Streptococcus suis* infection, pandemic influenza, and foodborne bacterial diseases.[14]

The main livestock farming in Vietnam is still at small scale such as in backyards and village farms. Investment in biosecurity is likely to be low, which may increase the risk of zoonotic diseases.[15] Lack of awareness and knowledge are associated factors with the occurrence of zoonotic diseases in humans.[16] A variety of practices of livestock workers can increase the risk of zoonotic infections.[11,17-23] Patterns of risk farming practice vary between regions due to different levels of agricultural industry development and farming traditions. These situations led to many challenges in zoonotic disease management.

Health literacy was first introduced in 1974 and has been increasingly important in public health and health care.[24,25] Besides providing knowledge regarding the health problem, health literacy is also interested in the ability of persons to use and apply information to make decisions related to their health. Many researchers indicated that better health outcomes are caused by the acquisition of new knowledge, more positive attitudes, greater self-efficacy, and positive health behaviors associated with higher health literacy.[26] The workers who are involved in the production of livestock still under-recognize this phenomenon.[27] This study aimed to determine health literacy of livestock farmers toward biosecurity to prevent zoonotic diseases. Findings from this study would provide scientific evidences for zoonotic disease prevention programs in agriculture areas with small-scale farming, the common livestock raising practice in developing countries.

Materials and Methods

Study design

A cross-sectional study using mixed method approach (quantitative and qualitative methods) was conducted from January to June 2019. An interviewer-administered questionnaire was used to determine general health literacy level and behaviors among eligible livestock farmers. In addition, in-depth interviews were performed to enhance the understanding of behaviors regarding zoonotic diseases in livestock. The study was approved by the Ethics Committee of the Faculty of Tropical Medicine, Mahidol University (No. MUTM 2019-011-01).

Study setting

This study was conducted in Thai Nguyen province, Vietnam (Figure 1). The province is a midland mountainous area located in northeastern Vietnam. This is a center for economic, cultural, and social aspects of the region. Agriculture (crop and livestock farming) is the main occupation and contributes a significant value for socioeconomic development of the province. Livestock productions are mainly contributed from small households, backyards, and small-scale farms. Pigs, poultry, and cattle/buffalo are the main livestock animals in the area. As cultural tradition, a typical rural family has dogs, pigs, chickens, ducks, and roosters. Ruminants are more popular in mountainous areas. Transformation from small-scale farms to intensive farms has been ongoing in recent years. Due to concerns about food safety, some households invest money into raising their own livestock at household scale for their own food demand.

Multi-stage sampling method was performed. Thai Nguyen province consists of 2 cities and 7 districts. These cities and districts were then stratified by topographic characteristics: city area, delta area, highland area, and mountainous area. Then one city/district was randomly selected per each area. Within each city/district, 2 communities were then randomly selected. Therefore, a total of 8 communities were selected to be the study sites. All eligible households/farms were contacted to participate in the study. One person who had close contact with livestock in each household/farm was invited to participate in the study.

Study participants

Questionnaire survey. Farmers aged 18 years or more who are raising at least one of these categories of livestock of pig, cattle/buffalo, goat, dog, and poultry were invited to participate in the study. The sample size was determined according to the estimated proportion of adequate health literacy among people with close contact to livestock at 62.7% with 7.0% acceptable error and 95% confidence. As this study was conducted in a province, the correlation within each cluster was assumed to be very low. Therefore, design effect was not considered in this study. The sample size required was 183. One participant per each farm/household was recruited.

In-depth interview. Participants for the qualitative study were purposively selected from farmers who participated in the questionnaire survey and have at least 2 years of experience working on raising livestock. One participant was chosen in each study site. A total of 8 farmers from 8 study sites were selected for the in-depth interview.

Instrument and measurements

A structured questionnaire was developed to access health literacy of respondents toward zoonotic diseases. The questionnaire consists of sets of questions to determine respondent's characteristics, farm's characteristics, information access, understanding, practices, and appraisal of health information toward the top prioritized zoonotic diseases, including avian influenza, rabies, *Streptococcus suis* infection, pandemic influenza, and foodborne bacterial diseases. The questionnaire was initially written in English and then translated to Vietnamese in lay language. The questionnaire was reviewed by bilingual health professional experts and later tested for validity and reliability before implementation (see Supplemental Material). Interview guides were used for in-depth interview to get further understanding on risk perception and practice patterns.

Questions regarding characteristics included both demographics (age, sex, education, ethnicity, income, and years of experience in livestock farming) and farm characteristics (farm scale, purpose of livestock farming, and waste management). Sources of information related to zoonotic diseases that the participant obtained were requested to determine information access. There were 29 yes/no questions regarding the understanding. Right answers were given a score of "one"; wrong answers were scored as "zero." Therefore, the understanding score ranged from 0 to 29. The frequency of practices toward zoonotic disease prevention was assessed by 25 questions. The 5-point Likert-type scale was used as "Never (1)," "Seldom (2)," "Sometimes (3)," "Often (4)," and "Always (5)." The total score of this section ranged from 25 to 125. A set of 12 questions was used to measure how the respondents appraise health information regarding zoonotic diseases. Respondents answered this set of questions by indicating their degree of agreement on each statement. The 4-point Likert-type scale was used to let the respondents express their degree of agreements as "Strongly agree (4)," "Agree (3)," "Disagree (2)," and "Strongly disagree (1)." The total score for the appraisal section ranged from 12 to 48.

Statistical analysis

For quantitative analysis, health literacy was determined using the sum of the scores from the understanding, appraisal, and behavior sections. Access information section was described in terms of common sources of health information that the participants obtained. This information was not included in the overall health literacy score. As there is no specific guideline to classify the health literacy level,[28] in this study health literacy was classified as adequate (score $\geq$80%); moderate (score 60%-79%); and inadequate (score $<$60%).

Quantitative data analysis was performed using Stata version 14.1. Descriptive statistics were used to describe variables including percentage, mean, median, standard deviation, and interquartile range (IQR). Normality of data for outcome variables was determined before using any descriptive or analytic statistical methods. Associations between health literacy score and independent variables were assessed by univariate/multivariate linear regression. The independent variables were tested including sex, age, ethnicity, education level, underlying diseases, residence, years of experience, farm scale, perceived income, and purpose of livestock farming. Statistically significant level was set at .05.

For qualitative data, codes and labels were used during word-by-word screening process.

Results

Demographics and socioeconomic level of participants

Overall, 218 participants have participated in the questionnaire survey. Socioeconomic characteristics of the participants are shown in Table 1. Participants' ages ranged from 20 to 84 years; more than half of participants (56.9%) were aged between 40 and 59 years. Approximately half of the participants were men (51.4%). More than 80.0% of participants attended primary and secondary school. Nearly three-quarters of participants were

Table 1. Socioeconomic characteristics.

VARIABLES	TOTAL		DELTA AREA		HIGHLAND AREA		CITY		MOUNTAINOUS AREA	
	N	%	N	%	N	%	N	%	N	%
Sex										
Male	112	51.4	22	41.5	37	62.7	20	37.0	33	63.5
Female	106	48.6	31	58.5	22	37.3	34	63.0	19	36.5
Age (years)										
Under 40	48	22.0	6	11.3	25	42.4	5	9.3	12	23.1
40-59	124	56.9	30	56.6	30	50.9	31	57.4	33	63.5
60 and above	46	21.1	17	32.1	4	6.7	18	33.3	7	13.4
Mean ± SD = 49.3 ± 11.5, min-max = 20-84										
Education[a]										
None	6	2.7	2	3.8	1	1.7	2	3.7	1	1.9
Primary school	49	22.5	7	13.2	25	42.3	12	22.2	5	9.6
Secondary school	127	58.3	30	56.6	24	40.7	35	64.8	38	73.1
High school	29	13.3	11	20.8	7	11.9	5	9.3	6	11.5
College/University and above	7	3.2	3	5.6	3	3.4	0	0.0	2	3.9
Ethnic										
Kinh	160	73.4	51	96.2	13	22.0	52	96.3	44	84.6
Nung	42	19.3	0	0.0	39	66.1	2	3.7	1	1.9
Tay	8	3.7	2	3.8	0	0.0	0	0.0	6	11.6
Other	8	3.6	0	0.0	7	11.9	0	0.0	1	1.9
Monthly income (VND)										
⩽5 million dong	79	36.2	17	32.1	24	40.7	26	48.2	12	23.1
>5 million dong	139	63.8	36	67.9	35	59.3	28	51.8	40	76.9
Median = 7, IQR = 5, min-max = 1-120										
Perceived income										
Insufficient	61	27.9	27	50.9	12	20.3	19	35.2	3	5.8
Sufficient	124	57.0	24	45.3	44	74.6	33	61.1	23	44.2
Have savings (more than sufficient)	33	15.1	2	3.8	3	5.1	2	3.7	26	50.0
Livestock farming as primary income										
Yes	64	29.4	18	33.9	14	22.7	17	31.5	15	28.9
No	154	70.6	35	66.1	45	76.3	37	68.5	37	71.1
Experience in livestock farming (years)										
<15	116	53.2	39	73.6	20	33.9	40	74.1	17	32.7
⩾15	102	46.8	14	26.4	39	66.1	14	25.9	35	67.3
Median = 15, IQR = 13, range = 1-60										

Abbreviations: IQR, interquartile range.
[a]Education: In Vietnam, primary school is from 1st to 5th year, secondary school is from 6th to 9th year, and high school is from 10th to 12th.

Kinh ethnicity (73.4%) and did not have history of any underlying disease (74.8%). About one-third of participants reported monthly household income of 5 million VND (USD215) or less and perceived that their household income was not enough for their primary needs. Livestock farming was classified as the primary income by only 29.4% of participants. More than a half of participants have been working on raising livestock for less than 15 years (53.2%) with a median of 15 years (interquartile range [IQR] = 13), ranging from 1 to 60 years.

Eight participants participated in an in-depth interview; 5 of them were men. The participants were aged between 31 and 62 years with 12 to 27 years of experience in livestock farming.

Livestock farming characteristics

Characteristics of livestock farms are shown in Table 2. In general, among 218 households, there were 120 (55.1%) medium scale farms and 98 (44.9%) small scale farms. Most farming practices were raising livestock combined with other agricultural work, particularly growing tea plants.

A large proportion of participants raised more than one type of livestock (73.4%). Avian and pig were the most common livestock, raised in 95.0% and 67.0% of households, respectively. Dog is considered as livestock in Vietnam, as people usually eat dog meat. Dogs were owned by 94.0% of participants, and 58.0% of households had from 2 to 4 dogs. Among households that were raising avian, 70.0% of them were raising ⩽50 avian. Among households that were raising pig, more than 40.0% raised ⩽10 pigs. Buffalo, cattle, and goat were the less common livestock in the study settings.

The main purpose of livestock farming was for sale (74.9%). More than 75.0% of households were raising livestock within their backyard. Waste management in livestock farming was varied. Biogas and composting were used by 47.3% and 22.5% of households, respectively. Meanwhile, 26.2% of households still discharged waste products to the surrounding environment, or they were used as fresh manure (11.9%). According to the in-depth interview, in some farms, avian wastes are normally used as fresh manure to fertilize plants, although these farms have biogas systems.

Health literacy toward zoonotic diseases

Four main dimensions of health literacy regarding zoonotic diseases were identified: access information, understand information, appraise information, and apply information (Behaviors).

Access information toward zoonotic diseases. Regarding the accessibility to information related to zoonotic diseases, the main sources of information were from broadcasting such as television, newspaper, and radio (Table 3). About 31.0% and 23.0% of participants said that they have heard about zoonotic diseases from animal health or public health personnel and friends, respectively. Internet and brochure were less common sources for the information. The in-depth interview suggested a lack of multidisciplinary integration between human and animal health. Public health personnel usually focused only on their discipline; only few of them have talked about diseases that can spread from animals to humans:

> Community health center does not have any opinion about the pig or raising pigs. They do not talk about diseases spread from animals to humans. Veterinary officials only talk about pigs, and have not mentioned that pigs can spread diseases to humans. No one propagated anything. (Male, Participant 8)

Understanding toward zoonotic diseases. Understanding of participants toward zoonotic diseases is shown in Table 4. A large proportion of participants could correctly identify that diseases from livestock can be transmitted to humans (85.3%). Understanding of participants regarding routes of zoonotic transmission was varied; more than half of them knew that zoonoses can be transmitted via direct contact (58.3%), ingestion (63.3%), blood or secretion contact (59.6%), and arthropod bites (79.8%). Interestingly, more than 65.0% of the participants did not know or answered incorrectly that humans can get the diseases from apparently healthy animals.

Questions related to specific diseases were asked to assess understanding about them. Regarding avian influenza, only 23.4% of participants knew that mammals can be infected with avian influenza. In addition, nearly a quarter of participants believed that avian influenza in humans is preventable by using antibiotics after contact with a sick avian (22.0%) and 63.3% of them do not know whether avian influenza is preventable by antibiotics or not. Participants' understanding toward influenza A(H1N1) was limited. Only a quarter of them knew that influenza A(H1N1) can be transmitted from human to human (24.3%) and it can cause pneumonia (24.3%). Washing hands with soap was believed to be a prevention measure by 37.6% of participants. In contrast, the participants seemed to have better understanding regarding rabies compared to others. A majority of participants knew that rabies can cause death in all patients (89.5%), the disease is preventable by vaccination (91.3%), and washing a wound with soap is not enough to prevent rabies (74.3%). However, only half of them knew that rodents can transmit the disease, and 32.0% of participants understood that rabies can be infected via animal scratch. Regarding *Streptococcus suis* infection, a large proportion of participants correctly understood that there are common ways of transmission such as eating Tiết canh (88.5%) and using mutual tools for cooked and uncooked food (73.9%). However, only 12.4% and 22.0% of the participants were aware that goats and healthy pigs, respectively, can be sources of infections. Regarding foodborne bacterial infection, nearly 90.0% of participants knew that eating raw or undercooked food can lead to bacterial infection of animal origin, and more than 60.0% believed that the bacteria can cause severe diarrhea. Interestingly, about one-third of participants believed that frequently feeding animals with antibiotics can help to prevent the

Table 2. Livestock farming characteristics.

VARIABLES	TOTAL		DELTA AREA		HIGHLAND AREA		CITY		MOUNTAINOUS AREA	
	N	%	N	%	N	%	N	%	N	%
Pig farm										
Medium	86	58.9	15	41.7	17	44.7	13	54.2	41	85.4
Small	60	41.1	21	58.3	21	55.3	11	45.8	7	14.6
Avian farm										
Medium	58	28.0	19	39.6	17	28.8	7	13.2	15	31.9
Small	149	72.0	29	60.4	42	71.2	46	86.8	32	68.1
Buffalo farm										
Medium	1	2.9	0	0.0	0	0.0	0	0.0	1	20.0
Small	33	97.1	10	100.0	12	100.0	7	100.0	4	80.0
Cattle farm										
Medium	0	0	0	0.0	0	0.0	0		0	
Small	35	100.0	33	100.0	2	100.0	0		0	
Goat farm										
Medium	4	80.0	0		4	80.0	0		0	
Small	1	20.0	0		1	20.0	0		0	
Distance from home to farm										
Within backyard	165	75.7	49	92.5	47	79.7	45	83.3	24	46.2
Separate from home	53	24.3	4	7.5	12	20.3	9	16.7	28	53.8
Purpose of livestock farming										
Sales	159	72.9	46	86.8	35	59.3	27	50.0	51	98.1
Family consumption	52	23.9	6	11.3	21	35.6	24	44.4	1	1.9
Sales in emergency needs	7	3.2	1	1.9	3	5.1	3	5.6	0	0.0
Waste management										
Biogas	103	43.5	24	41.4	16	25.8	22	34.9	41	75.9
Discharge to environment	57	24.1	9	15.5	27	43.5	18	28.6	3	5.6
Composting	49	20.7	16	27.6	6	9.7	19	30.2	8	14.8
Fresh manure as fertilizer	26	10.9	9	15.5	11	17.8	4	6.3	2	3.7
Other	2	0.8	0	0.0	2	3.2	0	0.0	0	0.0

Farm scale was define as medium (higher than 10 pigs, or 10 buffalos, or 10 cattle, or 10 goats, or 50 avian) and small (equal or less than 10 pigs, or 10 buffalos, or 10 cattle, or 10 goats, or 50 avian).

transmission of foodborne bacterial infection from animals to human (34.4%).

Appraisals toward zoonotic diseases. Regarding the appraisal toward zoonotic diseases, approximately two-thirds of participants agreed that they were really concerned about zoonoses (63.3%). More than half of them reported that human antibiotics can be used to treat sick animals, livestock farmers are not using antibiotics properly, and antibiotics resistance is a problem in the livestock sector. Almost all participants agreed that protective equipment (98.6%), vaccination (99.5%), and disinfection (99.1%) are important measures in zoonoses prevention. A majority of participants also agreed that humans should not consume sick animals (96.3%) or sell sick animals because these can contribute to dissemination of zoonoses (93.6%). More than three-quarters of participants agreed that it is necessary to report

Table 3. Source of information regarding zoonotic diseases.

VARIABLES	FREQUENCY	PERCENTAGE
TV	214	98.2
Newspaper/magazine	100	45.9
Radio	87	39.9
Animal health/public health personnel	69	31.7
Friends/family members	51	23.4
Internet	8	3.7
Brochure/banner	1	0.5

Table 4. Understanding of participants toward zoonotic diseases.

VARIABLES	YES N (%)	NO N (%)	DO NOT KNOW N (%)
General understanding toward zoonoses			
Diseases of livestock can be transmitted to human	186 (85.3)	22 (10.1)	10 (4.6)
Human can get zoonotic infection from apparently healthy animals	74 (33.9)	56 (25.7)	88 (40.4)
Human can get zoonotic infection via indirect contact with sick animals through materials that contact with sick animals	127 (58.3)	29 (13.3)	62 (28.4)
Human can get an zoonotic infection via ingestion of contaminated food such as meat, eggs, and blood	138 (63.3)	18 (8.3)	62 (28.4)
Human can get zoonotic infection via contact with blood or animals' secretions such as saliva	130 (59.6)	18 (8.3)	70 (32.1)
Human can get zoonotic infection via arthropods bites such as mosquito, fly, and tick	174 (79.8)	30 (13.8)	14 (6.4)
Composting is an appropriate method for waste management	137 (62.8)	41 (18.8)	40 (18.4)
All zoonotic diseases can be prevented by vaccination	123 (56.4)	18 (8.3)	77 (35.3)
Understanding about avian influenza			
Mammals can be infected with avian influenza	51 (23.4)	33 (15.1)	134 (61.5)
People can get avian influenza by eating undercooked egg from sick poultry	125 (57.3)	33 (15.1)	60 (27.6)
Avian influenza in human is mild and does not cause death	141 (64.7)	17 (7.8)	60 (27.5)
People can prevent avian influenza infection by taking antibiotics after contacting with sick animal	32 (14.7)	48 (22.0)	138 (63.3)
Understanding about influenza A (H1N1)			
Influenza A (H1N1) infection can cause pneumonia	53 (24.3)	12 (5.5)	153 (70.2)
Influenza A (H1N1) can be transmitted from human to human	53 (24.3)	28 (12.8)	137 (62.8)
Washing hands with soap can help prevent influenza A (H1N1) infection	82 (37.6)	9 (4.1)	127 (58.3)

(Continued)

Table 4. (Continued)

VARIABLES	YES N (%)	NO N (%)	DO NOT KNOW N (%)
Understanding about rabies			
People can get rabies from rodent bite	113 (51.8)	47 (21.6)	58 (26.6)
Only getting animal scratch will not cause rabies	70 (32.1)	106 (48.6)	42 (19.3)
Rabies can cause death in all infected patients	195 (89.5)	15 (6.9)	8 (3.6)
Rabies can be prevented by vaccination	199 (91.3)	4 (1.8)	15 (6.9)
After animal bite, washing the wound with soap is enough to prevent rabies	162 (74.3)	24 (11.0)	32 (14.7)
Understanding about *Streptococcus suis* and foodborne bacterial infections			
Goat can be infected with *Streptococcus suis*	27 (12.4)	13 (5.9)	178 (81.7)
People can get *Streptococcus suis* infection by eating Tiết canh	193 (88.5)	0 (0.0)	25 (11.5)
Healthy pigs are free of *Streptococcus suis*	48 (22.0)	42 (19.3)	128 (58.7)
People infected with *Streptococcus suis* can have purpura and ecchymosis	110 (50.5)	0 (0.0)	108 (49.5)
Streptococcus suis infection can cause hearing loss in human	20 (9.2)	5 (2.3)	193 (88.5)
Sharing tools for cooked and uncooked food can be a risk of *Streptococcus suis* infection	161 (73.9)	0 (0.0)	57 (26.1)
Eating raw or undercooked food can cause bacterial infection from animals	196 (89.9)	2 (0.9)	20 (9.2)
Foodborne bacterial infection can cause severe diarrhea in human	132 (60.6)	3 (1.4)	83 (38.0)
Feeding animal with antibiotics frequently can help prevent foodborne bacterial infection	32 (14.7)	75 (34.4)	111 (50.9)

sick or dead animals to local authorities (77.1%). Almost all of them also agreed that waste management as well as environmental protection are important (98.2%; Table 5).

Behaviors toward zoonotic diseases. A potential number of participants had behavior or practices that could increase the risk of zoonotic diseases infection (Table 6). Large proportions of respondents did not regularly use standard preventive equipment including gloves (66.1%), mask (63.8%), and boots (42.2%) while contacting with livestock. About 39.5% of participants reported that they often/sometimes handled an aborted fetus or placenta with bare hands. A quarter of participants said that they did not often clean equipment after work or did not use soap/disinfectant while washing hands. Washing hands is a common behavior among the participants; only 12.8% of participants reported that they did not usually wash hands after contacting with animals. According to the in-depth interview, participants pointed out reasons for these risk behaviors, including being uncomfortable wearing protective equipment, feeling that it is not worth paying for the protective equipment in small-scale farming, and being too rushed to wash hands and equipment with disinfectant:

> Due to small scale farming, many people do not really care about safety. (Female, Participant 2)

> Because they are in a hurry, they do many things, they don't care about their health. (Female, Participant 1)

> Because it is uncomfortable. It does not worth much money, each of it is just about tens of thousands. (Female, Participant 7)

More than 38.0% of participants did not regularly separate the sick animals from others. Particularly, in case of sick animals, 80.3% of participants said that they did not normally call for support or treatments from local veterinary

Table 5. Appraisal toward zoonotic diseases among farmers.

VARIABLES	DISAGREE	AGREE
Diseases that are transmitted between animals and human are my concern	80 (36.7)	138 (63.3)
Human antibiotics can be used to treat livestock diseases	106 (48.6)	112 (51.4)
Antibiotic usage of a majority of livestock farmers is not proper	92 (42.2)	126 (57.8)
Antibiotic resistance is currently a problem in livestock sector	90 (41.3)	128 (58.7)
Using protective equipment such as gloves, boots, and face mask is an important measure to avoid diseases transmitted between human and animals	3 (1.4)	215 (98.6)
Vaccination is an important measure to avoid diseases transmitted between human and animals	1 (0.5)	217 (99.5)
Disinfection is needed to perform annually to avoid diseases transmitted between human and animals	2 (0.9)	216 (99.1)
It is safe to consume sick animals	210 (96.3)	8 (3.7)
Sick animals should not be sold because this can enhance the dissemination of zoonoses	14 (6.4)	204 (93.6)
It is necessary to report to local authorities when animals get sick	50 (22.9)	168 (77.1)
Proper waste management in livestock is important to mitigate zoonotic transmission	5 (2.3)	213 (97.7)
Environmental protection in livestock is important to prevent zoonoses	4 (1.8)	214 (98.2)

workers; 23.4% of them sometimes/often used human medicine to treat their livestock, including human antibiotics (16.5%). Most participants (94.9%) did not report to the local governmental authorities if they had sick or dead animals. According to the in-depth interview, farmers may buy medicine to treat the animals by themselves or seek consultation and treatment from their livestock agencies. They will report to the local authorities only when the disease outbreak was previously announced. Only few participants reported that they used to eat or sell sick or dead animals. One participant reported that when some of his pigs died from foot and mouth disease, he got panicked and quickly sold the pigs at a cheaper price:

> My livestock had foot-and-mouth disease last year. When some of them died, I was panic and I sold as 2 million for 1 pig of 70 to 80 kg. A pig as usual must be about 3 million or more than 3 million. (Male, Participant 8)

A large proportion of participants did not often apply acaricides to prevent vector infestation (52.3%) or apply chemicals to disinfect raising areas (42.2%; Table 6). Most participants did not regularly use any disinfection measures for their visitors before going to raising areas (93.6%). Antibiotics were used as feed supplements by 34.4% of participants. Farmers sometimes regularly fed the livestock with antibiotics and thought that this would help increase the immunity and make the livestock healthier, according to the in-depth interview:

> This period, I am feeding the animals with antibiotics so that they have more antibodies. (Male, Participant 3)

> Human's biseptol is usually fed to dogs and chicken once or twice a week. When they take like that, they will be healthier. (Male, Participant 4)

The majority of the participants reported they normally do not vaccinate their livestock against common zoonotic diseases, namely avian influenza H5N1 (90.3%), influenza A (H1N1; 84.9%). Rabies vaccinations were more commonly used, compared to others; however, about 44.9% did not vaccinate their dogs. The in-depth interview suggested that farmers thought that vaccination is not necessary for small farming; or the disease might not occur in their farm:

> I often follow my experience. My farm scale is small, not a big farm, so I still don't know how all the vaccination should be done. (Female, Participant 2)

> I have never seen that phenomenon, so I do not vaccinate. (Male, Participant 3)

Table 6. Common behaviors of respondents regarding zoonotic diseases transmission.

BEHAVIORS	OFTEN/ALWAYS N(%)	SOMETIMES N(%)	NEVER/SELDOM N(%)
Use of protective measures			
Do not wear gloves	131 (60.1)	13 (6.0)	74 (33.9)
Do not wear mask	126 (57.8)	13 (6.0)	79 (36.2)
Do not wear boot	65 (29.8)	27 (12.4)	126 (57.8)
Personal hygiene and food safety			
Handle aborted fetus, placenta, amniotic fluid, and other discharge with bare hand	70 (32.1)	16 (7.3)	132 (60.6)
Do not wash equipment	20 (9.2)	37 (17.0	161 (73.8)
Do not use soap or disinfectant	18 (8.3)	33 (15.1)	167(76.6)
Do not wash hand after contact	12 (5.5)	16 (7.3)	190 (87.2)
Eat Tiết canh[a]	2 (0.9)	23 (10.6)	193 (88.5)
Eat raw/undercooked meat/food	0 (0.0)	3 (1.4)	215 (98.6)
Behaviors related to sick/dead animals			
Do not report to local governmental authorities when animals die or get sick	176 (80.7)	31 (14.2)	11 (5.1)
Do not call veterinarians to treat livestock	126 (57.8)	49 (22.5)	43 (19.7)
Do not keep sick animals away from rest of the herd	35 (16.1)	48 (22.0)	135 (61.9)
Use human medicine to treat sick animals	14 (6.4)	37 (17.0)	167 (76.6)
Handle animals when having cuts or wounds	5 (2.3)	9 (4.1)	204 (93.6)
Slaughter sick or dead livestock for consumption	0 (0.0)	7 (3.2)	211 (96.8)
Leave dead animals to surrounding environment	1 (0.5)	4 (1.8)	213 (97.7)
Sell the sick or dead livestock	0 (0.0)	3 (1.4)	215 (98.6)
Other common preventive measures			
Visitors do not use disinfection measures before going to raising places	199 (91.3)	5 (2.3)	14 (6.4)
Do not test the quality of water	186 (85.3)	26 (11.9)	6 (2.8)
Do not apply acaricides and other chemicals to prevent vector infestation	59 (27.1)	55 (25.2)	104 (47.7)
Do not apply chemicals to disinfect your raising areas	45 (20.6)	47 (21.6)	126 (57.8)
Use antibiotics as feed supplement	21 (9.6)	54 (24.8)	143 (65.6)
Use human antibiotics to treat sick animals	3 (1.4)	33 (15.1)	182 (83.5)
Vaccinations (among those who raised animals for specific vaccine)			
Do not vaccinate poultry against Avian influenza (n=207)	185 (89.3)	2 (1.0)	20 (9.7)
Do not vaccinate pigs against influenza A (H1N1) (n=146)	123 (84.2)	1 (0.7)	22 (15.1)
Do not vaccinate dogs against rabies (n=205)	60 (29.3)	32 (15.6)	113 (55.1)

[a]Tiết canh is a Vietnamese dish of raw blood pudding served with raw meat in Northern Vietnam. Pork and duck are the most common animals used to create this raw blood pudding.

Distribution of participants by health literacy level toward zoonotic diseases was shown in Figure 2. Approximately 60.0% of participants had inadequate understanding regarding zoonotic diseases. Adequate and moderate understanding accounted for 8.3% and 32.6%, respectively. Moderate and adequate appraisal accounted for 89.4% and 10.6% of participants, accordingly. A large proportion of participants acted at moderate application level (76.6%). Adequate application only accounted for 6.0% and inadequate application was 17.4%. Moderate level of health literacy accounted for a large proportion (81.7%), adequate (1.8%) and inadequate (16.5%).

Univariate and multivariate analyses were performed to determine factors associated with health literacy. The health literacy score was treated as a continuous variable. Results from

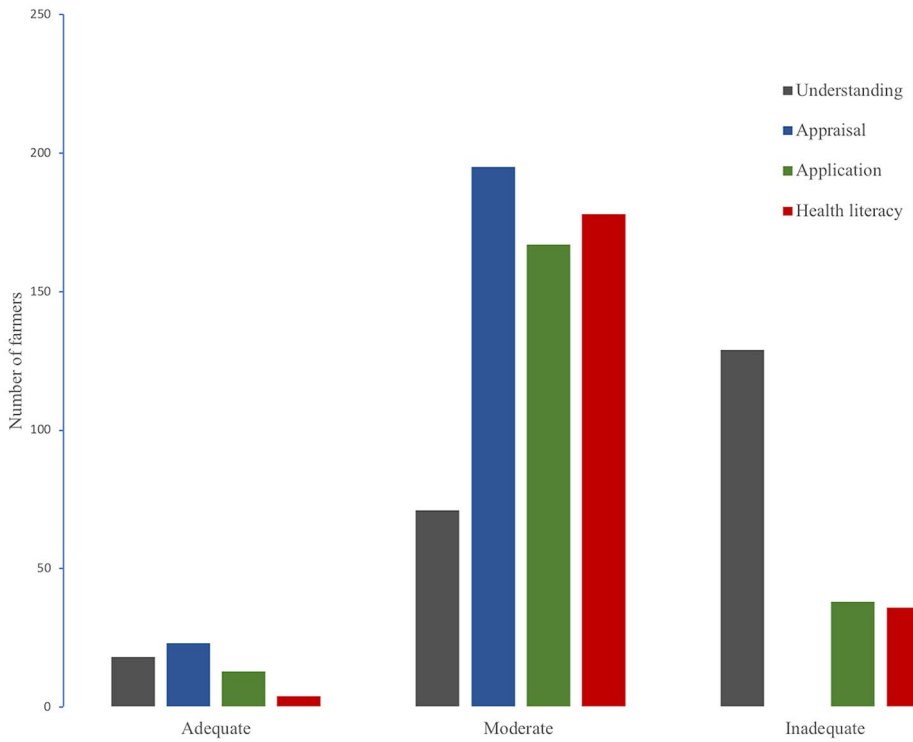

Figure 2. Health literacy level of participants.

univariate analysis showed some associated factors including farm scale, ethnicity, perceived income, and purpose of livestock farming. Participants who belong to minority ethnic groups had lower health literacy than those who are Kinh ($P = .008$). Participants with medium farm scale had higher health literacy than those with small scale ($P < .001$). Participants who perceived their income as insufficient had lower health literacy than those perceived it as sufficient or have savings ($P = .008$). Participants who raise livestock for family consumption or sale in emergency needs had lower health literacy compared to those raising livestock for sale ($P < .001$).

All significant factors from univariate analysis were included in multivariate analysis. Farm scale, ethnicity, and perceived income were significantly associated with health literacy of participants toward zoonotic diseases (Table 7).

Discussion

As a country that originated from agriculture, a large proportion of population in Vietnam is involved in the livestock sector. Farmers are exposed to zoonotic agents in every aspect of their work. In addition, agriculture practices, such as antibiotic use, waste management, among others, are important factors contributing to zoonotic diseases dissemination.[29] Findings of this study suggest that farmers were still having behaviors and literacy that may increase the risk of zoonotic infection.

This study was conducted in an area in which agriculture is the main occupation. Similar to other developing countries, a large proportion of agricultural work is based on small-scale farming with low biosecurity investment.[30,31] People usually plant crops together with livestock farming for secondary income and a domestic source of meat. Livestock is generally raised in their backyard. The majority of participants belonged to age group of 40 to 59 years, which is a common age group in the agriculture sector as young people tend to work in cities.[23,32-34] A significant number of participants still discharged waste from livestock to the surrounding environment or used fresh manure as fertilizer. In addition, qualitative results reveled that not all of waste from livestock is treated properly even though the farmers are using biogas, from avian in particular. By this improper waste management, the waste containing many types of zoonotic agents could come directly into the environment or be used as fresh fertilizer leading to water source contaminations, resulting in short-/long-term consequences to both human and animal health.[35]

Health literacy influences health behaviors and gives impacts on health outcomes and on the health costs in society.[24] The 4 dimensions are about competencies of health information processing including to access information, understand information, appraise information, and apply information. Most participants had moderate health literacy toward zoonoses in which a larger part skewed to the lower side. Many researchers indicated that better health outcomes are caused by the acquisition of new knowledge, more positive attitudes, greater self-efficacy, and positive health behaviors associated with higher health literacy.[26] However, this study found the process is problematic from the beginning while the participants have barriers in obtaining the information. Television, newspaper, and radio

Table 7. Univariate and multivariate analyses demonstrating associations between independent variables and health literacy score toward zoonotic diseases..

VARIABLES	UNIVARIATE ANALYSIS			MULTIVARIATE ANALYSIS
	MEAN SCORE (SD)	MEAN DIFFERENCE (95% CI)	*P* VALUE	MEAN DIFFERENCE (95% CI)
Sex				
Female	141.1 (13.0)	Ref	.57	
Male	142.1 (14.1)	1.05 (–2.58 to 4.68)		
Age (years)				
Under 40	139.9 (12.6)	Ref		
40 and above	142.1 (13.8)	2.16 (–2.21 to 6.53)	.33	
Ethnic				
Kinh	143.1 (13.3)	Ref	.008	Ref
Others	137 (13.6)	–5.45 (–9.5 to –1.41)		–5.99 (–9.76 to –2.24)
Education level				
Secondary school and lower	141.5 (13.8)	Ref		
From high school	142.4 (12.7)	0.98 (–3.91 to 5.87)	.69	
Underlying diseases				
No	141.9 (13.5)	Ref	.57	
Yes	140.7 (13.9)	–1.2		
Resident				
City/delta area	141.4 (13.2)	Ref	.79	
Highland Mountainous area	141.9 (13.9)	0.47 (–3.16 to 4.1)		
Years of experience				
<15	142.7 (14.1)	Ref	.29	
⩾15	140.7 (13.1)	–1.96 (–5.59 to 1.67)		
Farm scale				
Small	135.7 (12.1)	Ref	<.001	Ref
Medium	146.4 (12.9)	10.7 (7.3 to 14.04)		10.23 (6.04 to 14.42)
Perceived income				
Sufficient/Have saving	143.1 (13.5)	Ref	.008	Ref
Insufficient	137.8 (13.1)	–5.37 (–9.35 to –1.4)		–3.93 (–7.69 to –0.18)
Purpose livestock farming				
Sale	143.7 (13.5)	Ref	<.001	Ref
Family consumption, sale in emergency needs	135.9 (12.2)	–7.85 (–11.8 to –3.9)		0.44 (–4.26 to 5.14)

Abbreviation: CI, confidence interval.

were the most common sources for participants to obtain information about zoonotic diseases. These sources of information tend to be common for every aspect of daily life. However, information from the public media may provide only broad and nonspecific information about zoonotic diseases. Sometimes, the farmers may need specific and customized information related to their farm, in which the information can come from local veterinarians or local health workers. However, local veterinarians and health workers were not common sources of information in this study. This situation was confirmed by qualitative results that participants have concern about roles of local veterinarians, local health workers, and local authorities in zoonotic diseases prevention. Thus, effective communication between farmers and local veterinarians may help to improve understanding of farmers toward zoonotic diseases.

The participants appraised positively toward zoonotic disease prevention. The understanding and appraisals, however, could not be translated into practices. Many risk behaviors were reported in this study. About half of participants used boots, whereas less than 40.0% of participants wore masks and gloves. Although 98.0% of participants agreed that protective equipment is an important preventive measure, the farmers did not actually use them. The frequency of these personal protective practices was observed as low worldwide.[36] A previous study reported that reasons for not using protective equipment in farmers could be due to discomfort and inconvenience when working,[37] which is similar to our qualitative results. Washing hands was the most common practice among farmers.[32,34,36] Although a large proportion of participants knew that direct contact with animals' secretions can lead to infection, approximately 40.0% of participants reported handling aborted fetus or placenta with bare hands. Similar percentage was also reported in other work in Punjab, India.[38] This behavior not only can cause disease for human but also disseminate the diseases.

The farmers mainly diagnosed and treated their sick animals by themselves instead of seeking support from local veterinarians. Occasionally, they would seek advice at dealers where they also can buy medicines. The dealer was considered as the first line contact when the livestock got sick.[39] Lack of trust in the local veterinarians' knowledge and skills was the main concern, indicated by our qualitative result and previous study.[40] Many irrational uses of antibiotics were also found in this study. Nearly a quarter of participants used human medicine to treat their sick animals and a third used antibiotics as feed supplements. More than one-third of them believed that feeding animals with antibiotics can help to prevent the diseases; this is similar to a study which was conducted in many regions in Vietnam.[39] These antibiotic usages were strongly consistent with the understanding of participants and their appraisals about antibiotic uses. For instance, more than 40.0% of farmers indicated that human antibiotics can be used to treat animals and were unaware of antibiotic resistance. These problems had been reported worldwide, particularly in low- and middle-income countries where antibiotics can be easily accessible, purchased without any prescriptions. Improper usage of antibiotics including misuse and overuse contributes to antibiotic resistance leading to increasing mortality and morbidity from infectious diseases.[41-44]

Over a third of participants did not properly isolate sick animals from the rest of the herd. This could lead to greater losses in both human health and animal health by further disseminations of the diseases. Nearly 100% of participants agreed that disinfection and vaccinations are essential preventive measures and they must be performed regularly. However, half of them actually did not do so and several participants did not really know about the vaccines that they used for their livestock.

This study found that farm scale was a factor associated with health literacy of participants toward zoonotic diseases. Participants with small scale were more likely to have inadequate health literacy than those with medium scale. A larger scale farm could be the main source of income in the family, thus farmers had to pay more attention to disease prevention, because disease in animals could potentially impact on their investments. Besides, the belief that the animals raised themselves are more delicious and safer than those from commercial farm is common in this population. It is very dangerous for participants with inadequate health literacy and higher rates of risk behaviors to raise animals for consumption. They could be the first suffering from the disease once it occurs. Minority ethnic groups had lower health literacy toward zoonotic diseases than Kinh ethnicity, which is the majority ethnic group in Vietnam. Perceived income was also found as a factor associated with health literacy level.

This study applied health literacy concept to determine the risk of zoonotic disease infection among livestock farmers with moderate and small-scale farming. Health literacy covers different dimensions that are important for zoonotic disease prevention and control. In addition, the mixed method approach used in this study was helpful to gather additional information regarding the barriers and hidden reasons for risk behaviors. However, this study focused only on the 5 common zoonotic diseases in Vietnam. Although many health literacy aspects can be applied to any zoonotic diseases, some questions used in this study may be able to be specifically applied to the particular disease of interest. In addition, this study was conducted in only one province of Vietnam, where most livestock farming was conducted in small scale. Cluster effect was not considered in this study as the distribution of health literacy among different clusters showed similar patterns. Results from this study may not be applied to farmers with large-scale farming. However, small-scale farming has been reported to be at high risk for zoonotic diseases infection and dissemination, due to sub-standard practices. Understanding health literacy among these farmers would be useful for planning effective intervention to this target group. However, further study conducted in a larger and wider sample size is recommended to improve generalizability of the results.

Conclusions and Recommendations

Overall, livestock farmers had moderate health literacy toward zoonotic diseases. Most participants had moderate attitude and appraisal toward zoonotic disease prevention; however, they still had poor knowledge and behaviors toward the diseases. Many risk behaviors were observed, particularly not using protective equipment, improper disinfection practices, inadequate vaccination, improper antibiotics usage, and inappropriate waste management. As good understanding and good appraisals may not reflect good practices, conventional health education alone may not be effective for prevention and control of zoonotic diseases in the population. Local veterinarians and health workers should be encouraged to provide hands on education and coaching that fit to farmer baseline literacy. However, building trust is a key for successful collaboration between farmers and local government authorities.

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Author Contributions

KCB, SL, JK and OP developed the proposal, overall organized and wrote the manuscript. KCB, SL, and UNTT contributed to data collection, analysis, and manuscript writing. All authors checked and accepted the manuscript.

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Supplemental Material

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