

Avoiding bites and scratches? Understanding the public health implication of human–bat interactions in Ghana

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Abstract

Zoonotic pathogens cause an estimated 70% of emerging and re-emerging infectious diseases in humans, affecting various aspects of human development on a global scale. The significance of bats as a source of emerging infectious diseases is being progressively appreciated. This study was undertaken post-Ebola virus disease in West Africa and assessed the public health implications of human–bat interactions by exploring the reasons for contact between humans and bats, as well as reported actions taken upon experiencing bat bites or scratches. The paper highlights the nuances of human–bat interactions, stressing zoonotic disease risk awareness as well as the sources of information. The study used questionnaires to solicit information from 788 respondents in five communities with significant bat populations. We show that bat consumption was one of the main reasons for human–bat interactions. More men across the various communities ate bat meat. Only a small number of respondents (4.4%) reported being bitten by a bat, and 6.1% had been scratched by a bat. More than 21% had come into direct contact with bat blood. An even lower number went to the hospital after been bitten or scratched by bats. There was little knowledge on post-exposure management. The most common places human–bat interactions occurred were at home and on farms. Seventy-three per cent of the respondents believed that bats carried diseases, with Ebola virus disease being the most mentioned. Respondents indicated that the way they interacted with bats had not changed, even though they believed bats carried diseases and 46% stated that they had not changed the way they interacted with bats over the last two years. Apart from providing information on avoiding bites and scratches, a more holistic framework is needed to reduce human–bat interactions. The paper recommends a comprehensive and coordinated approach to optimizing an effective response to a potential bat-borne zoonotic disease spillover.

KEYWORDS

bat-borne zoonoses, bats, Ghana, public health, transmission risk

1 | INTRODUCTION

Zoonotic pathogens cause an estimated 70% of emerging and re-emerging infectious diseases in humans (Paige et al., 2014; Wong,

Lau, Woo, & Yuen, 2007). Bats carry more potential threats as reservoirs for zoonotic viruses than other mammals, as they host more viruses per species than other mammals (Olival et al., 2017). According to Calisher, Childs, Field, Holmes, and Schountz (2006)

and Newman, Field, Epstein, and Jong (2011) more than 60 viruses have been detected in bat tissue, and bats are reservoir hosts for highly pathogenic Nipah, Hendra and lyssa viruses (Leroy et al., 2005; Paterson et al., 2014; Pigott et al., 2014). Bats are the natural reservoir hosts for henipa encephalitic diseases with human-to-human transmission and death rates of about 75% (Hayman et al., 2013; Olival & Hayman, 2014; Plowright et al., 2014). Past research has also documented evidence of devastating spillover events of both lyssaviruses (Allworth, Murray, & Morgan, 1996; Wright et al., 2010) and filoviruses (Hayman et al., 2010; Leroy et al., 2005) from bats to people in some parts of Africa (Olival & Hayman, 2014). This includes the outbreak of Ebola virus disease in West Africa in 2014 (Pigott et al., 2014).

The growing number of studies citing bats as sources of emerging infectious diseases (Leroy et al., 2005; Hayman et al., 2010) could be attributed to the increasing interactions between humans and bats, resulting in a high risk of disease spillover to humans (Kagan, Aiello, & Larson, 2002; Lawson et al., 2017; Siegel, Rhinehart, Jackson, & Chiarello, 2007). Spillover infection occurs when a reservoir population with high pathogen prevalence encounters a new host population. In this paper, we use Power and Mitchell's (2004) definition of pathogen spillover as the "driving of disease dynamics in one host population by contact with pathogen propagules (regardless of transmission mode) from another host population as a result of high pathogen abundance in this reservoir population" (p. 79).

Thirteen species of fruit bats have been recorded in Ghana, in all the ecological zones with *Eidolon helvum* and *Epomophorus gambianus* accounting for over 75% of mist-net captures (Leach et al., 2017). Other common bat species include *Micropteropus pusillus*, *Rousettus aegyptiacus* and *Epomops franqueti* (Leach et al., 2017). Bats are hunted for food and/or for sale (Lawson, Ayivor, Ohemeng, & Ntiamoah-Baidu, 2016; Leach et al., 2017). Kamins et al. (2011) estimate that over 128,000 bats are sold each year as bushmeat in southern Ghana. Public health concerns relate to the role of bats as possible reservoirs of zoonotic diseases, the high human-bat interactions in some communities as well as poor structures for surveillance and monitoring. These coupled with the increasing movement of people and goods attributable to urbanization have influenced the rise and spread zoonotic diseases (Jebara, 2004). Emerging and re-emerging zoonotic diseases associated with bats have also been identified as public health concerns with both bioterrorism and pandemic potential requiring a coordinated multi-agency response, which combine information sharing with risk communication (Adongo et al., 2016; Jackson et al., 2006).

Efforts to control and eradicate infectious diseases have proven remarkably difficult (Paterson et al., 2014). Experiences from many countries have shown that an increased understanding of the attitudes of the people most at risk, their knowledge and practices concerning zoonotic diseases are key to developing awareness creation campaigns in reducing the risks of zoonotic disease transmission (Hiby, 2013; Massei et al., 2017). Surveillance, prevention and education concerning zoonotic diseases' transmission heightened in Ghana during the outbreak of EVD in West

Impacts

- We used participatory methods to elicit responses on human-bat interactions from 788 respondents in five rural and urban communities with significant bat populations.
- We show that bat consumption was a key motivation for human-bat interactions, with differences in gender, age and occupation.
- Increasing knowledge of bats and diseases had not significantly changed the extent of human-bat interactions in communities. A more comprehensive and coordinated approach to optimizing effective responses to a potential bat-borne zoonotic disease spillover is needed

Africa in 2014 (WHO, 2014). These activities were undertaken by the Government through its ministries, departments and agencies and various non-governmental agencies. According to Adongo et al. (2016), these steps included the establishment of an inter-ministerial committee under the leadership of the Minister of Health, a national EVD preparedness and a response plan structured around five thematic areas:

- Planning and coordination;
- Surveillance, situation monitoring and assessment
- Case management
- Social mobilization and risk communication
- Logistics, security and financial resources, increase in health education and community mobilization efforts in preparation towards containment in the event of an outbreak.

However, human-bat interactions remain insufficiently studied (Wood et al., 2012). There is still insufficient understanding of the social, economic, political or environmental dynamics and drivers at different scales that shape these interactions, or of the beliefs, understandings and cultural practices which surround human-bat contact (Wood et al., 2012). Bearing in mind the concerns shared about Ghana's preparedness to effectively deal with a possible zoonotic disease outbreak, we assessed the public health implications of human-bat interactions by exploring the reasons for contact between humans and bats, as well as reported actions taken upon exposure through bat bites or scratches. This paper highlights the nuances of human-bat interactions, focusing on zoonotic disease risk awareness, the sources of information on bats and zoonotic disease risk and how these can influence possible spillover of bat-borne zoonoses.

We sought to build on recent work by Kamins et al. (2015), Lawson et al. (2016, 2017), Ohemeng et al. (2017) and Ayivor et al. (2017). These studies were undertaken in various communities in Ghana before the outbreak of EVD in some West African countries. Kamins et al. (2015) focused on the use of the straw-coloured fruit

bat, *E. helvum*, as bushmeat in southern Ghana ($n = 577$). The study examined the characteristics of people involved in the bat-bushmeat trade and their perceptions of risk. On the other hand, Lawson et al. (2016, 2017) assessed the social, cultural and economic factors that influenced human–bat interactions in Ghana. Using several participatory methods, the authors focused on the straw-coloured fruit bat (*E. helvum*) and the Gambian epauletted fruit bat (*E. gambianus*) in two rural communities and one urban community. Lawson et al. (2016) ($n = 340$) sought to understand the behavioural and socio-economic factors that could facilitate henipavirus spillover to humans and identified direct exposure including contact with fresh bat meat through eating, hunting and processing bat meat. Gender was most strongly associated with exposure. In Lawson et al. (2017) ($n = 340$), people's framings and perceptions of bats were noted to influence human–bat interactions as well as the potential spillover of bat-borne viruses to humans. Finally, focusing on *E. gambianus* Ayivor et al. (2017) undertook an in-depth qualitative study ($n = 150$) in a rural community in southern Ghana. Though no reported cases of disease spillover from bats to humans were reported, respondents whose activities brought them closer to bats were found to be more likely to experience fevers.

The current study was undertaken in five communities, post-EVD outbreak, presenting varied settings of human–bat interactions. The settings included an urban setting with residential areas and high human traffic as result of a hospital and transit systems, and four rural, predominantly farming communities. Unlike the earlier studies, respondents in this study had experienced a real zoonotic disease risk and we sought to understand the changes in perceptions and behaviours that would have occurred (if any) because of a possible exposure to a zoonotic disease. Since education programmes were intense during the EVD outbreak in 2014, the study also assessed respondents' knowledge on post-exposure management. Finally, Lawson et al. (2016, 2017), Ohemeng et al. (2017) and Ayivor et al. (2017) employed convenience sampling method to target respondents from occupations known to have high interactions with bats such as hunters, butchers and farmers. In this study, respondents were randomly selected to present the views of a broader, more diverse sample. The evidence provided in this paper will prove useful to existing public health plans, ensuring that local voices are heard within the larger global effort to study and mitigate outbreaks of zoonotic diseases (Kamins et al., 2015).

2 | MATERIALS AND METHODS

2.1 | Study communities

Five communities known for human–bat interactions were purposively chosen for the study (Table 1, Figure 1). In the 37 Military Hospital study area, bat roosts can be found on most of the trees within the hospital, in the nearby residential areas (soldiers' barracks, nurses' and doctors' living areas), as well as in the nearby Parks and Gardens Department. Large numbers of fruit bats also roost on mahogany trees along the main road in front of the hospital and

TABLE 1 Study communities and respondents

Community	Frequency	Per cent
37 (Urban)	159	20.2
Tanoboase (Rural)	326	41.4
Ve-Golokuate (Rural)	121	15.4
Kpeve (Rural)	116	14.7
Gbefi-Tornu (Rural)	66	8.4

within the hospital compound (Hayman et al., 2012; Lawson et al., 2017), thus exposing patients, hospital visitors and the public to bat urine and faeces. Tanoboase is a small farming community along the Techiman-Kintampo road in the Brong-Ahafo Region. The bats roost in the Tanoboase sacred grove. Sacred groves are patches of forest set aside by local communities and protected by traditional norms for a variety of religious and sociocultural purposes (Ntiama-Baidu, 2000). The site is estimated to support over 2 million bats during the peak season. In Ve-Golokuate, the bats roost on large fruit trees in and around the town, in homes, schools, the community clinic and the chief's palace. Ve-Golokuate is located along the Tema-Jasikan road, within the forest-savannah transition zone. There is a large population of bats, mainly *E. gambianus*, in mango (*Mangifera* sp.), fig (*Ficus* sp.) and neem (*Azadirachta indica*) trees found in schools and churches, market places and people's homes within the community. Similarly, Kpeve and Gbefi-Tornu are located in the forest-savannah ecotone in the Volta Region. Gbefi-Tornu and host thousands of *E. gambianus* mainly in mango trees within households. At the Kpeve study site, however, there are is a large population of *E. helvum*, in huge silk cotton trees (*Ceiba pentandra*) within the community.

2.2 | Data collection

Data collection took place from September 2016 to December 2016. We adopted a multi-stage sampling method. The study sites were purposively selected based on evidence of bat occurrence. The second-stage household was randomly selected for the interviews. According to FAO (2004), households normally "comprise individuals who live in the same dwelling and who have common arrangements for basic domestic and/or reproductive activities such as cooking and eating" (p. 50). In each household, the head of the household and one other adult, in most cases the wife, were interviewed. Respondents were also randomly selected from public areas close to bus roosts such as markets, bus terminals and the entrance of the 37 Military Hospital. The questionnaire collected basic information on respondents' socio-demographic characteristics such as gender, age, religion and marital status; value of bats, reasons for contact with bats, places of human–bat contact and knowledge of bats and zoonotic disease risk, as well as their sources of information. If respondents indicated that they had previously been bitten or scratched by a bat, they were asked follow-up questions to ascertain exposure risk and to identify any symptoms of ill-health. The results from the household surveys were analysed using SPSS version 21 (IBM SPSS Statistics for Windows, Version 21.0.; IBM Corp.,

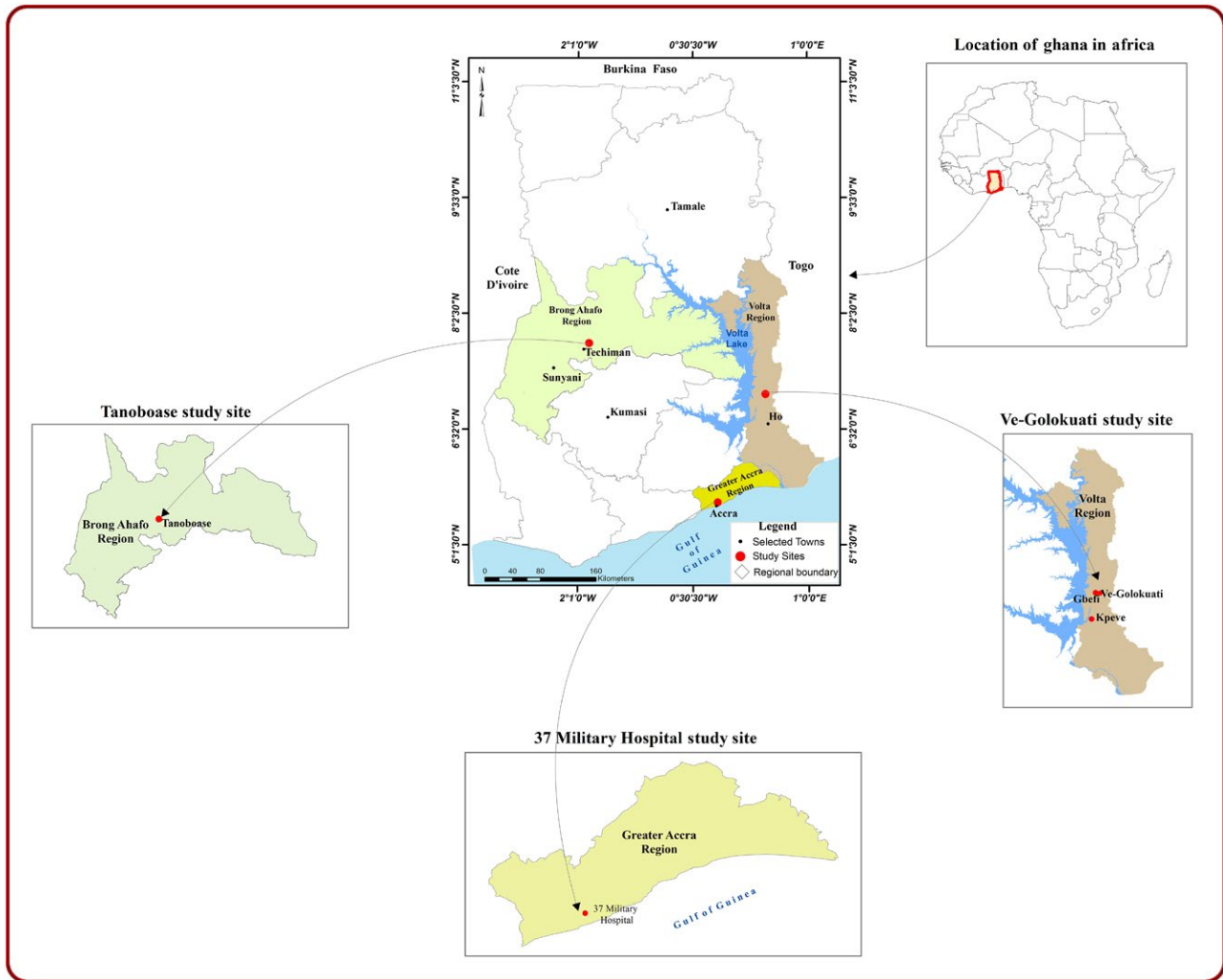


FIGURE 1 Map showing study sites [Colour figure can be viewed at wileyonlinelibrary.com]

Armonk, NY). Chi-square and multiple logistic regression tests were used to test statistical significance and effect that the independent (X) variables have on the probability of obtaining a particular value of the dependent variable.

2.3 | Ethical considerations

Ethical clearance for the study was obtained from the Noguchi Memorial Institute for Medical Research at the University of Ghana. All respondents were informed of the nature of the study and gave consent before proceeding with the interviews.

3 | RESULTS

3.1 | Characteristics of respondents

A total of 788 respondents participated in the study, 46.6% women and 53.4% men. Majority of the respondents (32.5%) had junior high school education, 20% had senior high school, 7.3% had tertiary education and 22% had no formal education. Fifty-eight per cent of

the interviewees were between the ages of 15–45 years. Farming was the predominant occupation (38.1%), followed by petty trading (18.5%). Hunters formed less than 1% of the study population.

3.2 | Reasons for human–bat contact

Bats were valued most as sources of food (67%). Bat consumption was the main reason for human–bat contact. More than 40% of all respondents ate bat meat, majority being men (69.1%). More men used bats for medicinal purposes (Figure 2).

More men were found to interact with bats. Most of the respondents who used bats for food were from Tanoboase followed by 37 Military Hospital study area and Kpeve. This could be linked to the kind of bats found in these areas (*E. helvum*), which were much bigger in size. The main methods for preparing bat meat were roasting (68.9%), boiling (68.3%) and frying (9.8%). In comparison to the previous studies, those who interacted most with bats, the reasons for human–bat interactions and methods for preparing bat meat for consumption had not changed after the Ebola outbreak (Kamins et al., 2015; Lawson et al., 2017).

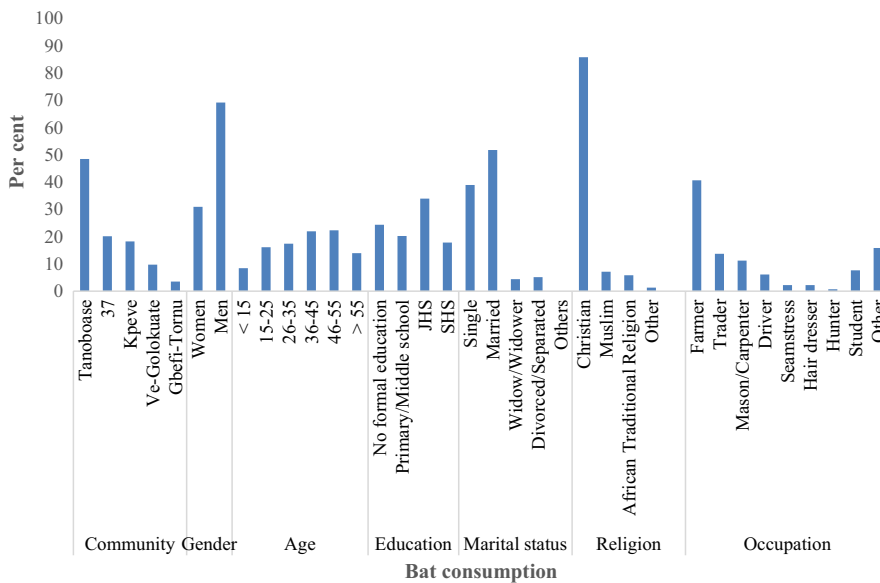


FIGURE 2 Bat consumption among respondents [Colour figure can be viewed at wileyonlinelibrary.com]

More than 60% of the respondents killed bats themselves or obtained them from bat hunters. Bat hunting was more common in the 37 Military Hospital study area and in Tanoboase. Markets and food vendors were also important sources of bat meat (22%). The study prioritized the areas of high human–bat contact, with the aim of identifying possible hotspots for disease transmission. As presented in Table 2, respondents encountered bats at home (42.8%), on their farms (31.8%), and in sacred groves (5.7%). Respondents who had trees with bat roosts close to their homes, especially in the 37 Military Hospital study area and in Ve-Golokuate often had bats flying into their homes. More women (52%) encountered bats in their homes.

A relatively small number of respondents (4.4%) reported being bitten by a bat, and 6.1% had been scratched by a bat, 21.3% had come into direct contact with bat blood. About 0.9% said they experienced some symptoms (mainly flu symptoms) after being bitten or scratched and 1.1% went to the hospital after been bitten or scratched by bats. The general perception was that bat meat was healthy and only 0.8% of respondents reported that they felt unwell after eating it. Herbal medicines and over the counter drugs obtained from pharmacies were cheaper and more accessible, as compared to hospitals. Some respondents mentioned the high cost of consultation fees, distance of clinics and hospitals as well as the time spent seeking treatments in hospitals as barriers.

3.3 | Perceptions and behaviours since the Ebola outbreak

Another objective of the study was to assess changes in respondents' perceptions of bats post-EVD. Although bats likely harboured a variety of pathogens (bacteria, parasites and viruses), only zoonotic viruses have been associated with human diseases (Sánchez & Baker, 2016) and these were therefore the focus this study. Seventy-three

TABLE 2 Places of human–bat contact

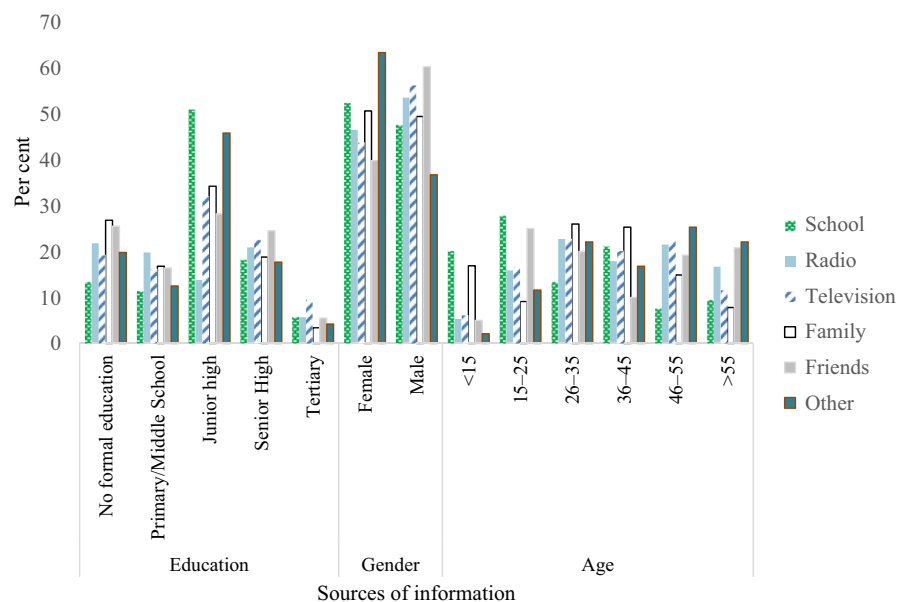
	Frequency	Per cent
Homes	308	42.8
Farms	229	31.8
Schools	28	3.9
Caves	8	1.1
Workplace	106	14.7
Other	41	5.7
Total	720	100

per cent of the respondents believed that bats carry diseases, with EVD being the main disease mentioned. Other diseases mentioned were rabies, malaria, tetanus and typhoid fever. Also, 96.9% of the respondents said they had heard of EVD, which they believed was transmitted mainly through bats, monkeys and “grasscutter” or the greater cane rat (*Thryonomys swinderianus*). Others said, “Ebola could be contracted through physical contact with infected persons” and was also “airborne.”

Forty-six per cent stated that they had not changed the way they interacted with bats over the last two years. Respondents who believed that bats could carry disease pathogens were found to be 2.1 times more likely to come into direct contact with bats, through hunting or bat meat consumption. Respondents who had prior knowledge of bats as possible carriers of disease pathogens were still found to be 3.2 times more likely to eat bat meat. In effect, their knowledge did not influence their behaviour towards bats. The reasons they gave were that there were no reported cases of EVD in Ghana, which meant it was still safe to eat bat meat. Another reason was that cooking bat meat properly “killed” any virus or disease pathogens in bat meat. Increasing knowledge of bats and diseases had not significantly changed the extent of human–bat interactions in communities. A more comprehensive

TABLE 3 Demographic characteristics and perception that bats carry diseases

Variable	Do you think bats carry diseases?				Chi-square	df	Sig.
	Yes		No				
	N	%	N	%			
Level of education							
No formal education	114	21.8	44	24.0	17.292	4	0.002
Primary/Middle school	108	20.7	18	9.8			
JHS	155	29.6	74	40.4			
SHS	102	19.5	39	21.3			
Tertiary	44	8.4	8	4.4			
Age							
<15	36	6.5	9	4.6	15.041	5	0.010
15–25	105	19.0	24	12.3			
26–35	127	22.9	35	17.9			
36–45	93	16.8	47	24.1			
46–55	116	20.9	39	20.0			
>55	77	13.9	41	21.0			
Gender							
Female	243	43.7	105	53.0	5.109	1	0.024
Male	313	56.3	93	47.0			
Religion							
Christian	487	89.4	161	83.0	12.239	3	0.006
Muslim	38	7.0	13	6.7			
African Traditional Religion	17	3.1	17	8.8			
Other	3	0.6	3	1.5			

**FIGURE 3** Sources of information associated with demographic characteristic [Colour figure can be viewed at wileyonlinelibrary.com]

and coordinated approach to optimizing effective responses to a potential bat-borne zoonotic disease spillover is needed. There was a statistically significant relationship between age, gender,

religion and the perception that bats carry diseases (Table 3). Those below 15 and above 55 were least likely to believe that bats carried diseases.

3.4 | Sources of information on bats and diseases

Identifying the sources of information on bats and zoonotic diseases is key in developing effective public health responses (Figure 3). Schools, radio, television, family members and friends are important sources of information with radio (87.9%) being the main source of information. School was an important source of information especially for those in Junior High School and among the women respondents (Figure 4). Television and friends were more popular among men than women. Other sources of information included newspapers and billboards. Eighty-seven per cent of the respondents indicated they were satisfied with the content of the information while 13% showed dissatisfaction. Their reason was that the choice of words was inappropriate and rather than teaching how to avoid contracting EVD it made them unnecessarily afraid of bats. Some also suggested that the information should also be given in the local languages and not only in English.

4 | DISCUSSION

Respondents between the ages of 36–55, men who hunted bats and farmers were more likely to consume bat meat compared to the other groups. These groups can be described as among those most at risk of bat-borne zoonotic disease spillover and needed to be targeted by public health messages. Women who prepared bat meat for consumption or for sale were also at risk. While only 0.8% described themselves as professional hunters, 32.9% of respondents killed the bats themselves and could be at risk as well. Direct exposure to the possibility of disease spillover involved bat hunting, which was common in Tanoboase and the 37 Military Hospital study area. Indirect exposure to disease risks resulted from regular exposure to bats, bat faecal droppings, bat urine and bat saliva through livelihood activities such as farming and fruit collection community meetings under trees on which bats roost (Leach et al., 2017).

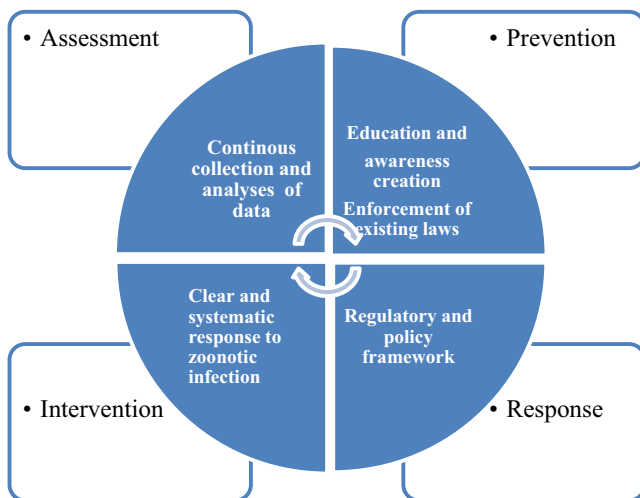


FIGURE 4 Framework for reducing transmission risk of bat-borne zoonoses [Colour figure can be viewed at wileyonlinelibrary.com]

A small number of respondents reported being bitten or scratched by a bat. An even lower number went to the hospital after being bitten or scratched by bats, revealing the poor post-exposure management strategies in place. Herbal medicines and over the counter drugs were seen as cheaper and more accessible, as compared to hospitals. Earlier studies by Kamins et al. (2015), Lawson et al. (2016, 2017) and Ohemeng et al. (2017) show low perception of disease risk especially among rural respondents. In this study, the increase in disease risk awareness could be attributed to the fact that this study was undertaken after the outbreak of EVD in West Africa, with the associated extensive campaigns undertaken by various agencies using different communication tools, on the need to wash hands properly as well as not eating bush meat. However, despite receiving information on the dangers of improper interactions with bats, 46% stated that they had not changed the way they interacted with bats over the last two years.

The way information on bats and diseases was obtained and utilized was influenced by some demographic factors such as age, gender and religion. For example, those below the ages of 15 and above the age of 55 were least likely to believe that bats carried diseases. This could be because those under 15 may lack to relevant knowledge and those above 55 are more likely to have set beliefs and also more likely to lack formal education. Relatedly, although education was inversely related to bat meat consumption, higher education was not linked to an increased perception that bats carried diseases. It is important to understand why people still handle bats despite public health warnings, to inform future communication strategies. The results highlight the complexity of human–bat interactions and show that apart from providing information on avoiding bites and scratches, and bush meat, a more holistic framework is needed to reduce human–bat interactions.

Radios remained key modes of relaying public health education especially in rural communities. Younger respondents obtained public health information from school, highlighting the potential of using school curricular and radio programmes to spread public health information. Existing public health messages regarding the risk of bat contact focus on human protection measures such as education about EVD transmission, advice on avoiding contact with wildlife such as bats and seeking medical advice (Quinn et al., 2014). Most communication messages rely on members of the public actively seeking more information and active media campaigns are often conducted during times of outbreaks and greater exposure risk (Thomas, 2014). They are largely reactive and not proactive and often do not emphasize the routes for spillover.

Stakeholders such as communities, policymakers, health officials, veterinary officers, need reliable and credible information about the bat-borne zoonoses to protect themselves and prevent infections. An effective public health strategy should promote an understanding of zoonotic diseases and correct misconceptions about zoonotic diseases and increase knowledge about bat-borne zoonotic diseases. A traditional public health approach outlines a process that provides the framework necessary to create a comprehensive and

coordinated approach to optimizing an effective response to a potential bat-borne zoonotic disease spillover. It involves assessing the status quo by gathering relevant data about zoonoses such as the social, cultural, spatial and temporal exposure risks, the epidemiology of henipavirus disease, ecology of bats as well as perceptions and values of bats. This information will be used to drive activities to prevent infection (Figure 4). Such preventive activities include education and outreach programmes using various communication tools. Responses should not target outbreaks but should rather target potential risk. This way the strategies will be proactive. It includes enforcement of existing laws and policies on wild-life conservation, policies on post-exposure management (PEM), including both wound management and receiving post-exposure prophylaxis, early detection using, both passive and active surveillance to detect disease (Levings, 2012). A clear and systematic response to zoonotic infection also includes a well-planned and coordinated support for victims.

5 | CONCLUSION

The results of the study have implications on the wider discussions on the Ghana's preparedness to deal with a possible zoonotic disease epidemic. Bats have many useful roles, and spillover of bat-borne viruses can occur when people encroach on bat habitats by undertaking livelihood activities such as hunting, trading and farming close to bat roosts and bat feeding sites. Consuming poorly prepared bat meat also put people at risk. This study was undertaken in five communities, post-EVD outbreak in West Africa, presenting varied settings of human–bat interactions. The settings included an urban setting with residential areas and high human traffic as result of a hospital and transit systems, and four rural communities. The results have shown the need for a more comprehensive strategy to reduce the risk of bat-borne diseases transmission, possibly linked to a broader national preparedness plan for emergency response for sustainability. Such a strategy should be long-term, inclusive and proactive and not reactive, hurriedly rolled out during outbreaks. Early warning systems assist countries with disease situations and prevent unintentional or intentional spread of the diseases to other countries. Preparedness also includes situational awareness (Levings, 2012). In the response to a significant zoonotic disease event, specific people, authorities, institutions, networks, systems and tools would be mobilized and applied according to existing plans, policies and procedures previously described. In addition, institutions such as schools, communities, households, especially those close to bat roosting and feeding sites need to be prepared on how to deal with emergencies when they occur. Finally, the study recommends a more detailed targeted investigation into the intersection of bat-borne zoonoses, socially differentiated risk to bat-borne zoonoses and well-being, to understand why people would consume bush meat, including bat meat, despite having received information discouraging consumption.

CONFLICT OF INTEREST

None.

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