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Social Determinants of a Potential Spillover of Bat-Borne Viruses to Humans in Ghana

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Abstract

Bats are well-recognized reservoirs of a number of zoonotic viruses including henipavirus. The straw-coloured fruit bat (*Eidolon helvum*) and the Gambian epauletted fruit bat (*Epomophorus gambianus)* can be found in many parts of Ghana, raising concerns about the possibility of a spillover of henipavirus from bats to humans. However the context-specific socio-economic factors that may increase points of contact between bats and humans have still not been adequately identified. Using a number of participatory methods, this in-depth investigation sought to understand the behavioural and socio-economic factors that could facilitate henipavirus spillover to humans in Ghana. Direct exposure included people coming into contact with fresh bat meat through eating, hunting and processing bat meat. Indirect exposure included sitting, selling under bat roosts as well as exposure to water contaminated by bat faeces. Gender was most strongly associated with exposure, compared to age and education. Perceptions of disease risk from bats were generally low among respondents. The study highlights the complexities of sustainably managing a potential henipavirus spillover into humans in Ghana. It recommends the establishment of a multidisciplinary team made up of ecologists, social scientists, legal, veterinary and public health experts to manage such a spillover. The paper also recommends continuous education to encourage behavioural changes in people and to develop sustainable and relevant zoonoses prevention practices especially among identified groups at risk.

Keywords: bats, emerging infectious diseases, henipavirus, natural reservoir, zoonoses

1. Introduction

An estimated 70% of emerging and re-emerging human infections are zoonotic (Jones et al., 2008). Bats are reservoirs of zoonotic viruses (Leroy, 2005; Wang & Eaton, 2007). According to Calisher et al. (2006) more than sixty viruses have been detected in bat tissue. Currently, bats are considered to be natural reservoirs of pathogenic viruses including Filoviruses (Ebola and Marburg viruses), Paramyxoviruses (Hendra and Nipah viruses, and Tioman virus), Lyssaviruses and Coronaviruses (Han et al., 2015; Paterson et al., 2014; Taylor et al., 2001). These viruses have attracted global attention in recent years for their severity and/or easy transmission (Han et al., 2015). Bats are potentially effective transmitters of emerging infectious diseases because they are capable of travelling long distances (Wang & Cowled, 2015). They may also feed on farms and commercial orchards, which often have domestic animals, and which can serve as amplifier hosts (Li et al., 2005; Breed et al., 2006). Wong et al. (2007) explain that the diversity of bat species and their unique biological and ecological features allow them to become hosts for a large number of medically important infectious agents.

The genus *Henipavirus* represents a group of Paramyxoviruses that are some of the deadliest of known human and veterinary pathogens (Croser, 2013). Recent studies have shown that *Eidolon helvum* serves as reservoir hosts for

henipaviruses (Hayman et al., 2008; Chua et al., 2002; Halpin et al., 2000; Marsh et al., 2012). Plowright et al. (2015) describe a series of hierarchical enabling conditions required for the spillover of emerging bat viruses:

- Reservoir hosts must be present
- Reservoir hosts must be infected
- If transmission is indirect, reservoir hosts must be shedding pathogen and virus must survive outside of its reservoir host with access to the recipient host
- Recipient hosts must be exposed to the source of the virus in sufficient quantity for an infection to establish
- Recipient hosts must be susceptible to the virus

As human populations increase so do interactions between bats and humans. The destruction of bat habitats as a result of urbanization, livelihood activities and natural environmental changes have influenced the level and intensity of human-bat interactions (Daszak et al., 2004; Harison et al., 2011; Han et al., 2015). The accelerating rate of emerging infectious disease poses significant and increasing health risks for people and animals worldwide (FAO, 2011; Paige et al., 2015; Daszak et al., 2004; Wilcox & Gubler, 2005). For example in Ghana the mode of virus transmission between fruit bats and spillover to other animals is not yet fully understood but most likely involves exposure to the urine or saliva of an infected bat (Chua et al., 2002; Halpin et al., 2000; Luby & Gurley, 2012; Smith et al., 2014). Improved transportation systems (Bobashev et al., 2008; Von Drehle, 2014) and cultural practices have potential impacts on the transmission of emerging infectious diseases. The Ebola outbreak in West Africa for example showed that behaviours and cultural norms related to preparing the dead for burial as well as funerals facilitates transmission of the virus (Dowell et al., 1999; Ravi & Gauldin, 2014).

There are also a number of behavioural and socio-economic factors that influence the frequency of human-bat interactions in urban and rural communities in Ghana. This paper sets out to identify these factors. It also identifies direct and indirect exposure as well as the behaviours that put people at risk of henipavirus spillover. Knowledge of these issues is vital in determining groups at risk of henipavirus spillover and for sustainably managing a possible zoonotic disease spillover.

2. Methodology

2.1 Study Areas

The research was undertaken in three communities (one urban and two rural) in Ghana (Figure 1). The targets for the study were populations living close to large bat roosts; the 37 Military Hospital, Tanoboase and Ve-Golokuati. The 37 Military Hospital study area is located in the Greater Accra Metropolitan Area (GAMA). The hospital, doctors' and nurses' flats, the soldiers' barracks, major streets, shops and bus stops in the area make the area important in terms of commercial activities and transportation. Bat roosts are found on trees in the hospital grounds, in residential areas and on the grounds of Parks and Gardens department located near the hospital.

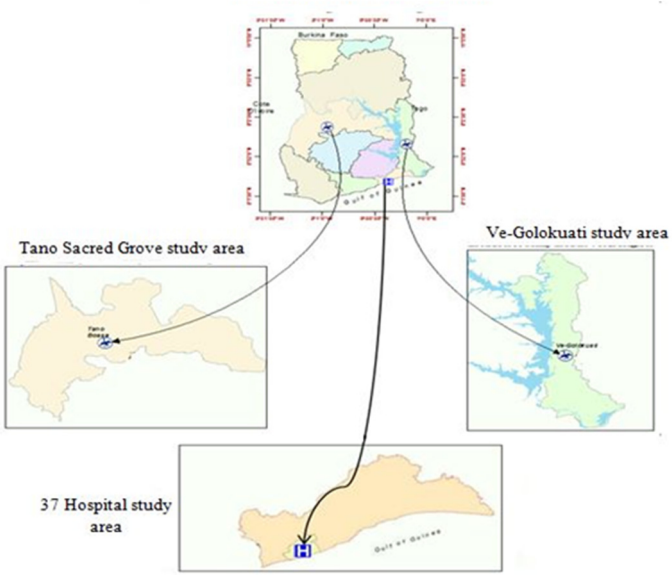

Figure 1. Study communities

Tanoboase, which is a rural site, is located near Techiman in the Brong Ahafo Region of Ghana. Most of the bats are found in the Tanoboase Sacred Grove. The sacred grove is made up of 130 hectares of semi-deciduous forest vegetation established as a conservation area by the community. Ve-Golokuati, the second rural site, is located in the Volta Region of Ghana. It is the district capital of the Afadzato South District (GSS, 2012). Bats were found in trees within the community, in the homes of residents, market place as well as school and church compounds. All three sites supported large bat roosts, the most abundant species being *Eidolon helvum* and *Epomophorus gambianus.*

2.2 Data Collection

The methodology used for the study was developed under the Dynamic Drivers of Disease in Africa Consortium (www.driversofdisease.org). The consortium used environmental, ecological, biological and social science methods to investigate whether spillover dynamics and virus transmission differ and how bat-human interactions differ between urban and rural sites in Ghana due to changes in biodiversity and land use. Primary data were collected by means of a number of qualitative and participatory methods such as focus group discussions, participatory landscape mapping, transect walks and semi-structured interviews.

Participants of the focus group discussions (FGD) were selected using the convenience sampling. Two focus groups (one with women respondents and the other with men respondents) were conducted at Tanoboase and at Ve-Golokuati. At 37 Military Hospital, two focus group discussions were organised at the Parks and Gardens Department, again for women and men, and one at the nurses' quarters which was attended by both women and men (Table 1).

Table 1. Focus group discussants in study areas

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

The focus group discussions sought information on the presence of bat roosting sites, seasonal abundance of bats, human-bat interactions, perceptions of bats, livelihood activities, consumption of bat meat and sources of bat meat. Because bat hunting was illegal in all three communities, participation in the discussions was voluntary. The physical layouts of the communities were mapped on large sheets of paper on the ground by the participants during the participatory landscape mapping. Participants were then asked to indicate settlement sites, local landscape features and types of land use activities on the map. The aim of the mapping exercise was to locate all the major landmarks of the community, together with the roosting and feeding sites of bats. The mapping activities were followed by transect walks through the study communities. During the walks, participants identified the roosting and feeding sites of bats and noted their proximity to community residential areas.

Targets for the semi-structured interviews were those whose livelihood activities brought them close to bats. After reconnaissance visits and discussions with community leaders, semi-structured interviews were held with 340 respondents. Stratified random sampling was used to select individuals – women and men, youth and elders, wealthier and poorer people and those of specialist occupational groups such as hunters and healers. The interview guide comprised of three main sections. The first section collected basic data on respondents' socio-demographic characteristics such as gender, age and marital status. The second section collected detailed information on the general living conditions of respondents; including home ownership, employment and income. The third section examined the various livelihood activities and how these may have brought people into contact with bats. It also assessed the various ways respondents' interacted with bats.

Key informant interviews were also held with heads of departments, doctors, nurses as well as chiefs and opinion leaders within the study communities. The interviews were useful in understanding the history of bats in the communities as well as how bats were framed.

2.3 Data Analysis

The focus group discussions as well as the notes from the participatory mapping and the transect walks were analysed qualitatively using thematic analysis. This involves identifying, analyzing and reporting patterns (themes)

within data (Braun & Clarke, 2006). According to Berg (2004), qualitative techniques allow researchers to share in the understandings and perceptions of others and to explore how people structure and give meaning to their daily lives. The results from the semi-structured interviews were analysed using SPSS version 20.0. Chi sqared tests were used to test significance with significance levels set at 0.05 (that is $p<0.05$).

2.4 Ethical Considerations

Ethical clearance for the study was sought from the Noguchi Memorial Institute for Medical Research of the University of Ghana. All respondents were informed of the nature of the study and gave consent before proceeding with the interviews. Minors were spoken to only after permission was sought from their parents.

3. Results

3.1. Background of Respondents

The total number of respondents involved in the semi-structured interviews was 340, made up of 164 women and 176 men. Some background characteristics of respondents are provided in Table 2.

Table 2. Age, gender and educational levels of respondents

	N	%
Age		
15-25 years	31	9.1
26-35 years	85	25.0
36-45 years	77	22.6
>45 years	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

Table 3. Ownership of household assets

Assets	No. of respondents who owned assets in:		
	Tanoboase (Frequency)	Ve-Golokuati (Frequency)	37 Military Hospital study area (Frequency)
Cars	12	19	43
Motorbike	14	19	13
Refrigerators	18	34	110
Television sets	56	68	125
Mobile phones	85	91	123
Internet	6	12	43
Radio sets	67	76	114
Sewing machines	27	36	52
At least one plot of land	65	54	90

In the absence of direct measurement, researchers often use proxy indicators of income based on household ownership of physical assets (Po et al., 2012). Housing conditions can also be a measure of the quality of life of household members. Hence the study collected information on the ownership of houses as well as some household assets to get an idea of the standard of living in the communities (Table 3). The standard of living was higher in the 37 Military Hospital study area which was also the urban site of the study.

3.2 Direct and Indirect Exposure to Henipavirus Risk

The study identified indirect exposure and direct exposure to henipavirus. Indirect exposure was through livelihood activities that brought people close to bats such as farming, sitting and/or selling under bat roosts (which happens in the 37 Military Hospital study area and Ve-Golokuati), as well as exposure to bat faeces through contaminated water as was reported in Ve-Golokuati.

Direct exposure included coming into contact with fresh bat meat through eating, hunting, and processing fresh bat meat. Bat hunting and consumption was higher in Tanoboase and the 37 Military Hospital study area, probably because the major bat species found at these two sites *E. helvum*, was bigger. This also means that this bat species is more at risk from over hunting (Harrison et al., 2011). Most respondents associated the least risk with cooking bat meat and the most risk with bat hunting (Table 4).

Table 4. Respondents' perception of degree of risk associated with bat-related activities

Activity	Threat posed:							
	No threat		Small threat		Significant threat		Serious threat	
	(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

3.3 Age, Gender, Education and Risk of Henipavirus Spillover

There was no significant relationship between age and consumption of bat meat (Table 5). There was also no statistically significant relationship between age and hunting, and age and the state in which bat meat was obtained.

Table 5. Age of respondent and bat meat consumption

Age of respondent	Consumption of bat meat			
	Not applicable (Frequency)	Yes (Frequency)	No (Frequency)	Total
15-25 years	1	8	21	30
26-35 years	5	32	45	82
36-45 years	6	31	39	76
>45 years	9	56	80	145
Total	21	127	185	333

However there was a positive association between gender and bat meat consumption. Bat meat was eaten by a significantly higher percentage of men than women (Table 6), Chi squared test p-value = 0.019.

Table 6. Gender of respondents and bat consumption

Gender of respondent	Do you eat bats			
	Not applicable (Frequency)	Yes (Frequency)	No (Frequency)	Total
Female	9	49	101	159
Male	12	78	84	174
Total	21	127	185	333

There was also a significant association between gender and bat hunting (Chi squared test p =0.002). Males were more likely to handle fresh bat meat and eat bat meat hence were more at risk. In Tanoboase there were "unspoken rules" that did not permit women to partake in bat hunting. In the 37 Military Hospital area the women at the Parks and Gardens as well as those who lived in the area saw bat hunting as a male activity, probably because of the amount of energy it took to use the catapult to hunt. In addition more males obtained their bat meat fresh (Table 7).

Table 7. Gender of respondents and state in which they obtained bat meat

Gender of respondent	Not applicable (Frequency)	Fresh (Frequency)	Already butchered (Frequency)	Smoked (Frequency)	Other (Frequency)	Total
Female	118	23	5	17	1	164
Male	99	45	1	28	2	175
Total	217	69	6	45	3	340

Generally participation in bat meat hunting, preparation and consumption decreased with an increase in education (Figure 2).

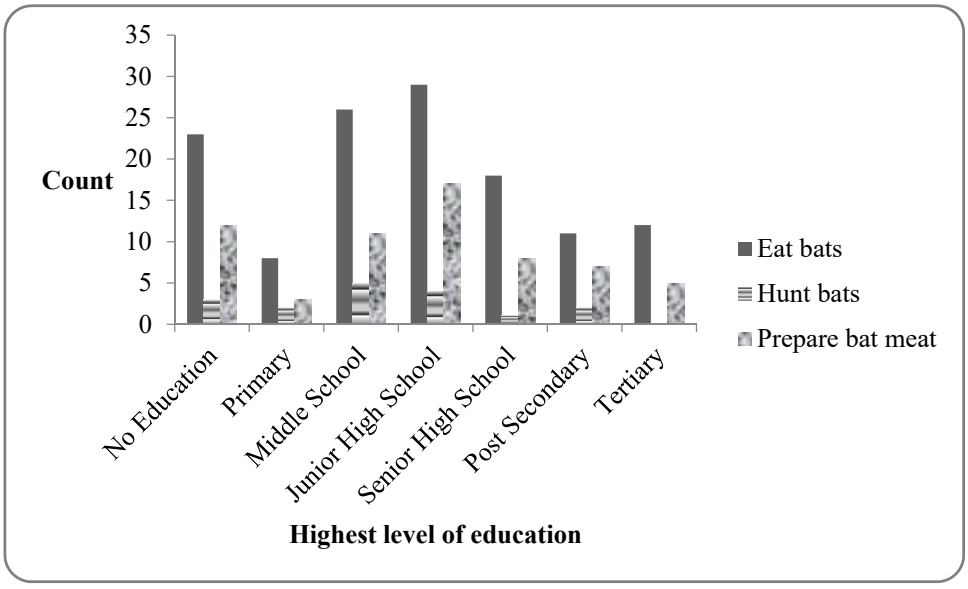

Figure 2. Education and participation in bat-related activities

However during the focus group discussions, some discussants mentioned that the consumption of bat meat was not restricted to people with less education; those perceived as relatively well-to-do and well educated also ate bat meat. Whilst they did not hunt themselves they obtained bat meat through hunters, vendors and local restaurant (*chop bar*) operators.

3.4 Livelihoods and Exposure to Risk

Although seventeen respondents said they hunted bats, none of them listed hunting as a main livelihood activity. A significantly higher proportion of farmers as compared to those with other occupations ate bat meat (Table 8). However the relationship was not statistically significant. Similarly more farmers hunted bats and also handled fresh bat meat.

Table 8. Livelihood activities and bat consumption

	Do you eat bats (Frequency)			
Livelihood activities	Not applicable	Yes	No	Total
Not applicable	0	1	1	2
Farming	6	43	41	90
Trading	5	19	36	60
Food vendoring	1	2	6	9
Dress making	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

3.3 Rural-Urban Dynamics and Exposure to Henipavirus Risk

There was a highly significant relationship between the type of community (rural/urban) and bat consumption (Chi squared test $p< 0.001$) (Table 9). The reasons for eating bat meat include taste and availability (Table 10).

Table 9. Community and bat consumption

	Do you eat bats		
Community	Not applicable (Frequency)	Yes (Frequency)	No (Frequency)
Tanoboase	6	52	43
Golokuati	12	29	67
37 Military Hospital study area	3	46	75
Total	21	127	185

Table 10. Reasons for bat consumption in communities

	Availability (Frequency)	Taste (Frequency)	Health benefits (Frequency)	Others (Frequency)
Tanoboase	17	21	2	3
Golokuati	8	18	0	0
37 Military Hospital study area	3	25	8	0
Total	28	64	10	3

42% of the commercial farmers and 33% of the peasant farmers said they saw bats on their farms. Reactions ranged from doing nothing, to driving the bats away and killing them. Some reported that the bats flew away when they saw the farmer approaching. The relationship between community and bat hunting was also significant.

4. Discussion

The locations of the bats in the various communities varied. In Tanoboase the bats lived in the Tanoboase Sacred Grove during the day and flew out to feed at night. In the 37 Military Hospital study area the bats were found in the military barracks, the nurses' and doctors' quarters, in people's homes as well as on the trees in the 37 Military Hospital and the Department of Parks and Gardens. In Ve-Golokuati the bats lived with the people, with bat roostings found on trees in homes and in the centre of the town. Most of the respondents associated hunting with high risk especially because of the methods used to hunt. Since the area was a high security zone protected by the military, hunters in the 37 Military Hospital study area could only hunt bats with catapults. This hunting method puts more hunters at risk of being bitten or scratched. Sticks and guns were also used to hunt in Tanoboase. Cooking bat meat was seen as the least risky bat related activity. They believed that process of cooking killed "whatever disease" was in the bat meat. The consumption of bat meat, especially poorly prepared bat meat, raises particular concern, as bats seem to host more zoonotic viruses per species than other taxa, including rodents (Luis et al., 2013).

Gender was a determinant of human-bat interactions. There was a significant association between gender and bat hunting (LeBreton et al., 2006; Kamins et al., 2014; Anti et al., 2015). Hunting was carried out mainly by males, putting more males at risk. During questionnaire survey most respondents were afraid to admit they hunted bats because the activity was illegal in all three study areas. Only nine of the respondents in Tanoboase, six in Ve-Golokuati and two in the 37 Military Hospital study area mentioned they were hunters. However during the focus group discussions it was evident that some of the respondents were also opportunistic hunters who hunted bats to supplement their income. Some also hunted bats for meat. Bat hunting and consumption was higher in Tanoboase and the 37 Military Hospital study area, mainly because the bat species found in these two areas (*E. helvum*) were bigger. Bat meat was also eaten by a significantly higher percentage of men than women. The relationship between gender and bat meat consumption showed that more men were at risk through consuming bat meat.

There was no significant relationship between age and bat meat consumption, bat hunting and the state in which the bat meat was obtained. However those 25 years and older are more likely to eat bat meat, with those older than 45 years the highest group eating bat meat. This compares positively with the findings of Anti et al. (2015) and Kamins et al. (2014). Most of those who ate bat meat did so because of the taste. The "high taste ratings" among consumers and relatively high prices charged suggest that bat meat is preferred by a certain class of people who could afford it (Kamins et al., 2011), showing that those at risk may cut across class and income groups, especially in urban areas. Interventions and communications on henipavirus spillover should thus target people of different ages and wealth categories.

Generally participation in bat meat hunting, preparation and consumption decreased with an increase in education. However there were some relatively well-to-do and well educated people who also ate bat meat. In their study in seventeen rural communities in Central Africa LeBreton et al. (2006), found that education influenced both butchering and eating of wild animals. However in their case, people with higher education were more likely to butcher and eat bush meat. The results on education and bat hunting in our study showed that generally the more educated a person was the less likely that they would hunt bats. Kamins et al. (2014) reported similar findings in studies from some communities in Ghana. This could be because those more educated had better livelihood options and could afford other sources of meat. It could also be that those generally well educated were more readily aware of the risks associated with but hunting and consumption.

There were significant differences in bat consumption in the rural and urban areas. In Tanoboase the bats lived in the sacred grove, which according to the participatory maps was outside the centre of the town. However in Ve-Golokuati the bats could be found on trees in people's homes increasing human-bat interactions.

This study has highlighted the complexities of sustainably managing a potential henipavirus spillover into humans in Ghana. It has brought to the fore the need to understand the socio-economic context of the human-bat interactions, the ecology of the bats, the epidemiology of henipavirus disease, legal and institutional regimes that influence the extent of bat-human interactions as well as the health structures in place for managing such a spillover. We thus recommend the establishment of a multidisciplinary team made up of ecologists, social scientists, legal, veterinary and public health experts to work with communities to prevent a potential spillover of henipvairus to humans (Few et al., 2013). We also recommend continuous health risk education to encourage behavioural changes of people and to develop sustainable and relevant zoonoses prevention practices especially among groups at risk.

Integrated approaches, such as the 'One Health' approach, are increasingly including socio-economic and cultural considerations in their design. Local knowledge is important and must be generated in a participatory manner recognizing the needs of the various socially differentiated groups.

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