

Short Research Article

An Evaluation of Meningitis Surveillance in Northern Ghana

ABSTRACT

Introduction: Public health surveillance is a key strategy in controlling and preventing meningitis outbreaks especially in northern Ghana which continues to suffer yearly focal outbreaks. The aim of this evaluation was to examine the operation and performance of the meningitis surveillance system and to determine whether the surveillance system as established within the Ministry of Health is achieving its objectives.

Design: This was a cross sectional study conducted in the Talensi District between February and March, 2015. The study employed a qualitative method approach. Nine In-depth interviews (IDIs) and two Focussed Group Discussions (FGDs) were held with key informants involved in meningitis surveillance. Surveillance records for meningitis were also reviewed and analysed at community, sub-district, district and the regional level.

Results: The study revealed that the surveillance system was simple, flexible and highly accepted by healthcare workers. The system was fairly representative, stable with good data quality. However, it had a low sensitivity and a low positive predictive value in detecting/reporting cases of meningitis. Cerebrospinal fluid samples of suspected cases were timely presented to the public health reference laboratory. On the contrary, feedback of confirmation results delayed. Also, lack of funding and motivation for surveillance activities, inadequate technical personnel to carry out lumbar puncture and non-availability of case definitions at health facilities were system challenges that affected meningitis surveillance.

Conclusion: Relatively, some of the primary objectives of the surveillance system are met. However, we believe that motivation of the community-based surveillance volunteers, a

24 construction of a regional public health laboratory and an effective training for healthcare
25 workers would strengthen the surveillance system in northern Ghana. Consequently, adequate
26 financial investment (especially through the government and other health-related
27 international organisations) is required.

28 **Keywords:** Meningitis, Surveillance, African meningitis belt, Talensi district, northern
29 Ghana

30 INTRODUCTION

31 Meningitis remains a global public health threat especially in sub-Saharan Africa which
32 continues to have seasonal incidence of the disease [1]. Despite several interventions to help
33 curb the situation, case fatality rate due to meningitis remains high ranging between 2% and
34 30% globally [1]. Main aetiological agents in bacterial meningitis are *Neisseria meningitidis*,
35 *Streptococcus Pneumoniae* and *Haemophilus influenzae* [2]. *Neisseria meningitidis* is of
36 major public health importance as it is responsible for the occurrence of Epidemic
37 Meningococcal Disease (EMD) in the 'African Meningitis belt' [3,4]. The African meningitis
38 belt is a sub-Saharan African region that extends from the west of Ethiopia to the east of
39 Senegal with about 300 million people at risk of the disease [4,5]. The meningitis belt
40 experiences seasonal annual focal outbreaks with large epidemics occurring every 8-12 years
41 [5].

42 There are 12 serogroups of *Neisseria meningitidis* based on the chemical composition of the
43 capsular polysaccharide [6]. Serogroup A accounts for most of the epidemics in the African
44 meningitis belt, serogroups B, C and W135 have also been reported [7,8]. Persons with
45 meningitis usually present with fever, headache, neck stiffness, vomiting and photophobia
46 [9]. Additionally, some neurological signs and symptoms such as lethargy, coma and
47 convulsions have been observed among meningitis victims [10]. Transmission of *Neisseria*

48 *meningitidis* among persons at risk of the disease is by respiratory droplets or direct contact
 49 with respiratory secretions [11]. Multiple interacting factors have been fingered as
 50 contributory factors that have put the lives of many living within the African meningitis belt
 51 at risk of meningitis. Existing evidence has shown that low socioeconomic status, climatic
 52 conditions (dry season), immunological susceptibility of the population and transmission of
 53 virulent strains are risk factors for EMD [4,12,13]. Behavioural factors, migration, previous
 54 infections and acute respiratory tract infections may also be contributory factors for the
 55 development of EMD [3].

56 The three northern regions (Upper East, Upper West and Northern) of Ghana lie within the
 57 African meningitis belt with annual focal outbreaks of meningitis during the dry season
 58 (October to April) [4]. Large scale epidemics occurred in 1996/1997 which affected 19,000
 59 people with 1,200 deaths in the three regions of the North [4]. In 2010, an outbreak of
 60 meningitis occurred in the Bongo district of the Upper East Region [4].

61 Persons diagnosed of meningitis are treated with antibiotics whilst mass vaccinations are
 62 provided to people in outbreaks areas. Polysaccharides vaccines against serogroups A, C, AC
 63 and ACW-135 meningococcal infections are affordable and readily accessible [3,12,14]. In
 64 2010, Ghana was part of a group of African countries that benefited from meningococcal A
 65 conjugate vaccine roll-out in the African meningitis belt with comprehensive mass
 66 immunizations campaigns [15]. Despite the availability of drugs and vaccines in the
 67 management of meningitis outbreaks/epidemics, case fatality rates in Ghana still remains
 68 high ranging between 36% and 50% [1]. However, it has been argued that high case fatality
 69 rates are largely due to poor data quality, poor motivation, late reporting of health events and
 70 inadequate feedback for public health action in Ghana [16,17]. Containment of epidemics
 71 and managing cases of meningitis depends largely on early detection and laboratory isolation
 72 of the causative organism [4]. Enhanced epidemiological and laboratory surveillance are

73 required to enable early detection of epidemics, identification of causative organism and
 74 administration of appropriate antimicrobials. Moreover, vaccines to protect populations are
 75 essential if a reduction in mortality and morbidity due to meningitis are to be achieved [4,18].
 76 In view of this, Ghana in 2002 adopted the World Health Organization Regional Office for
 77 Africa (WHO/AFRO) Integrated Disease Surveillance and Response (IDSR) strategy to
 78 surveillance in developing countries which has since been revised in 2011 to enable early
 79 detection and timely dissemination of information on priority diseases like meningitis for
 80 appropriate action [15,19, 20,21].

81 Although northern Ghana is located within the African Meningitis belt, and all the districts in
 82 the region operates a surveillance system that is in line with the 2011 WHO/AFRO IDSR
 83 guidelines, to early detect, confirm, report and timely respond to meningitis cases as well as
 84 assess the impact and effectiveness of MenAfriVac roll-out in 2010. However, since the
 85 introduction of IDSR, there has not been any specific evaluation of the surveillance system
 86 on meningitis in northern Ghana. The objective of this evaluation therefore was to examine
 87 how surveillance system on meningitis operates, its performance, determine whether the
 88 system is achieving its objectives and to make recommendations to improve the system. We
 89 focus on the Talensi district in the Upper East region of Ghana; a district known for large
 90 scale epidemics and yearly focal outbreaks of meningitis [4,22].

91 **METHODS**

92 **Study setting**

93 The Talensi district is one of thirteen (13) districts in the Upper East Region of Ghana [23].
 94 The Talensi district is made up of eight (8) sub-districts. The district and the Upper East
 95 Region as a whole completely lie within the African meningitis belt. Talensi district shares
 96 boundaries with Nabdam district to the North, Bolgatanga municipal to the West, East

97 Mamprusi district to the South East, West Mamprusi district to the South West and Bawku
 98 West to the East [23]. The target population under meningitis surveillance in the Talensi
 99 district is 85,164 [22, 24]. The district has two seasons; a short wet season from June to
 100 October and the rest of the year is a long dry season [25]. Most residents practice subsistence
 101 agriculture as their main means of livelihood. The district has a hospital in addition to other
 102 health facilities which include a health centre, clinics and Community-based Health Planning
 103 and Services (CHPS) compounds that provide healthcare services [23].

104 **Study design**

105 This was a cross sectional study that employed a qualitative method approach. Apart from its
 106 large scale epidemics and yearly focal outbreaks of meningitis [4], the Talensi District was
 107 also chosen because the region received technical and financial support in 2002 to fully
 108 implement IDSR in all districts in the region including the Talensi district [26]. Conducted
 109 between February and March, 2015, this study also adopted the updated guidelines for
 110 evaluating public health surveillance systems by the Centre for Disease Control and
 111 Prevention (CDC) as a guide in evaluating the meningitis surveillance system [27]. The
 112 WHO practical guidelines on control of epidemic meningococcal disease was also used in
 113 providing guidance on meningitis surveillance [28].

114 **Data collection**

115 Records at the Regional Health Directorate (RHD) of the Ghana Health Service, Talensi
 116 District Health Management Team (DHMT), eight (8) sub-district health facilities and six
 117 communities were reviewed. Records from January 2012 to December 2014 were reviewed
 118 which include IDSR 1 weekly report forms, IDSR 2 monthly report forms, laboratory
 119 register, IDSR immediate case-based report forms, line listing forms, case notification forms,

community-based surveillance summary report forms, monitoring charts and community register for vital events.

Interviews were conducted with key informants that are involved with meningitis surveillance at all levels in the Talensi district including the Regional Health Directorate.

Interviews conducted were focussed on surveillance objectives, data collection, data reporting, challenges with the surveillance system and their proposed recommendations to help improve the system. In-depth Interviews were conducted with the Deputy Director for Public Health (DDPH) and the Regional Disease Control Officer (RDCO) both at the regional level. At the district level, in-depth interviews were conducted with the Talensi District Director of Health Services (DDHS) and the District Health Information Officer (DHIO) whilst a Focussed Group Discussion (FGD) was held with three (3) Disease Control Officers of the Talensi DHMT. Also, in-depth interviews were held with the Physician Assistant, Disease Control Officer and Biomedical Scientist of the Talensi District Hospital. Similarly at the sub-district level, in-depth interviews were conducted with two (2) Community Health Officers. A FGD was held with six (6) Community-based Surveillance Volunteers (CBSVs). All IDIs and FGDs were recorded with audio tape recorders.

Case Definitions

The following case definitions were used for suspected, probable and confirmed meningitis cases during the meningitis surveillance evaluation.

Suspected meningitis case: Any person with sudden onset of fever ($>38.5^{\circ}\text{C}$ rectal or $\geq 38.0^{\circ}\text{C}$ axillary) and one of the following signs: neck stiffness, bulging fontanelle, convulsions, altered consciousness or other meningeal signs.

Probable meningitis case: Any suspected case with macroscopic aspect of Cerebrospinal fluid turbid, cloudy or purulent or with microscopic test showing Gram negative diplococcus,

144 Gram positive diplococcic, Gram positive bacilli; or leukocyte count of more than 10
145 cells/mm³.

146 *Confirmed meningitis case:* Isolation or identification of causal pathogen (*Neisseria*
147 *meningitides*, *Streptococcus pneumoniae*, *Haemophilus Influenzae b*) from the Cerebrospinal
148 fluid of a suspected or probable case by culture, Polymerase Chain Reaction or agglutination
149 test.

150

151 **System attributes**

152 Surveillance system attributes were assessed subjectively through interviews to provide a
153 proxy measure of how the meningitis surveillance system is performing. The surveillance
154 system attributes that were assessed include; simplicity, flexibility, stability, sensitivity,
155 acceptability, representativeness, positive predictive value, data quality and timeliness.

156 The surveillance system was rated simple as staff operating at the different levels of the
157 system are informed about their role in surveillance and are able to complete surveillance
158 forms with ease in about 5-10 minutes. Data analysis was simple, reporting levels are few
159 with information disseminated done timeously. The system was found to be very flexible, for
160 example, when the community register for vital events were modified in 2012; it was
161 immediately adopted without any challenge. Additionally, the stability of the surveillance
162 system was found to be good. Although there were no specific funds allocated for
163 surveillance, the Talensi DHMT and health facilities made use of administrative funds to
164 support surveillance. The system is therefore reliable and consistent in its operations for a
165 long time.

166 It was difficult to assess the true sensitivity of the surveillance system as no field research or
167 survey was conducted. However the level of case reporting from sub-district health facilities
168 to the Talensi DHMT was used as a proxy for the sensitivity of surveillance system. For

example in 2014, a total of five (5) confirmed cases were detected out of a total district population of 85,164 representing a sensitivity of 0.0059%. The sensitivity was therefore rated as low. The positive predictive value of the system was estimated by dividing the suspected cases from sub-districts that were confirmed at the zonal public health reference laboratory as having meningitis by the total number of suspected cases. All the thirteen (13) suspected cases were laboratory tested, out of which five (5) were confirmed positive. The positive predictive value was therefore estimated to be 5/13 which is equal to 38.5% meaning that the probability of meningitis cases that are identified by surveillance system as truly having the disease is 38.5%.

Also, all staff involved at different levels of surveillance was willing to participate in surveillance activities. They showed great concern and passion for surveillance although some staff complained of having to refer suspected cases to the Talensi district hospital for LP because they lack the necessary technical expertise. The acceptability of the surveillance system was rated high. The surveillance system was also fairly representative. For example, in 2014, the age range of meningitis cases was 2- 44 years with 3 (60%) females and 2 (40%) males. Out of the eight (8) sub-districts of Talensi district, confirmed cases came from four (4) sub-districts representing 50%. All cases occurred between week 10 and 12 of 2014. This is illustrated in Table 1.

Table 1: Distribution of meningitis cases by Age, Sex, Sub-district and week in the Talensi District, 2014

Cases	Age (years)	Sex	Week	Sub-district
1	19	Female	10	Tongo
2	14	Female	11	Namolgo/Kpatia
3	18	Male	12	Pwalugu
4	2	Male	12	Pwalugu
5	44	Female	12	Gorogo

190 In addition, data quality was not an issue as forms were always completed with valid data. Ad
 191 hoc phone calls or visits were made to sub-districts by the DHMT to ensure completeness and
 192 accuracy of data. Hence, data quality was rated as good. With respect to timeliness, suspected
 193 cases of meningitis usually present to sub-district health facilities after an average of 2 to
 194 3days of experiencing signs and symptoms. Lumbar puncture is done on the day of
 195 presentation and treatment immediately started whilst they await LP results. The sub-district
 196 DCO is immediately informed who also notifies the district DCO for the case to be monitored
 197 till laboratory findings from the region are obtained.

198 **Data Analysis**

199 The qualitative data was analysed by content analysis [29,30]. This was after in-depth
 200 interviews and FGDs were transcribed into field notebook that were further verified using
 201 field audio tape recorders to ensure that transcribed texts were accurate. The transcribed text
 202 were systematically analysed to obtain themes that were in line with the main objectives of
 203 the evaluation. The specific themes retrieved were meningitis surveillance system operation,
 204 resources and system performance. These themes are important in determining how the
 205 surveillance system timely detects, reports, analyse and respond to public health events.

206 **RESULTS**

207 The recommended surveillance system for meningitis in Ghana involves timely detection of
 208 suspected cases at community, sub-district and district levels with lumbar puncture for
 209 Cerebrospinal Fluid (CSF) done for all suspected cases at either sub-district health facility or
 210 a district hospital level. Gram staining/agglutination test should be carried out for all CSF
 211 samples collected at sub-district health facilities or district hospitals. Also, part samples of
 212 CSF of all suspected cases should be sent to the regional health directorate by the district
 213 health directorate. Samples are further forwarded by the regional health directorate to a zonal

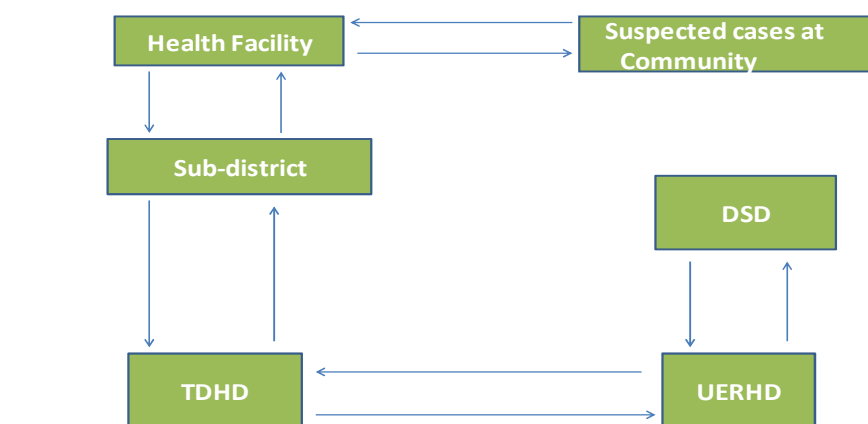
214 public health reference laboratory for confirmation test to be carried out by Polymerase Chain
 215 Reaction (PCR). The results of the confirmation is supposed to be reported timely to the
 216 regional health directorate, which also should provide timely feedback to the district that
 217 recorded the suspected case. All suspected or confirmed cases must also be reported timely to
 218 the national Disease Surveillance Department (DSD) of the Ghana Health Service. The
 219 district health directorate is expected to also provide timely feedback to the sub-district health
 220 facility that reported the suspected case for appropriate public health action to be taken.

221 **Flow chart of the Meningitis Surveillance System**

222 The flow of data information and dissemination within the surveillance system is shown in
 223 Figure 1. The reporting system was mainly passive with very little active surveillance carried
 224 out by CBSVs at the community level. An average of 5 to 6 suspected meningitis cases at
 225 the community level are usually reported to sub-district health facilities by CBSVs which are
 226 screened by the health facilities to determine which cases fit into the suspected meningitis
 227 case criteria. Some suspected cases also report directly to the sub-district health facility or
 228 Talensi District Hospital. The Disease Control Officer (DCO) at the health facility is
 229 immediately informed and the IDSR immediate case-based reporting forms are filled. The
 230 medical officer at the Talensi District Hospital carries out a Lumbar Puncture (LP) for
 231 Cerebrospinal Fluid (CSF) for gram staining by the biomedical scientist. Referrals are made
 232 to the district hospital from health facilities in the district without the capacity to perform LP
 233 and gram staining. Whilst treatment was on-going, samples of CSF and the filled IDSR
 234 immediate case-based reporting form is sent to the Talensi District Health Management Team
 235 which is then forwarded to the Regional hospital laboratory via the Regional Health
 236 Directorate for confirmation by agglutination test. A further analysis is done by sending part
 237 of the sample of the CSF to the zonal Public Health Reference Laboratory for final
 238 confirmation by Polymerase Chain Reaction (PCR). The results are later communicated to

the District DCO who also communicates the findings to the health facility in which the case presented. If the case is confirmed as meningitis, a team made up of District DCO, Community Health Nurse, and the CBSVs is constituted for a follow up to the community to meet contacts of confirmed case who are then educated on meningitis prevention.

Figure 1: Data reporting and feedback of meningitis surveillance flow chart in Talensi District, 2015.



Notes: TDHD= Talensi District Health Directorate, UERHD= Upper East Regional Health Directorate, DSD= Disease Surveillance Department, Data reporting and laboratory surveillance follow same pattern as shown by the arrows.

Description of components of the surveillance system

The main components of the surveillance system that were identified include the community, sub-district, health facility, district, regional and national levels. At the community level, CBSVs play a critical role in supporting healthcare workers, identify suspected cases of meningitis as well as carry out health education in the community.

Qualitative Findings

255 In an interview with the CBSVs on their routine task and challenges that confront them, one
256 of them recounted:

257 *"I go from house to house in my community to see whether there are people with signs and*
258 *symptoms of meningitis which I have been doing for more than twenty (20) years now. I have*
259 *difficulties reaching some of the houses by foot and would be glad if they could provide us*
260 *with bicycles. This was done more than ten (10) years ago. Another problem I have is that*
261 *some of the community members make mockery of me that after several years of being a*
262 *volunteer I have nothing to show"* (CBSV, FGD, Yameriga Community)

263 Similarly, another CBSV lamented;

264 *"We are not asking for monthly pay but if once in a while they can recognise our efforts it*
265 *will be fine. You people (healthcare workers) should also consider us first when you are*
266 *looking for casual workers in your health facilities because I have seen that some of you have*
267 *employed casual workers in your health facilities who have never sacrificed for healthcare in*
268 *the district. Also, what my colleague said is entirely true, some community members demean*
269 *the nature of our work and have made discouraging remarks such as we should leave this job*
270 *because if we even collect firewood and sell in the market it is far better"* (CBSV, FGD,
271 *Zubeong Community)*

272 At the sub-district health facility, the DCO collaborates with the CBSVs to refer suspected
273 cases immediately to the district hospital for appropriate investigations and management. The
274 DCO also completes the IDSR immediate case-based reporting form and sends samples of
275 CSF to the district level and makes follow up to contacts of all confirmed cases. IDSR
276 weekly and monthly report forms are prepared and submitted to the Talensi District Health
277 Management Team by the DCO. Table 1 shows a three year trend of meningitis cases in the
278 Talensi district with no fatality in 2014.

279 At the district level, the DCO sends CSF of all suspected cases from all sub-district health
 280 facilities to the regional level for the agglutination test. The IDSR immediate case-based
 281 reporting forms are also submitted to the Regional Health Directorate. Additionally, weekly
 282 IDSR forms, monthly IDSR and community-based surveillance summary report forms are
 283 submitted to the regional level. In an interview with DCOs at the Talensi District Health
 284 Directorate they reported the following:

285 *"Because meningitis is an epidemic prone disease, timely reporting of suspected cases is very*
 286 *good because we are always, even informed, verbally by telephone from the sub-district level*
 287 *before the necessary surveillance forms documentation get to us and we also report likewise*
 288 *to the Regional Health Directorate. However, our problems are that we have inadequate staff*
 289 *trained to take CSF samples and we cannot also carry out agglutination test in our district*
 290 *like other districts. Also, our CBSVs always complain that we don't motivate them for their*
 291 *work" (DCO, FGD, Talensi District Health Directorate)*

292 When the DCOs were asked what the Talensi district was doing to motivate CBSVs, one of
 293 them had this to say:

294 *"We wish we could do that but we don't receive funding allocated for surveillance activities*
 295 *in the district" (DCO, FGD, Talensi District Health Directorate)*

296 At the regional level, samples of CSF are taken to the zonal public health reference laboratory
 297 for final confirmation. The Regional Health Directorate reports all suspected and confirmed
 298 cases at national level at the DSD and provide feedback of confirmation of meningitis results
 299 to various districts in the region including the Talensi district which also relays the
 300 information to the respective sub-district health facilities for the appropriate public health
 301 action. However, feedback of confirmation of meningitis cases delays as laboratory results

are usually received within 3 to 4 days. One of the DCOs at the District Health Directorate complained that;

"Feedback of test results from the region often delay, our health facilities usually call us to find out whether their sample of the suspected case has been confirmed but we usually tell them we are yet to receive the confirmatory results from the regional level" (DCO, FGD, Talensi District Health Directorate).

Resources

There are no specific funds allocated for meningitis surveillance in the district. The total cost for meningitis surveillance is estimated based on the direct personnel cost plus the cost of stationary, transport, laboratory services and telephone per case. However, cost of medication was not considered in the estimation. The direct personnel cost was calculated by multiplying the number of person-hours spent on meningitis surveillance by the hourly salary rate of persons involved. Five (5) cases of meningitis were recorded in 2014 with three (3) DCOs actively involved in their surveillance. Their estimated person-hours per case and hourly salary were 6.5 hours and \$1.56 respectively. Therefore, three officers average direct personnel cost was \$30.49 to detect a case.

Cost of fuel for transport was estimated at \$6.78 whilst cost of stationary, laboratory services and telephone were estimated as \$0.78, \$3.5 and \$1.04 respectively for a case. Hence, the total estimated cost for meningitis surveillance per case in 2014 was \$42.59.

Level of usefulness

The surveillance system is very useful as data from the system has informed policy and decision making that has led to the formulation of policies on meningitis control and prevention for which Talensi district have not recorded any outbreak epidemics for the past 5

years. Also, the periodic half yearly and annual district and regional performance reviews have enhanced strategies to control and prevent meningitis epidemics. Data on meningitis has contributed to awareness creation in communities and alerts health care workers during the meningitis season.

DISCUSSION

The evaluation revealed that the surveillance system has achieved some of its objectives, despite some challenges. It found that the system was simple to operate, flexible and stable. The epidemic prone nature of meningitis might have accounted for the rating of these system attributes. These findings were consistent with studies by McKerr et al. in Taiwan who argue that such attributes were important for easy operation of a surveillance system [31]. The high acceptable attitude of healthcare workers and stakeholders was a good finding as high participation was paramount for early detection of meningitis cases [31]. It is therefore not surprising that data quality was generally good. Also, incidence of reported cases from different sub-districts in the Talensi district made the surveillance system representative, and further supports the high participatory role of healthcare workers and stakeholders involved in meningitis surveillance. However, low sensitivity and low positive predictive values reported in this study were possibly due to the low prevalence of meningitis cases in the Talensi district. The low prevalence of meningitis cases in Talensi district is similar to findings reported in Mali and Burkina Faso and could be attributed to the role-out of MenAfriVac in 2010 of which Ghana was part [15,32]. Additionally, reporting of suspected cases by health facilities to the Talensi district and the Regional Health Directorate were timely. However, there were delays in feedback in confirmation of laboratory results as samples of CSF sent to the Regional Health Directorate were forwarded to the zonal public health reference laboratory in Tamale, which is far and located outside the Upper East Region. The delay in feedback of laboratory confirmation of cases delays public health

350 action if such cases were found to be confirmed for meningitis. Sinclair et al. in India noted
 351 that because of the importance of feedback for immediate public health action, laboratory
 352 infrastructure need to be established throughout in a country to enhance laboratory
 353 surveillance [33].

354 The cost of detecting a case, \$42.59 during the evaluation was observed to be is similar to the
 355 cost reported by Griffiths and Erundu in Chad which was \$49.0 per case [34]. However, lack
 356 of funding for meningitis surveillance during the evaluation posed a major system challenge
 357 for its operation. This has resulted in lack of motivational packages for CBSV who play a
 358 critical role in community surveillance. This is in contrary to studies that observed that
 359 motivation of staff was essential for enhancing surveillance [35]. Such funding would have
 360 been important in training healthcare workers so they can carry out lumbar puncture as this
 361 will help enhance laboratory surveillance. Adopting active surveillance in the Talensi district
 362 as well as other districts in northern Ghana especially during the dry season will greatly
 363 enable healthcare workers to be on the alert and encourage them to display case definitions in
 364 health facilities for constant reminders.

365 **CONCLUSION**

366 Although the surveillance system for meningitis met some of its primary objectives, it is still
 367 confronted with operational challenges. It is important that the Ministry of Health/Ghana
 368 Health Service, the Government of Ghana and Non-Governmental Organizations interested in
 369 health make funding of meningitis surveillance a priority in northern Ghana. Investment in
 370 the surveillance system should address motivation of community-based surveillance
 371 volunteers as their work in the community is critical for local response and national vaccine
 372 impact monitoring and making policy decisions around the meningitis vaccine programmes
 373 in the meningitis belt. Healthcare workers should also be trained to provide them with the

374 needed skills and expertise to carry out lumbar puncture to avoid delays in CSF sampling. A
 375 public health reference laboratory should be built in the Upper East Region to enhance
 376 laboratory confirmation of results and prevent delays in feedback from the zonal public
 377 health reference laboratory. It is also imperative for communities especially in northern
 378 Ghana to be sensitized on meningitis case presentation as well as on the work of CBSVs to
 379 prevent discouraging remarks against them.

380 **Ethical Considerations**

381 Written informed consent was obtained from study participants. The Upper East Regional
 382 Health Directorate and the Talensi District Health Directorate granted approval for study to
 383 be conducted.

384

385 **REFERENCES**

- 386 1. Owusu M, Nguah SB, Boaitey YA, Badu-Boateng E, Abubakar AR, Lartey RA, Adu-
 387 Sarkodie Y. Aetiological agents of cerebrospinal meningitis: a retrospective study
 388 from a teaching hospital in Ghana. *Ann Clin Microbiol Antimicrob.* 2012;11:28. doi:
 389 10.1186/1476-0711-11-28.
- 390 2. Leimkugel J, Adams F A, Gagneux S, Pflüger V et al. An outbreak of serotype 1
 391 *Streptococcus pneumoniae* meningitis in northern Ghana with features that are
 392 characteristic of *Neisseria meningitidis* meningitis epidemics. *J Infect*
 393 *Dis.* 2005;192(2):192-9.
- 394 3. Hayden MH, Dalaba M, Awine T, Akweongo P, Nyaaba G et al. Knowledge,
 395 attitudes, and practices related to meningitis in northern Ghana. *Am J Trop Med*
 396 *Hyg.* 2013;89(2):265-70.
- 397 4. Gagneux SP, Hodgson A, Smith TA, Wirth T, Ehrhard I, Morelli G et al. Prospective
 398 study of a serogroup X *Neisseria meningitidis* outbreak in northern Ghana. *J Infect*
 399 *Dis.* 2002;185(5):618-26. Epub 2002 Feb 14.
- 400 5. Leimkugel J, Hodgson A, Forgor AA, Pflüger V, Dangy JP, Smith T, Achtman
 401 M, Gagneux S, Pluschke G. Clonal waves of *Neisseria* colonisation and disease in
 402 the African meningitis belt: eight- year longitudinal study in northern Ghana. *PLoS*
 403 *Med.* 2007; 4(3):e101.
- 404 6. World Health Organization. Meningococcal meningitis, 2015. Available:
 405 <http://www.who.int/mediacentre/factsheets/fs141/en/>, accessed on 16 July 2015.

7. Hodgson A, Forgor AA, Chandramohan D, Reed Z, Binka F, Bevilacqua C, Boutriau D, Greenwood B. A phase II, randomized study on an investigational DTPw-HBV/Hib-MenAC conjugate vaccine administered to infants in Northern Ghana. *PLoS One*. 2008 May ;3(5):e2159. doi: 10.1371/journal.pone.0002159.
8. David KV, Pricilla RA, Thomas B. Meningococcal meningitis C in Tamil Nadu, public health perspectives. *J Family Med Prim Care*. 2014;3(4):438-9. doi: 10.4103/2249-4863.148143.
9. Tacon CL, Flower O. Diagnosis and management of bacterial meningitis in the paediatric population: a review. *Emerg Med Int*. 2012;2012:320309. doi: 10.1155/2012/320309.
10. Codjoe SN, Nabie VA. Climate change and cerebrospinal meningitis in the Ghanaian meningitis belt. *Int J Environ Res Public Health*. 2014; 11(7):6923-39.
11. Huber CA, Pflüger V, Hamid AW, Forgor AA, Hodgson A, Sié A, Junghanss T, Pluschke G. Lack of antigenic diversification of major outer membrane proteins during clonal waves of *Neisseria meningitidis* serogroup A colonization and disease. *Pathog Dis*. 2013;67(1):4-10.
12. Hodgson A, Smith T, Gagneux S, Adjuik M, Pluschke G, Mensah NK et al. Risk factors for meningococcal meningitis in northern Ghana. *Trans R Soc Trop Med Hyg*. 2001;95(5):477-80.
13. Badolo O, Tiendrebeogo E, Novak RT, WuHM, Wei S, Djingarey MH, Diomande F, Kader Konde M, Clark TA, LaForce M, Messonier N, Tiendrebeogo SM, 2008. Surveillance of meningococcal disease in Burkina Faso. In: *Proceedings of the 16th International Pathogenic Neisseria Meeting*: 234.
14. Adokiya M, Awoonor-Williams J, Barau I, Beiersmann C, Mueller O. Evaluation of the integrated disease surveillance and response system for infectious diseases control in northern Ghana. *BMC Public Health*. 2015;15(1):75.
15. Vaccine Project & Partners. Meningococcal A conjugate vaccine roll-out in the African meningitis belt Meningitis, 2014. Available: http://www.who.int/immunization/sage/meetings/2014/october/1_MenA_vaccine_roll-out_SAGE_30Sep2014.pdf, accessed on 16 July 2015.
16. HMN and WHO. Country Health Information Systems: A Review of the Current Situation and Trends. Geneva: WHO; 2011
17. Ishikawa H, Kamei S. Revised Japanese guidelines for the clinical management of bacterial meningitis' *Rinsho Shinkeigaku*. 2014;54(12):1021-3.
18. WHO, CDC. Technical Guideliness for Integrated Disease Surveillance and Response in the African Region, Brazzaville, Republic of Congo and Atlanta, USA. 1-398, 2010.
19. Kabatereine NB, Malecela M, Lado M, Zaramba S, Amiel O, Kolaczinski JH. How to (or not to) integrate vertical programmes for the control of major neglected tropical diseases in sub-Saharan Africa. *PLoS Negl Trop Dis*. 2010;4(6):e755.
20. WHO-AFRO CDC. Technical Guideliness for Integrated Disease Surveillance and Response in Ghana. 2nd ed. Brazzaville, Republic of Congo and Atlanta, USA: WHO Regional Office for Africa; 2011.

21. Apanga PA, Akparibo R. Ebola: A Call to Strengthen the Healthcare System and Surveillance in West Africa. *IJHSR*. 2015; 5(1): 275-278.
22. The 2014 annual report. Talensi District Health Directorate, Upper East Region. Ghana Health Service
23. Apanga PA, Adam MA. Factors influencing the uptake of family planning services in the Talensi District, Ghana. *The Pan African Medical Journal*. 2015;20:10
24. GSS. 2010 Population and Housing Census: National Analytical Report. Accra: Ghana Statistical Service; 2013.
25. Koutangni T, Boubacar Maïnassara H, Mueller JE. Incidence, carriage and case-carrier ratios for meningococcal meningitis in the African meningitis belt: a systematic review and meta-analysis. *PLoS One*. 2015;10(2):e0116725.
26. Franco LM, Setzer J, Banke K. Improving Performance of IDSR at District and Facility Levels: Experiences in Tanzania and Ghana in Making IDSR Operational. Bethesda, MD: The Partners for Health Reformplus Project, Abt Associates Inc.; 2006.
27. Centre for Disease Control and Prevention. Updated guidelines for evaluating public health surveillance systems: recommendations from the guidelines working group. *MMWR* 2001; 50 (No. RR-13):1-35.
28. Control of epidemic meningococcal disease. WHO practical guidelines. 2nd edition. Available:
<http://www.who.int/csr/resources/publications/meningitis/whoemcbac983.pdf?ua=1>,
accessed on 15 July 2015.
29. Carter SM, Ritchie JE, Sainsbury P. Doing good qualitative research in public health: not as easy as it looks. *N S W Public Health Bull*. 2009;20(7-8):105-11
30. Blignault I, Ritchie J. Revealing the wood and the trees: reporting qualitative research. *Health Promot J Austr*. 2009; 20(2):140-5
31. McKerr C, Lo YC, Edeghere O, Bracebridge S. Evaluation of the national notifiable diseases surveillance system for dengue Fever in Taiwan, 2010-2012. *PLoS Negl Trop Dis*. 2015;9(3):e0003639.
32. Centre for Disease Control and Prevention (CDC).
Evaluation of meningitis surveillance before introduction of serogroup a meningococcal conjugate vaccine -Burkina Faso and Mali. *MMWR Morb Mortal Wkly Rep*. 2012 21;61(50):1025-8.
33. Sinclair D, Preziosi MP, Jacob John T, Greenwood B. The epidemiology of meningococcal disease in India. *Trop Med Int Health*. 2010;15(12):1421-35.
34. Griffiths U, Erundu N. Costs of current and improved meningitis disease surveillance in Chad. *BMC Health Serv Res*. 2014; 14(Suppl 2): P51.
doi: 10.1186/1472-6963-14-S2-P51
35. Leon N, Sanders D, Van Damme W, Besada D, Daviaud E, Oliphant NP, Berzal R, Mason J, Doherty T. The role of 'hidden' community volunteers in community-

492 based health service delivery platforms: examples from sub-Saharan Africa. Global
493 Health Action. 2015;8:27214.
494