Evaluation of viral haemorrhagic fever surveillance system with focus on Ebola virus disease, Bawku municipality- Upper East Region, Ghana, 2011- 2015

Francis Broni, Joseph O. Larbi, Edwin A. Afari, Kofi M. Nyarko, Donne K. Ameme and Ernest Kenu

Ghana Med J 2020; 54(2)supplement: 18-25 DOI: http://dx.doi.org/10.4314/gmj.v54i2s.4

Ghana Field Epidemiology and Laboratory Training Programme, Department of Epidemiology and Disease Control, University of Ghana, Legon, Accra

Corresponding author: Donne Kofi Ameme **E-mail:** amemedonne@yahoo.com
Conflict of interest: None declared

SUMMARY

Background: We evaluated the Viral haemorrhagic fever (VHF) surveillance system from 2011 to 2015 in the Bawku Municipality, Upper East region, Ghana to determine whether the goals of the surveillance system are being met and to assess the performance of the system attributes.
Design: Descriptive secondary data analysis.
Setting: Bawku Municipality
Data Source: Review VHF surveillance records, interviewed community-based surveillance volunteers (CBSVs) and reviewed vital events registers. We also assessed the system attributes by reviewing records and interviewing key stakeholders involved in VHF surveillance system with focus on Ebola using checklist and semi structured questionnaire developed based on the Centers for Disease Control and Prevention (CDC) guidelines.
Main outcome measure: System attributes of the VHF surveillance system
Results: Population under surveillance was 105,849. The system required detail information about suspected cases. However, it had a simple and clear standard case definitions, and was well integrated with the IDSR. There is a regular and timely flow of information. The system captured 155 suspected cases nationwide from 2011 to 2015 and all tested negative. Of these, Upper East Region reported 10 suspected cases including 4 suspected cases from Bawku Municipality.
Conclusion: The VHF surveillance system achieved its objectives. However, poor data quality, inadequately trained surveillance officers, and inadequate financial support are threats to the effectiveness of the system.

Keywords: Viral haemorrhagic fever, surveillance system evaluation, attributes, Bawku Municipality, Ghana
Funding: This work was supported by Ghana Field Epidemiology and Laboratory Training Program (GFELTP), University of Ghana

INTRODUCTION

Viral haemorrhagic fever describes severe illness associated with bleeding that may be caused by viruses. The term is applied to disease caused by *Filoviridae* (Ebola and Marburg) and others (Crimean-Congo haemorrhagic fever, Rift Valley Fever, Hantaan haemorrhagic fevers, yellow fever, dengue, Omsk haemorrhagic fever, Kyasanur forest disease). Ebola Virus Disease (EVD) is one of the VHF diseases that has been of great concern in Africa in recent times. The disease is deadly zoonotic disease of viral haemorrhagic fever in human with average case fatality of about 50% (ranges: 25% - 90%).[1]

The introduction of Ebola virus in the human population through animal to human transmission, person to person transmission by direct contact of body fluids/secretions of infected persons is considered the principal mode of transmission.[2] The first case of Ebola was discovered near Ebola River of Democratic Republic of Congo in 1976.[3] Since then EVD epidemics have occurred in Central Africa regions until recent widespread of outbreaks in West Africa.[1] However, in 1994, Cote d'Ivoire reported one case of Ebola in laboratory personnel who performed autopsy on infected chimpanzee.[4]

The 2013 – 2016 West Africa outbreak was largest ever in the history of mankind with 28,602 suspected cases and 11,301 deaths.[5] This outbreak affected six West African countries, United State of America, Spain, UK and Italy.[5,6]

The affected West Africa countries include; Guinea, Liberia, Sierra Leone, Mali, Senegal and Nigeria.[5,6] However, intense transmission occurred in Guinea, Liberia and Sierra Leone and minor transmission or isolated cases, with roots from West Africa outbreak occurred in Mali, Senegal, Nigeria, Spain, UK, USA and Italy.[7] EVD surveillance system before the outbreak was passive with suspected cases identified at health facilities.[8]

Public health surveillance and response is a major component of the Global Health Security Agenda.[9] A robust and reliable public health surveillance system is essential to the development of an efficient outbreak response.[10] According to the World Health Organisation, a public health surveillance system which can immediately detect and report cases of illness compatible with EVD must be in place to monitor and respond promptly in the face of public health emergencies.[11] Though EVD has not been recorded in all West African countries, it is important to improve preparedness and response in all countries so that appropriate public health responses can be rapidly initiated.[12] Again, most of these countries share similar health system characteristics and challenges which can also lead to similar epidemics with the affected countries.[13]

Ghana has a surveillance system in place for viral hemorrhagic fevers (VHF) since the inception of second edition of Integrated Disease Surveillance and Response (IDSR) in 2011. However, there is no documented evidence that the VHF surveillance system has been evaluated in the Upper East Region. Regular evaluation of the VHF surveillance system is recommended to ensure that weaknesses in the system are identified and strengthened. The objectives of viral haemorrhagic fever surveillance system are to detect cases early for prompt management and control, and to monitor burden of the disease and pattern of spread.

We evaluated the surveillance system for the period 2011 to 2015 in the Bawku Municipality in the Upper East Region, with particular focus on Ebola. We sought to determine whether the goals of the surveillance system are being met and to assess the performance of the system attributes.

METHODS

Study site

We conducted evaluation of the surveillance system by reviewing data covering 2011 to 2015. The evaluation carried out between 17 December 2015 and 9 January 2016 in Bawku Municipality of the Upper East Region, Ghana. The municipality is one of the 13 districts in the Upper East Region with estimated population of 105849 [14] and shares boundaries with Pusiga District to the north, Binduri District to the south, Garu-Tempane District to the east and Bawku West to the west. Bawku Municipality operates a three-tier health care system, consisting of community, sub-district and district. The lowest level of health care system in Bawku is the Community-based Health Planning and Services (CHPS), which provides community level health services including the treatment of minor ailments, home-visits, community outreaches, education and health promotion.

Figure 1 Map of Bawku Municipality[15]

The Bawku Municipality is divided into seven health administrative sub-districts with 20 health facilities consisting of one hospital, seven health centres, nine Community Based Health Planning Services (CHPS) Zones, two clinics and one maternity home. Each sub-district has disease surveillance unit that monitor and report on 43 reportable diseases including EVD. There has not been any confirmed case of Ebola virus disease (EVD) in the Bawku Municipality.

Study Design
We conducted descriptive study of the VHF surveillance system with special focused on EVD in Bawku using the "Updated Guidelines for Evaluating Public Health Surveillance Systems' of Centers for Disease Control and Prevention (CDC) [16]. We assessed usefulness of the system by considering policies that have been made and their contribution to the prevention and control of VHF. We visited health facilities to review VHF surveillance records focusing on Ebola. We also interviewed the Community-based surveillance volunteers (CBSVs) and reviewed vital events registers. We also assessed the system attributes by reviewing records and interviewing key informants involved in VHF surveillance using checklist and semi structured questionnaire.

Flexibility was assessed based on integration of the system with other surveillance systems and adaptability to changing needs of the system. Sensitivity was evaluated as the proportion of suspected cases detected by the system. We determined acceptability of the surveillance using completeness and timeliness of reporting. Timeliness was determined by number of reporting sites that reported every Monday before 12 noon and the period it took for District Health Directorate to receive information from health facilities when cases were suspected.

We further assessed stability of the system by considering the interruption and functionality of system. Data from District Health Information Management System 2 (DHIMS 2) database, case based forms and weekly reporting forms were abstracted to determine data quality and completeness. Data quality was assessed on available case based forms with proportion of variable fields completed. We analysed quantitative data using Epi Info 7 and generated summary descriptive statistics. We used content directed analysis to summarize qualitative responses by themes.

Ethical Considerations
The Director of the Diseases Surveillance Department of the Ghana Health Service granted approval for the access and use of the data for this review. Permission was officially obtained from the Regional Health Directorate of Ghana Health Service, Upper East Region. We further obtained permission from the Municipal Directorate of Ghana Health Service, Bawku Municipal for the use of the data. Consent was obtained from interviewees. Data held on computers were encrypted with a password which was made available only on a need to know basis. This evaluation was carried out to improve the health system process and service in the district.

RESULTS

Population under surveillance
The population under the VHF surveillance in the Bawku Municipality in 2015 was 105849. This number included everybody irrespective of the age and sex.

Case definition of VHF versus Ebola Virus Disease used at Bawku Municipality A suspected case of VHF is defined as a person with an acute onset of fever of less than 3 weeks duration in a severely ill patient and any 2 of the following; haemorrhagic or purpuric rash; epistaxis (nose bleed); haematemesis (blood in vomit); haemoptysis (blood in sputum); blood in stool; other haemorrhagic symptoms and no known predisposing factors for haemorrhagic manifestations.

Definition for confirmed case:
Confirmed case was defined as: A suspected case with laboratory confirmation or epidemiologic link to confirmed cases or outbreak.

However, for the purpose of interest in EVD, the case definition for EVD was as follows:
A suspected case of EVD was defined as any person ill or deceased who has or had fever with the following symptoms: headache, vomiting, nausea, diarrhea, intense fatigue, abdominal pain, general muscular or articular pain, difficulty in swallowing, difficulty in breathing, hiccoughs and signs of haemorrhage, such as bleeding of the gums, nose-bleeding, conjunctival injection, red spots on the body, bloody stools and or melaena (black tarry stools), or vomiting blood (haematemesis).

Surveillance officers at all levels demonstrated mastery of the case definition and considered it clear and simple to apply. A probable case was defined as any person alive or dead having contact with a case of EVD and with a history of acute fever; or any person of history of acute fever and three or more of the following symptoms: headache, vomiting, nausea, diarrhea, intense fatigue, abdominal pain, general muscular or articular pain, difficulty in swallowing, difficulty in breathing, hiccoughs or unexplained death; or a person without any symptoms having had physical contact with a case or the body fluids of case within the last three weeks. The notion of physical contact may be proven or highly suspected such as having shared the same room or bed, cared for patient, touched body fluids or closely participated in a burial (physical contact with the corpse).

The case definition also included a community case definition. In the outbreak period the community case definition was to increase the index of suspicion in the communities where no case is found.

The alert case includes history within the previous one month of travel to any place with confirmed EVD outbreak or contact with someone from any place with confirmed EVD outbreak who has been sick with febrile illness or confirmed of Ebola. Unexplained fever, sudden and unexpected death or history of fever with signs of bleeding.

A confirmed case was defined as a suspected or probable case that is laboratory confirmed. Laboratory confirmed cases must test positive for the virus antigen, either by detection of virus ribonucleic acid (RNA) by reverse transcriptase-PCR (RT-PCR), or by detection of IgM antibodies directed against Ebola.

Stakeholders

The stakeholders for VHF surveillance system in Bawku municipality include the Municipal Health Management Team (MHMT) led by Municipal Director of Health Service, the Municipal Assembly, Municipal Hospital, the sub-districts health facilities and CBSVs. They were responsible for policy implementation and made decision for VHF including Ebola virus disease (EVD) surveillance system in the municipality.

Table 1 Frequency distribution of Key informants, EVD surveillance system Bawku Municipality, 2015

Key Informant	Sex (%)		Total (%)
	Male	Female	
Director	0(0.0)	1(100.0)	1(100)
MSO	1(100.0)	0(0.0)	1(100)
DCO	12(92.3)	1(7.7)	13(100)
PHN	0(0.0)	2(100.0)	2(100)
HIO	3(75.0)	1(25.0)	4(100)
CHO/CHN	6(75.0)	2(25.0)	8(100)
PA	1(50.0)	1(50.0)	2(100)
CBSV	11(100)	0(0.0)	11(100)
Total	34(81.0)	8(19.0)	42(100)

Forty-two informants were interviewed. Majority of the respondents were males 80.9% (34/42). Among the categories of informants, Disease Control officers were the majority 30.95% (13/42).

We also identified stakeholders at regional level. They include Deputy Director of Public Health (DDPH), Regional Surveillance Officers and Regional Health Information Officers. They formulate policies and make decision for VHF surveillance system. Surveillance officers at the National Disease Surveillance Department collate all information on VHF (EVD in context) for the country, analyze national data, report and make recommendations to the Ministry of Health for policy considerations. Noguchi Memorial Institute of Medical Research (NMIMR) was responsible for testing all suspected EVD samples in the country.

Resource situation in the surveillance system

With the exception of the municipal health directorate which had two computers, 3 cartons of gloves and 2 overall coats. No hospital, health center of CHPS compound in the municipality had any of these items. No health system level in the Bawku municipality had a non-contact thermometer.

In all the facilities visited, personal protective equipment (PPEs) were not available for use except the municipal health directorate that reported of receiving some. The municipal hospital had one gun thermometer that was used at the out patients department (OPD). Regarding human resource training on EVD, 42.9% (18/42) informants interviewed did not receive any form of training at all. These include 61.1% (11/18) community based surveillance volunteers, 33.3% (6/18) community health officers or nurses and 5.6% (1/18) physician assistant.

Operation of the system

The community-based surveillance volunteers (CBSV) reported any unusual event to the nearest health facilities through phone calls, in-person, or the suspected cases self-report or are brought to the health facility through the out-patient department (OPD), antenatal clinic (ANC), maternity home, assessment centre and other special clinics. The health care worker at the screening desk took temperature and asked of at least one sign of bleeding from any site of the body or bloody diarrhea. Suspected cases were reviewed by a clinician using the case definition to classify cases and document in the patient's record book. The information is then entered into consulting room register by nurse. The patient is immediately isolated, and clinician immediately calls the public health officer or disease control officer to complete the case-based form for the suspected cases and list all contacts. Blood samples were then taken for laboratory investigation. The municipal health directorate was immediately notified on phone and copy of case-based forms sent within 6 hours depending on distance and ready availability of means of transportation to Bawku. The municipal health directorate ensures that the blood samples together with completed case-based forms are sent to regional surveillance unit for onward submission to Noguchi Memorial Institute of Medical Research (NMIMR) for laboratory investigations. These are done within 48 hours. The district also shares copies of the case-based forms for the suspected cases with the regional surveillance unit.

The Noguchi Memorial Institute of Medical Research (NMIMR) conducts test for Ebola virus first and also tests for other viral haemorrhagic fever agents. Laboratory findings were reported to the national surveillance department for onward transmission/communication to

the regional surveillance department within three days. feedback was given to the municipal health directorate within 72 hours after the samples are sent for analysis. The report is communicated to all the hospitals and health facilities through phone calls and durbar. The national surveillance department informed other partners involved in EVD surveillance system through weekly epidemiological reporting communique. Figure 2 indicates the flow of information in the Ebola surveillance system.

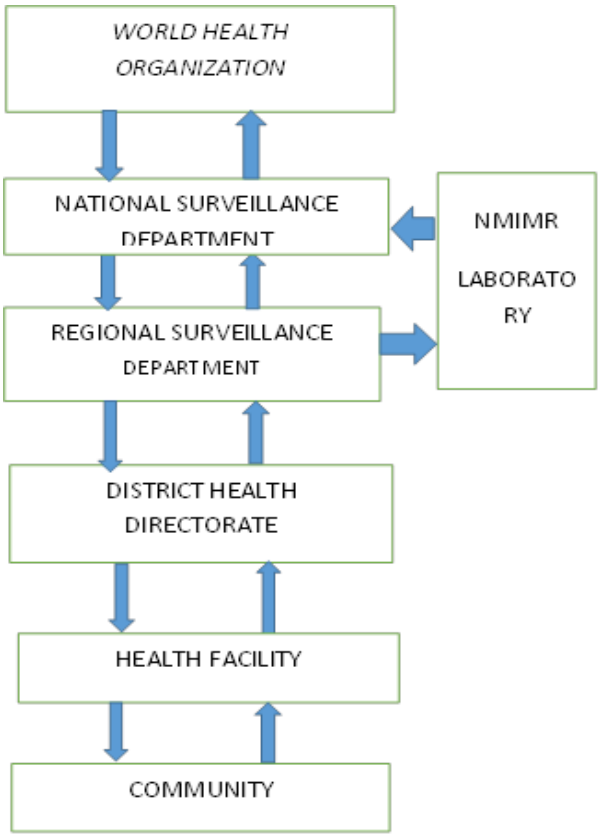

Figure 2. VHF surveillance system information flowchart, Bawku municipality, 2015

Data Collection and Reporting

The VHF surveillance system in Bawku Municipality used both active and passive case search to collect data. At the community all suspected cases were recorded in the community vital events register or note book and immediately reported to the nearest health facility. Clinicians at health facilities recorded details of suspected Ebola cases into patient record book and consulting room register. Following this, active case search and contact tracing was done to identify more cases. Routinely, the disease control officers also performed active case search in the health facilities by reviewing previous admission records for suspected cases.

Suspected cases were reported to the municipal health directorate within one hour of seeing the case at health facility. Blood samples of suspected cases were taken and together with completed case-based form, these were submitted to regional health directorate within 12-24 hours. Within 48 hours, the region submitted the sample together with a copy of case based/ case investigation form to NMIMR for laboratory investigation. The outcome of the laboratory investigations was communicated to national surveillance department in less than 24 hours after the specimen had been received. The national surveillance department in turn communicates the finding to the region in less than a 24 hours through phone calls and emails. The district receives laboratory reports within 72 hours after the specimen was submitted to the region through phone calls and email from the region.

Data confidentiality

At the health facility, district and regional levels, files containing hard copies of case based forms were shelved. At the hospital hard copies of case based forms were stored in a cabinet under lock and key. Computers at district, regional and national levels had passwords. However, the district stored the hard copies of the case based forms in a wooden cabinet under lock and key.

System attributes

Simplicity

The system was complex. Detailed personal information about the suspected case is required. It also required monitoring and contract tracing of suspected and confirmed cases respectively. Samples for laboratory investigation required prompt transportation with the highest safety precautions to Noguchi Memorial Institute for Medical Research. However, the case definition is very simple and easy to apply by all trained personnel.

Flexibility

The system was flexible and well incorporated into Integrated Disease Surveillance and Response (IDSR). It adapted to changes in the new case definition for Ebola without major reconfiguration of the system. It used the same staff and resources of other disease surveillance systems for its operation.

Stability

The system was stable; it had not seen any interruption for the previous years. Weekly and monthly reporting was consistent and prompt. All stakeholders at all levels work to sustain the functionality of the system.

Acceptability

The system was accepted at all levels. Every stakeholder was willingly participating and supporting the system. Reporting rate of the municipality was 100 percent.

All reporting sites submit report regularly and promptly. The reporting sites report on zero case as required every week.

Timeliness
The suspected cases at the health facility level were reported to district health directorate within an hour. Samples and case base forms were sent to Regional Surveillance Unit within 24 hours for onward submission to NMIMR. The reports of laboratory investigation were received by districts within 72 hours through phone calls after the samples were delivered to the region. The weekly and monthly reports were received on time and transmitted appropriately to other levels within the required time.

Data quality
The majority of information in the case based forms were completed for most of the suspected cases. However, variable fields for date, sex and travelling history were not filled for some of the suspected cases. There was a data validation team but it was not functional.

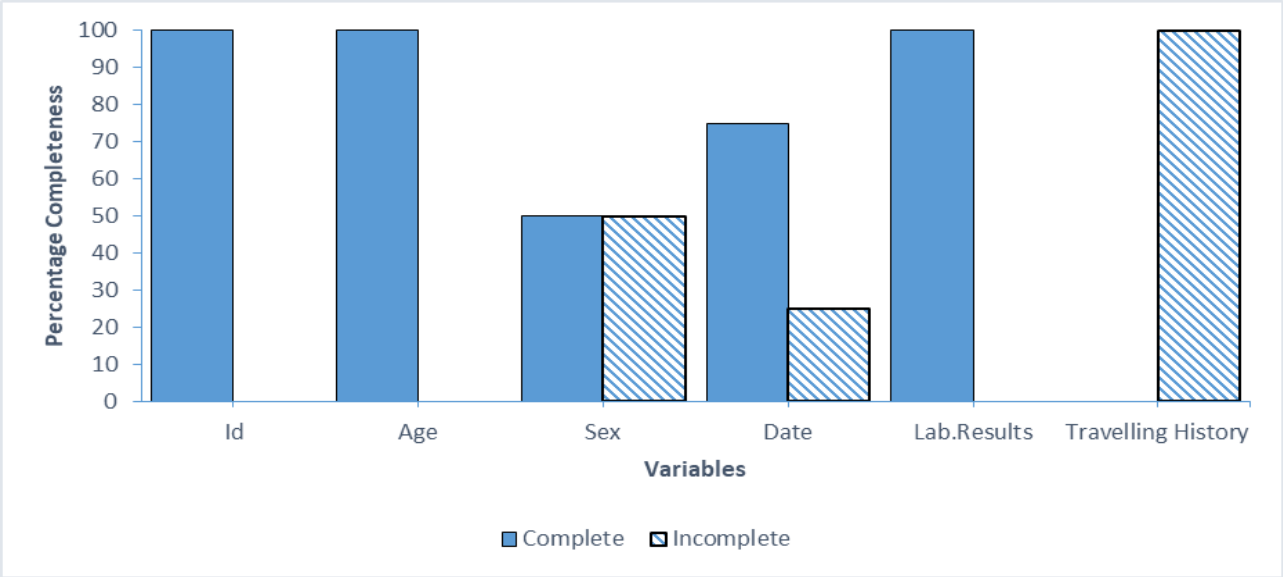

Figure 2 Completeness of selected variables for VHF Case based form, Bawku municipal

Feedback
Feedback was prompt at all levels. The national gives feedback to region through phone calls, weekly epidemiology bulletin and support visits. The laboratory reports together with the case-based forms were sent to the region. The region sent immediate feedback through phone calls; and copies laboratory reports are sent later through regional health directorate to district.

The district informs the health facilities and staff by phone calls, supportive supervisory visits and information is also disseminated at durbar. The district health management team promptly briefs the district health committee of the reports.

Sensitivity
The system was zero reporting between 2011 and 2013, however, between 2014 and 2015, the level of case detection in the system went from zero to 155 suspected cases. The system was capable of detecting an outbreak through case confirmation at the NMIMR. However, all suspected cases tested negative and hence the system was able to rule out an outbreak of EVD.

Predictive value positive
There were 155 suspected cases reported for the entire country during the period under evaluation. Of the total cases, 10 (6.5%) suspected cases were reported from Upper East Region. The Bawku Municipal reported 4 (40%) out of the 10 suspected cases for the region. All the cases tested negative for Ebola virus and other VHF viruses. Thus, the predictive value positive (PVP) was zero percent (0%) for the entire country.

Usefulness
The information gathered from the surveillance system was used to enhance training for health and surveillance staff at all levels. It was also used by the district to establish effective Ebola emergency preparedness plan. The district has further put in place measures to monitor anybody travelling to or from Ebola confirmed positive regions or countries.

It has also helped in the establishment of monitoring office for Ebola at Paga. This office coordinates and reports weekly to the office of Regional Minister.

DISCUSSION

The study addresses an important global public health issue on VHF surveillance with focus on EVD in the context of health system strengthening. The findings from this study indicated some strengths of the VHF surveillance system in Bawku municipality as well as the Upper East Region. These include timeliness of reporting and receiving feedback, acceptability, and representativeness of the system. Feedback was prompt and regular at all levels of the VHF surveillance system. The reporting was regular and prompt at all reporting sites, from the community to national.

Although, our study further found the system to be complex, it had clear objectives and a simple case definition. The system is largely accepted by all the stakeholders. However, the study also showed major gaps in proper functioning of the VHF surveillance after years of IDSR implementation in Ghana. We observed data quality and validity issues with suspected EVD cases, problems regarding inadequate resources and training of staff. A similar study in Ghana and another in Guinea on Ebola surveillance also revealed that poor data quality, data availability and validity were major problems which resulted in the large Ebola outbreak in West Africa.[6,10] Public health response to disease outbreaks is affected by completeness and accuracy of information available.[10]

A study on Ebola virus disease surveillance and response preparedness in northern Ghana showed some weakness in the surveillance system in Ghana.[17] These weaknesses include data quality (completeness and validity), ineffective feedback to lower reporting levels, and inadequate resources for training surveillance officers.[17] The current study in Bawku municipality revealed similar problems. Our finding also agrees with that of Wiwanikit, which stated that limited resources and training of health professionals affect the quality of Ebola surveillance activities.[18] Another study also revealed that political will, health investment, and human resource development are the major hindrances in building dependable health systems and surveillance responses for disease outbreaks in West Africa region.[19]

Overall, the surveillance system had some strengths. The system is well integrated, stable and easily adapted to changes without any major reconfiguration. The system has clear objectives and simple case definition which is easy to apply. There is clear channel of communication and feedbacks are regular. The suspected cases of EVD were investigated by highly trained specialist at the P-3 laboratory. From the available data from the facilities that reported during the period under review, the country-wide predictive value positive was zero percent. Thus, for all the suspected cases that were tested for viral haemorrhagic fever all were negative. Awareness on EVD was high due to the West African Ebola Outbreak. The case definition for a suspected case was very sensitive and this was important in ensuring that no case of EVD was missed. Even though investigating many suspected EVD cases is expensive, the cost of missing one case of EVD is incalculable.

The weaker attributes of the system such as data quality could be attributed to inadequate training of surveillance officers on data collection and management that give rise to the poor completeness and validity found in this evaluation. This could in turn be partly attributed to the aforementioned financial constraints in the face of competing state priorities so common in developing countries such as Ghana.

LIMITATION

For a part of this evaluation, we analysed secondary data whose quality may not be optimum. However, we performed data quality checks to improve the data quality before analysis.

CONCLUSION

The VHF surveillance system operated in Bawku Municipality can detect cases of EVD early and prevent spread of outbreaks. Stakeholder interests and participation in the operation of the system are high. However, poor data quality, inadequately trained surveillance officers, and inadequate financial support are threats to the effectiveness of the system.

REFERENCES

1. Feldmann H. Geisbert TW. Ebola haemorrhagic fever. *The Lancet* 2011: 377(9768), 849–862. https://doi.org/10.1016/S0140-6736(10)60667-8
2. United States Centers for Disease Control and Prevention. Ebola (Ebola Virus Disease) Transmission. US CDC, Atlanta 2018. Retrieved: https://www.cdc.gov/vhf/ebola/transmission/index.html. On: 15 June 2018
3. WHO. Ebola virus disease fact sheets detail. WHO. 2018. Geneva. Retrieved: http://www.who.int/news-room/fact-sheets/detail/ebola-virus-disease on: 20 September, 2018
4. World Health Organization. Ebola and Marburg virus disease epidemics preparedness, alert, control, and evaluation - Ebola-and-Marburg-virus-disease-

epidemics-preparedness, -alert, -control,-and-evaluation. (No. WHO/HS E/PED/CED/2014.05). WHO Geneva. 2014.
Accessed: http://www.euro.who.int/__data/assets/pdf_file/0004/268753/Ebola-and-Marburg-virus-disease-epidemics-preparedness,-alert,-control,-and-evaluation-Eng.pdf?ua=1 on 12 April, 2015

5. Boisen ML, Hartnett JN, Goba A, Vandi MA, Grant DS, Schieffelin JS, … Branco LM. Epidemiology and Management of the 2013 – 16 West African Ebola Outbreak. *Annual Review of Virology* 2016: Vol. 3:147-171. https://doi.org/10.1146/annurev-virology-110615-040056
6. Sacks JA, Zehe E, Redick C, Bah A, Cowger K, Camara M. Introduction of Mobile Health Tools to Support Ebola Surveillance and Contact Tracing in Guinea, *Glob Health Sci Pract*. 2015; 3(4): 646–659.
7. WHO. Emergencies preparedness response. National and regional surveillance systems. Ebola: Health systems recovery. WHO Geneva, 2018. Accessed:http://www.who.int/csr/disease/ebola/health-systems-recovery/surveillance/en/ on 8 September, 2018.
8. Stone E, Miller L, Jasperse J, Privette G, Beltran JCD, Jambai A, Kpaleyea J, Makavore A, Kamara MF, Ratnayake R. Community Event-Based Surveillance for Ebola Virus Disease in Sierra Leone: Implementation of a National-Level System During a Crisis. *PLOS Current Outbreaks* 2016; 7:8.
9. MacDonald PD, Cressman G, McKay, Loo S, McClure E, MacGuire E. Real-time surveillance and response system for Ebola and other emerging infections. *J Public Health Inform*. 2017; 9(1): e138
10. Awini AA, Bonney JHK, Frimpong JA, Ampofo WK, Koram KA. Information gaps in surveillance data and effects on the Ghanaian response to the Ebola outbreak in West Africa. *Ghana Med J*. 2017; 51(3): 115–119.
11. WHO. Emergencies preparedness response. Ebola publications: surveillance, contact tracing, laboratory. WHO Geneva. 2018. Accessed: http://www.who.int/csr/resources/publications/ebola/surveillance/en/ on 8th September, 2018
12. Vora NM, Arthur RR, Swerdlow DL, Angulo FJ. Preparation of at-risk West African countries for Ebola. *The Lancet* 2015:485
13. Nyarko Y, Goldfrank L, Ogedegbe G, Soghoian S, Aikins AD, NYU-UG-KBTH Ghana Ebola Working Group. Preparing for Ebola Virus Disease in West African countries not yet affected: perspectives from Ghanaian health professionals. *Globalization and Health* 2015; 11:7
14. Ghana Health Service. Upper East Regional Health Directorate 2015 Annual Report. Ghana Health Service, Bolgatanga. 2016.
15. Ghana Statistical Service. District Analytical Report Bawku Municipality. Ghana Statistical Service. Accra. 2010.
16. Technical Working Group. Updated Guidelines for Evaluating Public Health Surveillance Systems: Recommendations from the Guidelines Working Group: (548222006-001). MMWR 2001: 50(RR13);1-35. doi:10.1037/e548222006-001.
17. Adokiya MN, Awoonor-Williams, JK. Ebola virus disease surveillance and response preparedness in northern Ghana. *Global Health Action* 2016: 9(0). https://doi.org/10.3402/gha.v9.29763
18. Wiwanikit V. Ebola virus infection: What should be known? *North Am J Med Sci* [serial online] 2014; 6:549-52.
19. Wiwanikit V, Tambo E. Ugwu EC, Ngogang JY, Zhoy Z-N. Are surveillance response systems enough to effectively combat and contain the Ebola outbreak? *Infect Dis Poverty*. 2015; 4(1): 7.