Original Contribution

Knowledge, Attitude, and Practice Regarding Zoonotic Risk in Wildlife Trade, Southern China

Hongying Li^{1,5}, Francesca Daszak,² Aleksei Chmura,¹ Yunzhi Zhang,^{3,6} Philip Terry,⁴ and Mark Fielder⁵

¹EcoHealth Alliance, New York, NY

²Hajim School of Engineering and Applied Sciences, University of Rochester, Rochester, NY

³Yunnan Institute of Endemic Diseases Control and Prevention, Dali, China

⁴School of Business and Innovation, Kingston University, Kingston, UK

⁵School of Life Science, Engineering and Computing, Kingston University, Kingston, UK

⁶Present address School of Public Health, Dali University, Dali, China

Abstract: Current wildlife trade practices in China lead to significant interactions between humans and animals and drive the emergence of zoonotic diseases. The at-risk behaviors, knowledge, and attitudes that influence health-related behaviors in relation to animal contact and safety measures in the trade remain poorly understood. A self-administered questionnaire survey was conducted among 947 adult Internet users in three provinces in southern China to assess knowledge, perceived disease risks, at-risk behaviors, and the association of these factors with other demographic factors among the target population. Few of the participants possessed sufficient knowledge of zoonotic diseases. Although most participants were opposed to the use of wild animal resources, many reported keeping wild animals as pets (30.7%) and eating wild animals (30.5%). The majority of participants (76.3%) believed the disease transmission via wildlife trade, but few connected contact with animals to sickness (18.5%) and only slightly more than half sought post-exposure treatment (54.4%). These results reveal low levels of knowledge and perceived risk regarding disease emergence from the animal–human interactions in wildlife trade and uncover the gaps in knowledge and attitudes as key challenges to the development of health behavior change interventions pertaining to wildlife trade.

Keywords: Zoonotic disease, Wildlife trade, Knowledge, Perceived risk, Behavioral change

INTRODUCTION

The Wildlife Trade and Zoonotic Disease Emergence

The wildlife trade is a major risk factor for the emergence of zoonotic diseases that account for 75% of emerging infectious diseases in human populations (Jones et al. 2008; Smith et al. 2009). Human–animal interactions in wildlife trade practices create interfaces for pathogen spillover from

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Correspondence to: Hongying Li, e-mail: li@ecohealthalliance.org

their natural reservoirs to other animals and humans. Furthermore, disease can spread through the movement of animals over long distances from their natural habitats to densely populated human environments (Daszak et al. 2007; Karesh et al. 2007). Human activity in the wildlife trade has been identified as a risk factor for the emergence of severe acute respiratory syndrome (SARS) in 2002 and the re-emergence of highly pathogenic avian influenza (HPAI) in 2003 in China (Burgos and Burgos 2007; Field 2009; Peiris et al. 2004). In December 2019, a wildlife-origin novel coronavirus, SARS-CoV-2, was identified as the pathogen causing coronavirus disease 2019 (COVID-19). This virus has ultimately led to a pandemic that has, at the time of writing, caused more than 3 million deaths globally (Wenjie et al. 2020; World Health Organization 2021; Zhou et al. 2020). Epidemiological research has revealed a link between some early human cases and the exposure of these individuals to a local live animal market in Wuhan, China, where SARS-CoV-2 was detected and isolated from environmental samples (Chinese CDC Novel Coronavirus Response and Risk Assessment Group 2020; Huang et al. 2020; Xinhua News Agency 2020a). Although further data suggested that the local market in Wuhan was not the original source of the outbreak, the trade of live wild animals was identified as a possible starting point of the pandemic (Joint WHO-China Study 2021).

In China, where wildlife is regarded as a source of medicine and delicacy, a variety of small mammals, birds, and reptile species are traded and consumed by both rural and urban populations with the financial means to do so. This is especially the case in southern China, which is highly biodiverse and harbors an abundance of species (Chow et al. 2014; Fabinyi 2012; Zhang and Yin 2014). Previous studies regarding human behavior in relation to the wildlife trade in China suggest a potential risk of disease emergence at such human–animal interfaces as hunting, transporting, slaughtering, and consuming wild animals (Yang et al. 2007; Zhang et al. 2008; Zhang and Yin 2014). However, there has been limited research in different Chinese provinces to understand the risky human–animal interactions and public awareness of zoonotic diseases. Most of these studies have targeted specific diseases (e.g., HPAI) or small populations that have contact with certain animals (e.g., at poultry or bird markets) (Kim et al. 2011; Ma et al. 2014; Xiang et al. 2010; Zhao and Davey 2017). Two studies have provided a broad overview of human–animal interactions with a variety of animal taxa in different scenarios in southern China (Li et al. 2019, 2020).

However, these only focused on rural communities presumed to have more opportunities to be in contact with wild animals. The dynamic interactions between humans and diverse animal species, and potential zoonotic pathogens in the wildlife trade require further investigation in order to develop a more comprehensive understanding of the at-risk behaviors, attitudes, and knowledge in relation to the emergence of zoonotic diseases within the general population.

Required Health-Related Behavior Changes in Wildlife Trade Practices

The socioeconomic damage caused by infectious diseases introduced by the trade of wild animals underscores the need for both policy and public health-related behavioral changes to mitigate the associated disease risk (Fonkwo 2008; Karesh et al. 2005; United Nations Environment Programme and International Livestock Research Institute 2020). Previous efforts to improve policies relating to wildlife trade practices have been developed primarily from the perspective of conservation and have overlooked the health aspect when developing behavioral change programs. However, in response to the COVID-19 pandemic, both local authorities and the general public in China have demonstrated a strong motivation to address these wildlife trade issues in order to protect public health (Xiao et al. 2021). The Huanan market in Wuhan was immediately closed following the identification of its association with COVID-19, and a national ban on the consumption of terrestrial wildlife was enacted (Xinhua News Agency, February 24, 2020b). Following the emergence of COVID-19, a survey of 74,040 Chinese citizens found that more than 90% of respondents supported more stringent wildlife trade policies, and some respondents expressed a willingness to stop consuming wildlife (Shi et al. 2020). However, similar changes in attitudes toward the wildlife trade and conservation were observed in China before and after the SARS outbreak (Yang et al. 2007). The challenge remains to enable a fundamental change in human behaviors in order to achieve lasting benefits to public health (Conrad 2012; IPBES 2020).

Knowledge, Attitude, and Practice Survey to Understand Potential Barriers to Change

A much better understanding of at-risk behaviors, perceived risks or benefits, and level of knowledge among

target populations is required to establish the readiness to act and achieve the necessary change (Champion and Skinner 2008; Zhang et al. 2008). Knowledge, attitude, and practice (KAP) research is widely used in public health and conservation scholarship to collect information about public understanding of a phenomenon (knowledge), evaluative responses to a situation (attitudes), and observed actions or behaviors (practices) among a target population (Gumucio et al. 2011; World Health Organization 2008). This method has also been used to guide the development, implementation, and evaluation of public health interventions with the assumption of a linear relationship between knowledge, attitude, and behavior change (Fan et al. 2018; Launiala 2009; Muleme et al. 2017). Although some scholars have questioned the accuracy of KAP data and, therefore, its ability to inform interventions (Mallah et al. 2020), this method can provide data on individual knowledge and attitudes toward the wildlife trade and zoonotic disease risk, and can explore human–animal contact behaviors, the protective measures that individuals take, and treatment-seeking behaviors that with relevance to zoonotic disease emergence. This method can also access a variety of factors that may represent potential barriers to health behavior change in relation to wildlife trade practices.

METHODS

Survey Design

The survey was based on a questionnaire that comprised of five sections: (1) demographics; (2) knowledge regarding zoonotic diseases; (3) experiences of illness/sickness and perceived causes; (4) experience of contact with wild animals; and (5) attitudes toward the wildlife trade. The questionnaire included a number of response formats, including dichotomous, multiple choice, open-ended options, and Likert rating scales. Educational information was embedded in the questionnaire through the inclusion of graphs demonstrating different types of human–animal contact in wildlife trade, treatment-seeking suggestions, and correct answers that participants could access once they had completed the questionnaire. One question concerning beliefs about the transmission of disease from wildlife to humans was asked both before and after an educational presentation, to explore the immediate effect of information exposure on participants' knowledge and

perceptions (Supplementary Materials I) (Fielding et al. 2008; Gumucio et al. 2011).

Target Population

Corresponding to previous offline surveys undertaken by our group, this survey was developed to exclusively target adult Internet users (≥ 18 years old) in the same three provinces in Yunnan, Guangxi, and Guangdong Provinces, owing to the prevalence of trade in wildlife and the historical record of infectious disease emergence in these provinces (Li et al. 2019, 2020). A target sample size of 1068 was calculated based on a conservative estimate of a population of approximately 121 million Internet users with a 95% confidence level and a 3.0% margin of error (China Internet Network Information Center (CNNIC), 2017 January).

An estimated 61.2% of the Chinese population (854 million people) has access to the Internet, the majority of whom are urban residents (73.7%) aged 20–49 years (65.6%) (China Internet Network Information Center (CNNIC) (2019). Therefore, by targeting the different demographics represented by Internet users, compared to the existing research among the rural communities, our aim was to expand current knowledge by gaining perspectives from younger adults with higher average incomes and different occupations and life experiences relative to those residing in rural areas. This self-administered online survey also provided a degree of privacy and security for the exploration of sensitive topics, including the wildlife trade, which has not been widely investigated in face-to-face interviews due to the illegality of this practice.

Ethical Review and Informed Consent

The research protocol, consent form, and all participant materials, including the recruitment message and questionnaire in both English and Mandarin, were reviewed by Hummingbird IRB, and favorable ethical opinion was received on November 7, 2018 (No. 2018–73). Participation in the study was strictly voluntary. Following an introduction on the webpage that gave detailed information about the survey, an electronic consent form was presented in Mandarin which detailed protection of participants' confidentiality/anonymity, potential risks of participation, and their right to withdraw from the study (Supplementary Materials II). Upon clicking an “Agree” button to confirm they had read the information, were 18 years of age or

older, and were voluntarily participating, participants had access to the questionnaire.

Recruitment

Participants were recruited and the survey was presented using the Chinese online survey platform Sojump (<https://www.sojump.com>). This platform possesses a database of 2,600,000 individuals across all 31 of China's province-level administrative regions. A survey notification targeting the eligible participants in the three provinces was randomly distributed using Sojump's proprietary software. All recipients had the option to respond or not. The notification included a standardized message and a unique barcode directing each participant to the detailed introduction page of the online survey. The survey was distributed irrespective of user preferences regarding the wildlife trade, activism, public health, or conservation.

Data Collection

The questionnaire was made available for a maximum of 30 days. The survey could be completed on computers or smart phones, and participants were free to exit any survey page at any time. All data were confidential, and no personal identifying information was recorded. Questionnaire data were temporarily saved on the survey platform, protected by password and only accessed by the study researchers until the end of the 30-day survey period. All data were then transferred to be stored on a password-protected Excel database, and access was limited to study researchers for the purposes of conducting analysis.

Data Analysis

The data were analyzed using RStudio (version 1.2.1335 © 2009–2019 RStudio, Inc.). Descriptive statistics were used to summarize the data. Pearson Chi-square and Fisher's exact test were used to characterize associations between participants' demographic backgrounds and their knowledge, attitudes, and practices. These tests were also used to assess participants' knowledge, attitude change, and the effectiveness of the educational information presented in the survey. The effect size (odd ratios) and Cramér's V were considered when determining associations between these factors. A 95% confidence level was adopted in all analyses.

RESULTS

In January and February 2019, 1,243 questionnaires were distributed to the target population in Yunnan, Guangxi, and Guangdong Provinces. Of these, 947 questionnaires were completed and returned, with a response rate of 76.2%. The median time taken to complete the survey was 4 min and 20 s. Although the number of participants did not meet the designed target sample size of 1068, a sample size of 947 is sufficient with an acceptable margin of error of 3.18% with a 95% confidence level (Kotrlík and Higgins 2001; Suresh and Chandrashekara 2012).

Demographic

The majority of participants were under 40 years of age (67.8%) and held college or university degrees (77.7%). Most worked in indoor environments, such as schools or office buildings (63%) or factories (11.0%), and the median monthly income was 4,001 to 6,000 CNY. A large proportion of the participants were young adults in the 18–25 age group (44.4%) with incomes of less than 4,000 CNY (42.1%) (Table 1). The demographic background of study participants corresponds to that of general Internet users in China (China Internet Network Information Center (CNNIC), 2019 August), except that a larger proportion of study participants had completed college or other forms of higher education.

Knowledge Related to Zoonotic Disease Risk

More than half of the participants recognized the zoonotic origin of HPAI (81.9%), but not that of SARS (30.9%), or other zoonotic diseases such as HIV/AIDS (21.4%), Middle East Respiratory Syndrome (MERS) (21.4%), and Ebola (43.6%) that have occurred in China and elsewhere. When compared to responses to a similar survey conducted among Internet users in the same three provinces in 2016 (Chmura 2017), the number of people who considered SARS to be a zoonotic disease has decreased ($p < 0.01$, OR = 3.18) (Table 2).

Most participants cited rodents (77.5%) and domestic animals, including poultry and swine (77.2%), and domestic pets (58.9%) as potential sources of pathogens that can be transmitted to humans, followed by bats (44.2%) and wild birds (37.5%) (Table 3). No significant associations were found between participants' knowledge of

Table 1. Demographic Characteristics of the Survey Participants

Variable	Total (<i>n</i> = 947)	
	<i>n</i>	%
<i>Gender</i>		
Female	507	53.5
Male	438	46.3
Other	2	0.2
<i>Age (years old)</i>		
18–25	420	44.4
26–30	256	27.0
31–40	203	21.4
41–50	57	6.0
> 50	11	1.2
<i>Monthly income (CNY)</i>		
≤ 2000	191	20.2
2001–4000	207	21.9
4001–6000	236	24.9
6001–8000	175	18.5
> 8000	138	14.6
<i>Educational attainment</i>		
Primary school	9	1.0
Secondary/polytechnic school	150	15.8
College/university	736	77.7
Graduate school/beyond	52	5.5
<i>Province</i>		
Yunnan	317	33.5
Guangxi	315	33.3
Guangdong	315	33.3
<i>Working environment</i>		
Animal market	65	6.9
Artisan/produce market	48	5.1
Factory	104	11.0
Home	45	4.8
Office building/school	597	63.0
Restaurant/food stall/store	36	3.8
Hospital/clinic	41	4.3
Outdoor labor-related	11	1.2

zoonotic disease and either their education level or other demographic traits.

Perceived Disease Risks from Contact with Animals in the Wildlife Trade

Approximately 60% (*n* = 567) of participants reported having experienced an illness in the past 12 months. The

most commonly reported symptoms were fever with headache and severe fatigue or weakness (32.6%) and fever with muscle aches, cough, or sore throat (24.7%). Some participants (36.0%) believed that spoiled food or unclean water were the cause of their symptoms, followed by contact with sick people (25.7%) and/or wild animals (18.5%). Among those participants who experienced fever with rash (*n* = 29), the leading perceived cause was contact with wild animals (37.9%) (Fig. 1).

At the start of the survey, 76.3% of participants believed that diseases are likely to be transmitted from wildlife to humans through wildlife trade. The educational information included throughout the questionnaire led to a change in responses (*p* < 0.05), and by the end of the survey, 81.7% of participants believed that diseases are likely transmitted in this way. Nonetheless, 18.3% of participants remained neutral or held opposing views on whether diseases are transmitted by wild animals (Supplementary Materials III Table 1). Participants demonstrated strong support for public education on the disease risks of the wildlife trade, with the most-recommended educational formats and platforms being movies and documentaries (63.1%), school lessons or campaigns (62.3%), and the use of social media (56.2%) (Supplementary Materials III Table 2).

Human–Animal Contact and Protective Practice

Although almost half (48.1%) of the survey participants reported having never had any contact with wild animals as described in the questionnaire, some reported keeping wild animals as pets (30.7%), eating wild animals (30.5%), handling freshly killed wild animals or animal parts (25.3%), being scratched or bitten by wild animals (20.2%), or having received a wound when butchering wild animals (13.5%). In each type of contact, wild birds were the most commonly reported as being handled and consumed, followed by wild boars. Different types of contact with other mammals known to carry zoonotic pathogens, including bats, civets, and non-human primates (NHPs), were also reported (Fig. 2). No significant differences in animal contact behaviors were found among participants in different age, education, or income groups, or those from different provinces. However, participants working in school or office building environments were more likely to report never having handled freshly killed wild animals (*p* < 0.01, Cramér's *V* = 0.21), never having been scratched or bitten by wild animals (*p* < 0.01, Cramér's

Table 2. Knowledge of Zoonotic Disease Among Internet Users in Yunnan, Guangxi, Guangdong Provinces Based on 2016 and 2019 Surveys

Zoonotic disease		2016 (<i>n</i> = 422)		2019 (<i>n</i> = 947)		<i>p</i> value	OR
		Yes	No	Yes	No		
HIV/AIDS	<i>n</i> (%)	121 (28.7)	301 (71.3)	203 (21.4)	744 (78.6)	< .01	1.47
SARS	<i>n</i> (%)	248 (58.8)	174 (41.2)	293 (30.9)	654 (69.1)	< .01	3.18
MERS	<i>n</i> (%)	109 (25.8)	313 (74.2)	203 (21.4)	744 (78.6)	0.07	1.28
Avian influenza	<i>n</i> (%)	352 (83.4)	70 (16.6)	776 (81.9)	171 (18.1)	0.51	1.11
Ebola	<i>n</i> (%)	157 (37.2)	265 (62.8)	413 (43.6)	534 (56.4)	0.03	0.77
SARS and avian influenza	<i>n</i> (%)	265 (62.8)	157 (37.2)	583 (61.6)	364 (38.4)	0.66	1.05
All above	<i>n</i> (%)	54 (12.8)	368 (87.2)	75 (7.9)	872 (92.1)	< .01	1.71

Table 3. Knowledge About Animals that Potentially Carry Zoonotic Pathogens (*n* = 947)

Animal taxa	Yes		No	
	<i>n</i>	%	<i>n</i>	%
Bats	419	44.2	528	55.8
Wild Pigs/Boars	310	32.7	637	67.3
Rodents	734	77.5	213	22.5
Birds	355	37.5	592	62.5
Reptiles	194	20.5	753	79.5
Non-human primates	190	20.1	757	79.9
Elephants	31	3.3	916	96.7
Pangolins	137	14.5	810	85.5
Bears	67	7.1	880	92.9
Civets	278	29.4	669	70.6
Domestic pets (e.g., cat, dog)	554	58.5	393	41.5
Domestic animals (e.g., poultry, swine)	731	77.2	216	22.8

$V = 0.25$), or never having been wounded when butchering wild animals ($p < 0.01$, Cramér's $V = 0.21$).

Most participants reported using masks (66.1%) or gloves (75.9%) as protective equipment when in contact with wild animals (Supplementary Materials III Table 3). Participants reported that the most acceptable protective measures they would take in the future when interacting with wild animals were wearing gloves (80.6%), washing hands (79.5%), and wearing masks (76.1%). Many participants would also choose to shop at non-live animal markets (57.8%), buy only farmed animals (41.4%), or avoid butchering wild animals (47.4%) (Supplementary Materials

III Table 4). Among those participants who had been bitten, scratched, or otherwise wounded when handling wild animals ($n = 491$, 51.8%), only a little over half (54.4%) sought treatment from medical professionals, while others chose to rinse, sterilize, or cover the wound themselves (Supplementary Materials III Table 5).

The Use of Wild Animals and Wild Animal By-Products

Most participants held an overall negative view of the use of wildlife or wildlife by-products, including the consumption of wildlife or wildlife by-products as medicine. However, when asked about captive-bred wild animals or their use in traditional medicine, more participants gave neutral responses or were less affirmative (Fig. 3). Of those participants who have consumed wild animals or their by-products ($n = 518$, 54.7%), few (8.4%) had proactively sought out the items they consumed. Rather, these items had been provided by family members (21.4%) or friends (30.5%) or had been prescribed by doctors (14.3%) (Supplementary Materials III Table 6).

DISCUSSION

Insufficient Knowledge of Zoonotic Disease and Wildlife Despite Altered Attitudes

Although previous studies have reported changes in public attitudes toward wild animals in China following outbreaks of disease, such as SARS and HPAI (Yang et al. 2007; Zhang et al. 2008), public knowledge of zoonotic disease remains

Figure 1. Self-reported sickness in the past 12 months and perceived causes. The number of participants who reported experiencing different symptoms (labeled in colors) in the past 12 months, and what they believed to be the likely cause of the symptoms.

Figure 2. Activities involving contact with different animal species. Values and colors represent the numbers of participants who reported specific types of contact; values in parentheses represent the total number and percentage of participants who reported the type of contact.

Figure 3. Attitudes on the use of wildlife and their by-products. Percentage of participants who held different levels (labeled in colors) of views regarding the use of wildlife and their by-products.

poor. For example, bats have been identified as the natural reservoir of the SARS coronavirus that infected civets, the intermediate host, which then transmitted the pathogen to human populations (Li et al. 2005); however, the present study revealed a lack of knowledge regarding these two animals as potential hosts of zoonotic disease. Meanwhile, between 2016 and 2019, the number of people who considered SARS to be a zoonotic disease had decreased. This may be due to a difference in the age of survey participants, as the population enrolled in the current survey was younger than that in the 2016 survey and, thus, may have had less experience with SARS. However, the difference may also be an indication that public memory regarding the outbreak has faded over time. On the other hand, HPAI, which has emerged repeatedly in China in recent years, was widely recognized as a zoonotic disease by the survey participants.

Observed attitude changes toward the trade in wildlife among the Chinese population (Shi et al., 2020) have been seen as a positive indicator of both reduced consumption and disease risk. However, the continued post-SARS wildlife trade, together with evidence from this study regarding changes in public knowledge over time, indicates that a general emphasis on the threat is inadequate to sustain public awareness. Surveys conducted pre and post the West African Ebola outbreak further revealed that even a recent pandemic may not affect public awareness of disease risk (Pike et al. 2020). For the ongoing COVID-19 pandemic, the overall duration of public attention was too short in some countries to maintain the public's vigilance and sensitivity to take precautionary measures (Hu et al. 2020). Moreover, attitudes are only one of many factors that influence intentions and behaviors, and they can be a poor predictor for behavior change, as demonstrated in a number of studies (Kollmuss and Agyeman 2002; Liu et al. 2011). Strict control of wildlife trade may suppress trade and consumption and potentially reduce human–animal contact in the short term. However, long-lasting disease risk reduction relies on behavioral changes that require tackling underlying social and personal factors, and improving basic knowledge of the wildlife trade and zoonotic diseases (Eskew and Carlson 2020; Klöckner 2013).

Human–Animal Interactions and Perceived Risks

In comparison with previous offline studies conducted among rural communities (Li et al. 2019), the participants enrolled in this study had fewer opportunities to come into

contact with wild animals. This was attributed in part to their urban living and working environments. However, the main pathways of contact with animals reported in this survey were similar to those of rural participants, and more urban participants reported contact with non-human primates. These similar human–animal interaction patterns are among different populations, and the fact that both SARS and COVID-19 outbreaks started in the first-tier cities in China, suggests changing patterns of access to wild animals based on proximity to natural environments. The risk factors associated with zoonotic disease emergence may largely exist specifically in the intensive contact with live wild animals in a proactive manner, such as participating in wildlife trade practices, rather than being associated with specific living environments. Participants did not typically connect their contact with animals to the illnesses they had experienced, even for cases of respiratory infection and influenza-like symptoms that are closely linked to SARS and HPAI. This low level of perceived risk of potential zoonotic disease may be a factor in participants' inadequate treatment-seeking behaviors following exposure, as revealed in this study.

Nevertheless, the study found that consuming wild animals or their by-products was seldom self-motivated, but was predominantly prompted by family members and friends offering the items or providing opportunities for consumption. This result differs from existing studies reporting personal curiosity and the novelty or rarity of wildlife as the main reasons for initial consumption (Yang et al. 2007; Zhang et al. 2008). This study also revealed positive attitudes regarding the recognition of disease transmission through the trade of wildlife and against the use of wild animal resources. These perceptions may potentially help to pave the way for reduced human–animal contact in the wildlife trade. However, the risk of disease emergence exists as long as high-risk behaviors are performed even by small numbers of people. Therefore, further research is needed to identify these at-risk populations in order to implement targeted risk-mitigating interventions.

Considerations and Challenges for Developing Health Interventions in the Wildlife Trade

In addition to insufficient knowledge of the relationship between wildlife and disease that may influence perceptions of zoonotic disease risk and hamper appropriate health-related behavior changes, we must be mindful of gaps in

“attitude-behavior” and “intention-behavior” observed in both conservation and public health behavior change programs (Faries 2016; Nilsson et al. 2020). Participants reported taking some protective measures when in contact with wild animals, such as wearing gloves or masks, and these were, in general, considered to be acceptable measures. However, various socioeconomic factors may affect individual decisions to take specific protective action, including the degree to which a person believes that a certain behavior will help reduce risk, compared to the potential time or economic cost of that behavior. This is a critical consideration with regard to the risk-mitigation measures that some presumed at-risk populations, such as wildlife farmers or vendors, are willing to take. In particular, the frequent contact these groups have with animals requires a significant amount of personal protection equipment, which may be expensive to buy and the wearing of which may slow down the individual’s work (Yuantari et al. 2015). In addition, shopping at the supermarket, buying farmed animals, or not butchering wild animals by self were considered by fewer participants as acceptable protective measures, which was likely due to the limited room for change among the participants who had taken these measures or had no other choice.

Although brief exposure to relevant information can lead to an immediate increase in awareness among the targeted population, as shown by the use of educational messages and graphs embedded in this survey and other studies (Trevino et al. 2020), narrowing the knowledge gap to significantly change attitudes will require long-term effort. In addition, efficient models for human behavioral change in wildlife trade practices are hard to elucidate without a better understanding of the perceived benefits, barriers, and self-efficacy linked to the behaviors that need to be changed (Champion and Skinner 2008; Faries 2016; Klöckner 2013), as well as other social, economic, and cultural factors that affect wildlife trade practices. These challenges are further compounded by the different end goals of conservation and public health campaigns.

CONCLUSION

The online survey method limited our findings to Internet users from certain demographic backgrounds, while voluntary participation may have excluded people not familiar with or interested in the topic. Meanwhile, despite its huge and diverse database, convenience sampling via the Sojump

platform had the potential to create representation bias. Therefore, the results of this study may not be generalizable to all Internet users in Yunnan, Guangxi, and Guangdong Provinces. Other limitations include the accuracy of self-reporting on the KAP survey and the depth and specificity of questions in a short questionnaire designed to increase the response rate. Nevertheless, the study makes an important contribution to our understanding of the knowledge, attitudes, and behaviors of different demographics, and to our understanding of human–animal contact and zoonotic disease risk in relation to wildlife trade from the perspective of public health. The results allow for comparison and synthesis with existing evidence, identify gaps and challenges in transferring knowledge and attitudes into behavior change, and contribute to the development of targeted and in-depth surveys and subsequent interventions based on their findings.

The current COVID-19 pandemic exemplifies how a public health crisis can bring about changes to wildlife trade practices, although such a large-scale zoonotic disease outbreak is very rare compared to more routine practices of wild animal hunting, farming, and trading for which conservation goals have generally been pushed to promote behavioral change. Further research will be needed to evaluate the sustainability of these changes and their impacts on the public’s zoonotic risk knowledge, attitudes, and behaviors post COVID-19. Meanwhile, cross-sectoral collaboration in policy making and community interventions that recognize the connection between human and animal health is critical to bring about behavioral change in relation to human–animal interactions in the wildlife trade to benefit both public health and wildlife conservation. Further research on each of these domains is recommended to understand how their specific perspectives should be addressed when developing public education and behavioral change programs.

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DECLARATIONS

CONFLICT OF INTEREST The authors declare that they have no conflict of interest.

ETHICAL APPROVAL This study was reviewed and approved by Hummingbird IRB (No. 2018–73). All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

INFORMED CONSENT Informed consent was obtained from all individual participants included in the study.

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