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Understanding framings and perceptions of spillover

Preventing future outbreaks of bat-borne zoonoses

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Abstract

Purpose – Bats provide many ecosystem services and have intrinsic value. They also act as host reservoirs for some viruses. Several studies have linked zoonotic diseases to bats, raising questions about the risks bats pose, especially to people living close to bat roosts. Through a series of case studies undertaken in three communities, the purpose of this paper is to explore the various ways in which framings and perceptions of bats can influence a potential spillover of bat-borne viruses to humans in Ghana. It assesses the social, cultural and economic factors that drive human-bat interactions and posits that understanding the socio-economic contexts in which human-bat interactions occur is key to the success of future communication strategies.

Design/methodology/approach – Primary data collection methods included participatory landscape mappings, transect walks, focus group discussions and questionnaire surveys.

Findings – Perceptions of bats vary and are influenced by personal beliefs, the perceived economic benefits derived from bats and the location of bat roosts. Activities that put people at risk include bat hunting, butchering and consumption of poorly prepared bat meat. Those who live and work close to bat roosts, and bat hunters, for example, are more at risk of bat-borne zoonotic disease spillover. Disease risk perceptions were generally low, with high levels of uncertainty, indicating the need for clearer information about personal protective practices.

Originality/value – The results of the study may well inform future risk communication strategies as well as help in developing effective responses to zoonotic disease risk, disease outbreaks and the conservation of bats in communities.

Keywords Risk, Community, Communication, Perception, Health, Framing, Participatory research

Paper type Research paper

1. Introduction

The interactions between humans and animals date back many centuries. Several studies have assessed the factors that influence human-animal interactions, with particular reference to human-wildlife interactions. Morzillo *et al.* (2014) enumerated contexts of human-wildlife interactions including recreation, hunting, subsistence, transportation, land use and passive-appreciation activities. These interactions fall on a continuum from positive to negative, thus requiring a constant need for assessment to manage potential

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human-wildlife conflict as well as possibilities of risk – such as those associated with zoonotic disease spillovers. Spillover infection occurs when a reservoir population with a high pathogen prevalence comes into contact with 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).

There is a diversity of viewpoints on how humans and wildlife should interact, which can lead to conflict. For example, wildlife has always been an important source of income and bushmeat (Ntiamoa-Baidu, 1987; Elliott *et al.*, 2002; Fa *et al.*, 2003; Milner-Gulland *et al.* 2003). Wildlife products are often major items of consumption and have high medicinal and spiritual values (Scoones *et al.*, 1992; Ntiamoa-Baidu, 1998; Elliott *et al.*, 2002). However, most emerging and re-emerging infectious human diseases are zoonotic, with a substantial number originating from wildlife (Luis *et al.*, 2013). According to Simons *et al.* (2014, p. 2085), the re-emergence of factors that affect the degree and rate of contact between animals and humans are "important for spillover of any zoonotic emerging infectious disease". Drivers include human activities such as tourism, agriculture, deforestation and livestock farming. For example, the spread of Nipah virus to pigs (and thence to humans) in 1998 in Malaysia is associated with the movement of fruit bats from their forest environment to cultivated orchards and pig farms (Chua *et al.*, 2002; Looi and Chua, 2007).

In some urban and rural areas in Ghana, two bat species, the Gambian epauletted fruit bat (*Epomophorus gambianus*) and the straw-coloured fruit bat (*Eidolon helvum*), live close to humans (Ayensu, 1974). They play vital roles in the provisioning of ecosystems services such as seed dispersal, pollination, improving soil fertility and nutrient distribution (Calisher *et al.* 2006; Muscarella and Fleming, 2007; Boyles *et al.*, 2011). They are also known bio-indicators due to their sensitivity to climate change, environmental degradation and contamination of agrochemicals accumulation (Hutson *et al.*, 2001; Jones *et al.*, 2009). According to Calisher *et al.* (2006) and Newman *et al.* (2011), more than 60 viruses have been detected in bat tissue, and bats are reservoir hosts for highly pathogenic Nipah, Hendra, Lyssa and Ebola viruses (Leroy *et al.*, 2009; Paterson *et al.*, 2014; Pigott *et al.*, 2014). They are the natural reservoir hosts for henipa – encephalitic diseases with human-to-human transmission and death rates of about 75 per cent (Olival and Hayman, 2014; Plowright *et al.*, 2014). Past research has documented evidence of devastating spillover events of both lyssaviruses (Allworth *et al.*, 1996; Wright *et al.*, 2010) and filoviruses (Leroy *et al.*, 2009; Hayman *et al.*, 2010) from bats to people in some parts of Africa (Olival and Hayman 2014). The outbreak of Ebola virus disease in West Africa in 2013 has been traced to bats (Leroy *et al.*, 2009; Pigott *et al.*, 2014).

The closeness of interactions between humans and bats has resulted in an increased risk of disease spillover to humans. Henipavirus spillover from bats could occur through exposure to bat blood, saliva, faeces or urine (Kagan *et al.*, 2002; Siegel *et al.*, 2007). Indirect transmission occurs when individuals come into contact with contaminated water, food or soil (Shakespeare, 2002). Hunting and processing of bats for consumption potentially exposes humans to zoonotic pathogens from bats through bites, scratches, bodily fluids, aerosolization of salvia, faeces and urine (Wolfe *et al.*, 2005; Leroy *et al.*, 2005). In addition, social and cultural dimensions in Ghana influence the ways bats are constructed and framed as well as the degree of human-bat interactions (Hashmiu, 2005; Mickleburgh *et al.*, 2009; Wilkie *et al.*, 2005; Wilkie, 2006). The lack of diagnosed human cases, surveillance and monitoring are also key challenges for risk communication. This, coupled with the increasing movement of people and goods as a result of urbanisation and globalisation, has led to a rise in the emergence and re-emergence of diseases, including zoonoses (Jebara, 2004; Smith, 2006).

Emerging and re-emerging zoonotic diseases have been identified as major public health concerns with both bioterrorism and pandemic potential, and as requiring co-ordinated multi-agency responses which combine information sharing with risk communication (Jackson *et al.*, 2006; Kshirsagar *et al.*, 2013). Efforts to control and eradicate infectious diseases have proven remarkably difficult (Paterson *et al.*, 2014). A globally concerted effort, facilitated by the Global Rinderpest Eradication Programme and implemented through a highly effective international coordination mechanism, was required to eradicate Rinderpest. Although Rinderpest is not contracted by humans, this zoonotic disease has "had a profound influence on public heath", revealing a trajectory of economic loss, growing poverty, undernourishment and, as a consequence, infectious diseases (Morens *et al.*, 2011, p. 503). Disasters such as recent outbreaks of Ebola virus disease, Middle East respiratory syndrome coronavirus, avian influenza and severe acute respiratory syndrome demonstrate the ongoing public health limitations in "preparedness, surveillance, response capacity and other critical capacities" (WHO, 2016, p. 80). The Sendai Framework for Disaster Risk Reduction 2015-2030 provides the impetus for global action in relation to disaster risk and emergency response. Furthermore, the SRGRR offers the impetus for strengthening health systems and emergency management, calling for the implementation of integrated and inclusive measures at both national and local levels (UNISDR, 2015). The public health dimensions of zoonotic disease have, to date, been informed by large-scale disease surveillance and monitoring with little exploration of the local and contextual factors that both influence risk and shape responses (Grace *et al.*, 2013).

Ghana's medium-term development strategy, the Ghana Shared Growth and Development Agenda, makes disaster risk reduction one of the pillars of its national development strategy. It explains how disaster risk reduction should be carried out to attain socio-economic resilience through the National Disaster Management Organisation (NADMO). However, disease risk has not been emphasised despite ongoing fears of a possible future zoonotic disease spillover in the sub-region. This paper thus breaks new ground, making an original contribution to the disaster management and public health literature by showing how local experiences and contexts shape risk exposure and thus inform risk communication. It explores how, in Ghana, bat framings and perceptions, and bat-human interactions, can influence spillover of bat-borne viruses to humans. Finally, the paper posits that understanding the socio-cultural and economic contexts in which human-bat interactions occur is key to the success of future communication strategies.

The sociological concept of "framings" offers a means to explore people's diverse understandings and interpretations of a phenomenon. Framings are informed by cultural beliefs and norms, daily experiences, social and economic processes as well as by the exposure to scientific, research, policy processes and political agendas, yet are seldom explicitly articulated (Leach *et al.*, 2005). It is particularly useful when seeking to comprehend exposure to risk, as it examines how individuals understand both exposure and risk.

2. Methods

2.1 Study communities

The targets for the study were populations living close to large bat roosts (based on bat population density) in Ghana (Robson, 2002). Three communities, the 37 Military Hospital study area, Tanoboase and Ve-Golokuate, were selected based on the level of human-bat interactions, their role in the bat bushmeat trade as well as number of bats roosts (Figure 1).

The 37 Military Hospital study area is located in the Greater Accra Metropolitan Area. Bat roosts can be found on most of the trees in the hospital, the nearby residential areas (soldiers' barracks, nurses' and doctors' quarters), as well as in the nearby Parks and Gardens Department. Tanoboase, a rural site, is located near Techiman in the Brong-Ahafo Region of Ghana. Most of the bats are in the Tanoboase Sacred Grove. The sacred grove comprises 130 hectares of semi-deciduous forest vegetation established as a conservation

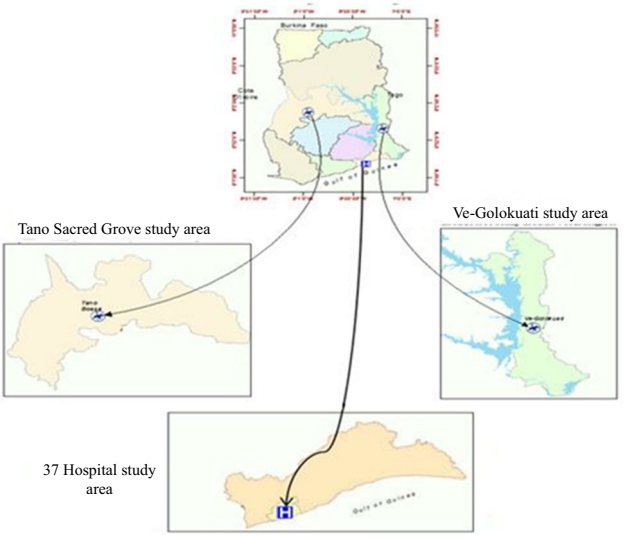

Figure 1.
Study communities

area by the village of Tanoboase, in which activities such as hunting, farming and logging are prohibited. Ve-Golokuati, the second rural site, is located in the Volta Region of Ghana. In Ve-Golokuati, the bats roost on large fruit trees in and around the town; in homes, schools, the community clinic and the chief's palace.

2.2 Data collection

Data collection took place from November 2012 to January 2014, with the aim of understanding perceptions around bats and disease risks. Primary data collection used a combination of methods. The household survey allowed for a quantitative analysis of differential perceptions and responses across the three communities. This was complemented by in-depth qualitative focus group discussions and interviews. Spatial and temporal analysis was undertaken through transect walks, social mapping and seasonal calendar techniques. Participatory modelling helped to test, compare or critique existing views of bats and disease risk. This method proved helpful because it incorporated the knowledge and opinions of the local people. Opinion leaders, those who had in-depth knowledge of the origin of bats in the communities and those whose livelihoods brought them close to bats, or lived and worked close to bat roosts were purposively selected. During the participatory modelling, participants mapped the physical layout of the communities on large sheets of paper with marker pens, indicating settlement sites, landscape features and land use activities. The mapping exercise helped to locate all the major landmarks of the community, together with the roosting and feeding sites of bats. The maps were then photographed.

Separate focus group discussions were conducted for men and women (Table I). Participants from the target occupations, hunters, farmers, traders, health workers and those who lived and worked close to bat roosts shared information on human-bat interactions, perceptions of bats, consumption of bat meat and seasonal abundance.

The snowball sampling technique was used to locate members of the various target groups, differentiated by gender, age, poverty/wealth, residential status and occupation. In all, 340 respondents who interacted with bats in varying ways were involved in the survey. The questionnaire collected basic data on respondents' socio-demographic

characteristics such as gender, age and marital status; explored the general living conditions of respondents (including home ownership, employment and income) and examined the various livelihood activities and how these may have brought people into contact with bats. This paper focuses on the section of the questionnaire that assessed respondents' interaction with bats and how this put them at risk of disease spillover (Lawson *et al.*, 2016).

The focus group discussions as well as the notes from the participatory mapping and the transect walks were analysed qualitatively using thematic analysis (Braun and Clarke, 2006). The results from the household surveys were analysed using SPSS version 20. χ^2 tests were used to test statistical significance.

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 Background of respondents

Table II presents some background characteristics of respondents. The total number of respondents involved in the questionnaire survey was 340, made up of 164 women and 176 men, most of whom were over 45 years (Table II). Tanoboase had the highest number of respondents with no education whilst the 37 Military Hospital study area had the highest number of respondents with secondary and post-secondary education.

Table I. Participants for the focus group discussions

Community	Female	Male
37 Military Hospital study area	6	14
Tanoboase	98	38
Ve-Golokuati	15	21
Total	119	73

Table II. Age, gender and educational levels of respondents

	n	%
Age (years)		
15-25	31	9.1
26-35	85	25.0
36-45	77	22.6
> 45	147	43.2
Gender		
Female	164	48.2
Male	174	51.8
Education		
No education	54	15.9
Primary	34	10.0
Junior high school	69	20.3
Senior high school	48	14.1
Post-secondary	42	12.4
Tertiary	31	9.1
Middle school	62	18.4

3.2 Bat framings, perceptions and spillover

In all three research sites, respondents' framings of bats influenced human-bat interactions. Generally, framings focused on the history of bats in the communities, perceived benefits (especially economic benefits) obtained from the bats, the location of bat roosts and religious and cultural beliefs.

3.2.1 History of bats in communities. In Tanoboase, cultural framings and representations associated bats with the Tano Sacred Grove. The belief was that the bats had been sent by their gods, were sacred and needed protection. The chief thus enforced strict no-hunting policies. At the 37 Military Hospital study area, there were also stories about the origin of the bats. One was that the bats had followed a sick chief from Kyebi who had died at the hospital in the 1960s. Since he was buried at night when the bats were out feeding, they had remained at the hospital grounds to date, waiting to accompany the chief back to his palace. Respondents were unsure of the origin of these stories. The bats in Ve-Golokuati had moved to the area about 15-20 years ago, likely in response to increasing hunting pressures, bush fires, agricultural conversion and disturbances in other areas.

3.2.2 Perceived benefits of bats. Respondents' perceived benefits obtained from bats can be found in Table III. Bats were most valued as sources of meat, food and income and these fuelled hunting activities. A few respondents at the Parks and Gardens believed that bats were important in the dispersal of fruit (especially mango) and other rare seeds. Cashew seed dispersal was also mentioned in Tanoboase as an important ecosystem function performed by bats (Table III). In Tanoboase, bats were also seen as a tool for developing tourism potential. Similarly, some community leaders in Ve-Golokuati believed that bat conservation would attract researchers, tourists and development activities to the area.

3.2.3 The location of bat roosts in communities. Generally, respondents' perceptions of bats improved with distance from bats roosts. Perceptions were generally negative among fruit farmers in Tanoboase, especially cashew farmers, as well as those who lived close to bat roosts. They lost income when bats fed on the fruits, especially cashew, sometimes leaving half-eaten fruits still hanging on the trees. The perception of bats in the military barracks and the 37 Military Hospital as well as in the nurses' quarters was also negative. Respondents complained that the bats:

- defecated and urinated on their clothes, walls, cars and other properties;
- were noisy;
- had a foul smell, especially after it rained;
- were hideous-looking; and
- left half-eaten fruits lying about.

Benefits	Frequency
Meat and food	71
Source of income	53
Tourism and development	32
Bat dropping as manure	15
Pollination and seed dispersal	8
Health	6
Other ecosystem functions	3
Research	2
Protection of sacred grove	1
Use of bat wings used for drums	1
Play toys for children	1

Table III. Respondents' perceptions of the benefits from bats

In the Parks and Gardens Department, attitudes towards the bats were generally positive among the male respondents. This was directly linked to the fact that they benefitted economically from bat hunting. In contrast, the women who worked at the Parks and Gardens Department were generally indifferent to the presence of the bats.

Generally, most people in Ve-Golokuati were indifferent to the bats' presence. Those who expressed reservations were mostly people living near to bats roosts. The reasons cited for negative perceptions towards bats were similar to those mentioned at the 37 Military Hospital. In addition, the bats made a lot of noise, especially at dawn when they returned from their feeding sites, and bat faeces contaminated and stained harvested rainwater.

3.2.4 Religious, cultural and personal beliefs. Ethnicity did not appear to affect the consumption of bats at the 37 Military Hospital study area as those who ate bat meat came from different parts of the country. However, religion played an important role. Some respondents belonged to religions that forbade them to eat certain kinds of meat. Others did not eat bat because of cultural beliefs. Religious and cultural beliefs were dominant in Tanoboase. For example, an elder, related to the chief of Tanoboase, did not eat bat because it was a taboo, particularly for those from the royal household. Another Tanoboase respondent explained that:

> Bats are very strong creatures and not easy to kill. They die slowly and painfully. Because of this it is believed that those who eat bat meat experience slow and painful deaths.

Still others did not eat bat meat for personal reasons, especially because they believed that bats "urinated and defecated on themselves making them smell". Those who ate bat meat said it was "lean meat, very delicious and made a person strong and healthy".

3.3 Behaviours and activities that put people most at risk of bat-borne zoonotic diseases

The highest risk of disease transmission, as identified by researchers (Calisher *et al.*, 2006; Newman *et al.*, 2011; Kuzmin *et al.*, 2011), involves a range of direct and indirect exposures to bat urine, blood and faeces (including through intermediary domestic animals and through consumption of contaminated foods). With a lack of statistics on morbidity and mortality, the factors that put people at the greatest risk were determined by assessing the various activities that brought respondents into contact with bat saliva, blood, urine and faeces. Inquiries regarding knowledge of disease transmission/spillover mechanisms during the focus group discussions showed that there was little knowledge of disease risk among respondents. Survey respondents associated risk primarily with bat hunting and consuming poorly prepared bat meat (Table IV). This confirmed comments made by some focus group participants who did not associate risk with the cooking and smoking of bat meat since "the bat was dead" (Box 1). In Tanoboase the bats were often smoked in the bush before being brought to the market. Hence the sale of fresh bat meat was not common. Also in the 37 Military Hospital study area, there was

Table IV. Respondents' perception of degree of risk associated with bat-related activities

	Threat posed							
	No threat		Small threat		Significant threat		Serious threat	
Activity	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Butchering/preparing bat meat for consumption	63	18.5	20	5.9	30	8.8	29	8.5
Eating poorly prepared meat	63	18.5	18	5.3	14	4.1	41	12.1
Hunting	59	17.3	23	6.7	20	5.9	51	15.0
Cooking	73	21.4	18	5.3	13	3.8	9	2.6

Box 1. Some reasons for engaging or not engaging in risky bat-related activities mentioned during the focus group discussions

Butchering/preparing

- The blood can get on your hands.
- The blood can mix with your blood and that is dangerous.
- Now there is Ebola you have to be careful.
- You can get infected with diseases.

Eating

- Eating is not a problem if the meat is well cooked.
- Bats are dirty I do not see how anyone can eat them.
- I do not eat bat meat often so it is no problem.
- When you eat the meat, it enters your stomach and then it is digested so you cannot get sick.
- Bats can cause stomach ache.

Hunting

- Bats have very sharp teeth, their saliva can get on you and make you sick.
- If you have a gun, no problem.
- They are dead so they cannot harm you.
- Shooting is dangerous.
- Ebola is spreading.
- You can be arrested.

Cooking

- Ebola does not go away even if you cook the meat.
- If the meat is not well cooked, it can be risky.
- It must be cooked well for the meat to be safe.

very little perception of risk associated with eating bat meat. As one "chop bar" (local restaurant) operator said:

> If you cook the bat meat well you do not have a problem […] the way we cook our soups, the soup stays on the fire for hours so all the things that can give diseases will die.

Since the outbreak of the Ebola virus disease in 2014, the consumption of bat meat has raised particular concern, as bats host more zoonotic viruses per species than other taxa, including rodents (Luis *et al.*, 2013).

3.4 Identifying groups at risk

According to Simons *et al.* (2014), the re-emergence of factors that affects the degree and rate of contact between animals and humans also affects the possibility of zoonotic disease spillover. Four categories of people who have high potential exposure to the henipavirus disease emerged from the interviews and focus group discussions. Their exposure is linked to where they live and work, and to the nature of their interactions with bats. Within each category, there are other demographic factors such as age and gender that influence the degree of exposure. The four categories, each of which is discussed in more detail below, are:

(1) fruit farmers (especially cashew farmers);

(2) hunters;

(3) traders; and

(4) those who live or work close to bat roosts (such as residents living with bats in Ve-Golokuati and health professionals and hospital maintenance staff working at the 37 Military Hospital and the workers at the Department of Parks and Gardens).

Fruit farmers: majority of the respondents in Tanoboase were farmers and a higher proportion of the farmers, as compared to those from other occupations, ate bat meat (Table V). However, the relationship was not statistically significant. Similarly, more farmers hunted bats and handled fresh bat meat.

The participatory maps showed that most of the farms in Tanoboase are within walking distance of the farmers' homes. Tanoboase village has a central space or "community centre" that serves as a meeting place. Villagers' homes were generally far away from the sacred grove where the bat colony resides. Respondents rarely saw the bats on their farms during the day but found evidence of bats' night-time feeding each morning when they arrived at their farms. Whilst half-eaten mango, cashew and pawpaw were generally disposed of or fed to livestock, it was not uncommon for farmers to handle such fruits with their bare hands. Since the half-eaten fruits often had bat saliva on them, this potentially puts handlers at risk of zoonotic diseases either through direct transmission or through spillover from the bats to livestock and then to humans. When farmers did see bats on their farms, 45 per cent said they did nothing whilst 38 per cent said they tried to kill them (Figure 2). Killing bats, especially with stones and sticks, could also expose farmers to zoonotic disease risk through scratches or bites from the bats or through exposure to bat blood, urine and faeces.

Hunters: hunters, as suggested above, are also exposed to disease risk. Hunting of bats was not officially permitted at the 37 Military Hospital, where the bats were protected by the military. People hunted in the grounds of the Department of Parks and Gardens which is a few metres from the hospital. Bat hunting with catapults potentially exposed hunters to greatest risk because the bats were not killed outright. Injured bats would fall to the ground and could sometimes still fly a few metres. Most respondents were opportunistic hunters who hunted bats to supplement their income. Bat hunting was higher in Tanoboase (Figure 3). This could be attributed to the type of bat species found here (*E. helvum*), which were bigger than *E. gambianus* found in Ve-Golokuati. In Ve-Golokuati, personal consumption was the main reason for hunting as explained by one respondent:

> I know it sells for GHC 2.00 in the market but I don't sell any bat meat. I just shoot a few down with a catapult when I feel like eating bat meat.

Table V. Livelihood activities and bat consumption of respondents

Livelihood activities	Do you eat bats (frequency) Not applicable	Yes	No	Total
Not applicable	0	1	1	2
Farming	6	43	41	90
Trading	5	19	36	60
Food vendor	1	2	6	9
Dress maker	0	2	10	12
Hair dresser	0	0	1	1
Food	0	2	3	5
Artisanal	2	11	24	37
Construction	1	1	2	4
Unemployed	1	8	10	19
Teaching	2	3	1	6
Military service/health care	0	12	23	35
Gardening	1	3	12	16
Total	19	107	170	296

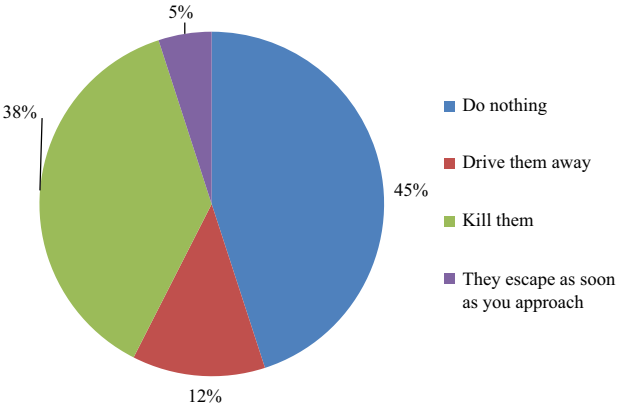

Figure 2.
Actions taken by farmers in Tanoboase when the saw bats feeding on their farm

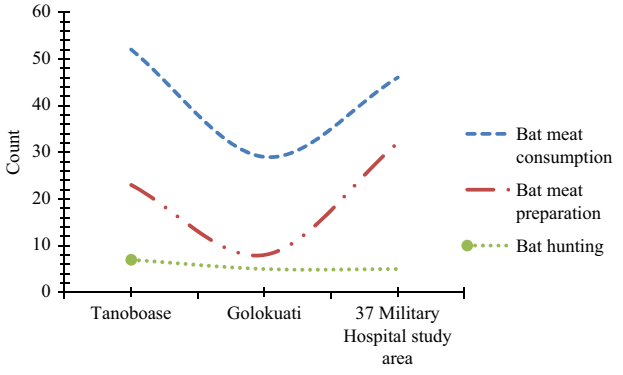

Figure 3.
Bat hunting, bat meat consumption and preparation by respondents

All forms of hunting potentially expose people to bat-borne zoonotic diseases, through collecting dying bats, through being bitten or scratched and through exposure to the bats' bodily fluids.

Traders: trading, an important economic activity in all three communities, could also be a potential form of exposure to bat-borne zoonotic diseases. First of all, in Ve-Golokuati and at the 37 Military Hospital, some trading took place under or close to trees supporting bat roosts. Items sold, including cooked food and vegetables, could be contaminated easily by bat urine and faeces. Second, some of the hunters were involved in the bat meat trade. Purchasers were not restricted by income, education or residence. During the focus group discussions, one participant at the 37 Military Hospital study area said:

> Some of those who come to buy the bat meat are "big men". They come in their big cars and place their orders. I roast them and pack them nicely and they pick them up when I call them.

Those who live or work close to bat roosts: the fourth category of people potentially exposed to risk is workers, health professionals, residents who live and work near bats and bat roosts. At the Military 37 Hospital, it is those who live in and around the military barracks, nurses and doctors' quarters. Ve-Golokuati had the highest number of respondents saying that they had seen bats around their water sources which included streams. Some of them had installed rainwater harvesting units on their roofs, which directed the rainwater from the roofs to large earthenware pots or containers. This could be why rainwater was an important source of water to some respondents (Table VI). These residents face a peculiar risk as the harvested rainwater, which they used for domestic purposes, was sometimes contaminated with bat faeces.

4. Discussion

The interactions between humans and bats have social, economic, environmental as well as health implications. People's framings and perceptions of bats influence human-bat interactions and potential spillover of bat-borne viruses to humans. Identifying the behaviours and activities that put people most at risk of bat-borne zoonotic diseases as well as the social groups that are at risk is important in designing effective strategies to deal with potential risks.

Factors that influenced participants' bat framings included recognition of the benefits from bats (especially economic benefits), the location of bat roosts in communities and individual belief systems. The evidence suggests that some people are more likely to be exposed than others. Those who live and work close to bat roosts, harvest rainwater from their roofs, hunt, butcher, and eat poorly cooked bat meat experience the greatest number of exposures to the risk of zoonotic infection. Fruit and cashew farmers in bat-feeding sites in rural communities and workers at the 37 Military Hospital are also at risk. Further research on human surveillance could usefully focus on these categories of people.

Disease prevention measures, which acknowledge socio-cultural beliefs and economic significance, could directly target the practices of bat hunting, farming and fruit cultivation, the location of trading sites and other points of exposure. The Sendai Framework for Disaster Risk (2015-2030) calls for inclusive forms of engagement and partnership. The Framework also encourages the use of traditional, indigenous and local knowledge and practices, as appropriate, to complement scientific knowledge in disaster risk assessment and the development and implementation of policies, strategies, plans and programmes. In line with this, this paper advocates for increased education on the possibilities of bat-borne disease spillover, especially targeting communities with high human-bat interactions, whilst paying attention to the complexity of how different categories of people interact with bats and with sensitivity to the economic and cultural values of bats. More education is thus needed, both to highlight risk and to emphasise the intrinsic values and ecosystem benefits of bats (Lawson *et al.*, 2016). Communication strategies should include information on behaviour, perceptions and values of bats, the epidemiology of bat-borne viruses, ecology of bats and the viruses, as well as the social, cultural, spatial and temporal exposure to risks.

Disease risk perceptions were generally low, with high levels of uncertainty, indicating need for clearer information about personal protective practices. Messages must convey the need to avoid unsafe contact with bats' bodily fluids, through new methods of handling live and dead bats. Dissemination will require participatory methods of knowledge sharing such as images, stories, songs and plays. Using local languages will help disseminate the message. The strategy must be dynamic and flexible to allow for effective monitoring and revisions when necessary. Support at various scales, from national to community levels, is important for buy-in and also to facilitate the implementation of rapid outbreak response, if and when necessary (Figure 4).

Table VI. Respondents' sources of drinking water

	Tap/ pipes	Boreholes	Streams	Harvested rainwater	Sachet water	Other
Tanoboase	74	20	9	0	0	0
Ve-Golokuati	56	2	38	12	3	0
37 Military Hospital study area	91	3	0	0	18	2

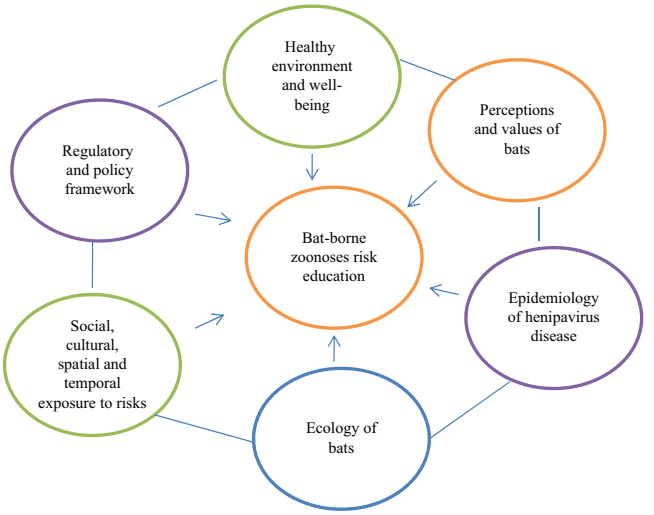

Figure 4.
Bat-borne zoonoses risk education in Ghana

5. Conclusion

According to the Sendai Framework, disaster risk reduction and management depends on coordination mechanisms within and across sectors and with relevant stakeholders at all levels, and it requires the full engagement of all state institutions at national and local levels and a clear articulation of responsibilities (UNISDR, 2015). This research has shown many different ways in which people are potentially at risk of zoonotic disease spillover from bats, including through the way they store drinking water, what they do with damaged fruit, how vendors protect their food as well as through direct hunting and consumption. The results of this study suggest that interventions need to be carefully targeted to specific categories of people, and be integrated into broader development programmes that aim to improve rural people's livelihoods (or if necessary offer alternative, less bat-dependent livelihoods), access to basic infrastructure and amenities such as potable water and education and also reduce poverty (LeBreton *et al.*, 2006; Kamins *et al.*, 2015; Lawson *et al.*, 2012).

Bat-borne zoonotic diseases present a potential challenge to the health and well-being of many communities in Ghana. Learning from successful control and eradication of diseases, the first line of defence will be the deployment of state-of-the-art approaches to diagnosis and surveillance to provide a network of global intelligence on their spread and an assessment of risk presented (Tomley and Shirley, 2009). Strengthening disaster risk governance by enhancing cooperation between disaster risk management institutions and health authorities, through establishment and strengthening of national disaster risk reduction platforms, with the involvement of the health sector is clearly critical (WHO, 2016; UNISDR, 2015). In keeping with the Sendai Framework for Disaster Risk, public health and zoonoses should be mainstreamed into Ghana's disaster risk reduction plans and integrated into NADMO's activities. Attention must also be paid to the specific behaviours and activities that put certain people and social categories at greater risk than others and risk communication has to focus on a range of bat-human interactions, rather than emphasising a one-size-fits-all message.

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