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Descriptive Characterization of Epidemic Meningococcal Serogroup W in the Upper West Region of Ghana

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Authors' contributions

This work was carried out in collaboration between all authors. Authors FAB and GKA drafted the manuscript. Authors BS, WO and FAB conducted rapid test as well as culture of CSF specimen. All data management and data analysis were performed by authors GKA, KA, IBN and AB. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

Aims: In recent time, Nm W outbreaks have been on the increase in the African meningitis 'belt'. One of such outbreaks occurred in the Upper West Region of Ghana from December, 2015 to April 2016. The epidemiological features of the outbreak are descriptively characterized and an overview of the reactive vaccination provided.

Study Design: Descriptive.

Place and Duration of Study: Upper West Region of Ghana from December, 2015 to April 2016.

Methods: Data on all cases of meningitis during the outbreak was obtained from the Disease Surveillance Department of the Ghana Health Service. Variables such as age, sex, district of

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residence, reporting district, health facility reported, date seen at health facility, date of onset, laboratory results, outcome and vaccination coverage were used for all analysis.

Results: Between epidemiologic weeks 1 and 7 of the outbreak, the predominant causative organism was Neisseria meningitidis (Serogroup Nm W) forming 70% of all bacterial meningitis cases recorded. Nadowli-Kaleo, Jirapa and Nandom recorded the highest number of confirmed cases with the cases crossing epidemic thresholds in weeks 5,4 and 5 respectively. Majority of confirmed Nm W cases (46 cases) were found in ages 15 years and above. A reactive vaccination campaign was undertaken following the outbreak and a target coverage of 98.4% achieved.

Conclusion: Neisseria meningitidis serogroup NmW is increasingly becoming a major cause of bacterial meningitis and there is the need to institute effective control measures to mitigate its effects. Urbanized areas like Jirapa, Nadowli-Kaleo, Lawra and Nandom districts should have alert and epidemic thresholds reviewed frequently to facilitate early detection and improve early and effective response including vaccination.

Keywords: Neisseria meningitides; epidemic threshold; epidemic week; vaccination.

ABBREVIATIONS

MCV : Meningococcal Conjugate Vaccine
ESRI : Environmental Systems Research Institute
Nm W: Neisseria meningitidis Serogroup W
NNV : Nervous Necrosis Virus
AEFI : Adverse Event Following Immunization
ICG : International Coordinating Group on Vaccine Provision

1. INTRODUCTION

Meningococcal disease remains a major public health challenge in the African "meningitis belt", which stretches from Senegal in the West to Ethiopia in the East [1]. These epidemics are traditionally associated with *Neisseria `meningitidis* belonging to serogroup A. Over time, Nm serogroup A epidemics have declined with serogroup Nm W outbreaks becoming the major threat to public health in the African meningitis belt [2]. *Neisseria meningitidis* serogroup W is associated with 1%–8% of all cases of sporadic meningococcal disease worldwide [3], and the proportion of healthy carriers in the general population ranges from 1% to 10% [4]. Traditional risk factors for meningococcal disease include household contact with a known patient, overcrowding, exposure to tobacco smoke, viral upper respiratory infection, asplenia, and complement deficiencies. Maintaining healthy habits, like getting plenty of rest and not coming into close contact with people who are sick, helps prevent meningitis outbreaks, keeping up to date with recommended immunizations is the best defense against meningococcal disease [5]. Meningococcal vaccines protect against most forms of meningitis; the meningococcal polysaccharide vaccine is approved for use for individuals 2 years of age. Meningococcal conjugate vaccine (MCV) was licensed in 2005 and is approved for use in individuals who are 2–55 years of age. The vaccine is quadrivalent and confer protection against serogroups A, C, Y, and W [5,6].

Ghana experienced widespread meningococcal meningitis epidemics in 1984/85 and 1996/97. During the 1996/1997 epidemic, about 19,000 people were affected with 1,200 deaths [7,8]. The 1996/97 outbreaks involved all the 24 districts and 34 districts respectively in the three regions of the northern sector of the country [7]. Since then the country has experienced minor and focal outbreaks each year during the dry season, stretching from October to April each year in the three northern regions lying within the African meningitis belt. [9]. The Upper West region just like the two other northern regions in Ghana is endemic for meningococcal disease with unpredictable epidemics. Meningitis cases are reported throughout the year with upsurge of cases during the harsh, dry and dusty harmattan season. The present study was conducted following a large scale bacterial meningitis outbreak that occurred in the Upper West region of Ghana with 4 districts (namely; Jirapa, Nandom, Nadowli/Kaleo and Lawra) severely affected between December 2015 and April 2016. All cases were monitored at the district and regional levels using the alert and epidemic thresholds. Cerebrospinal fluid samples were taken from suspected meningitis cases and laboratory confirmed by culture. The Upper West Regional Health directorate embarked on a subsequent vaccination campaign following the outbreak. Here, we examine the

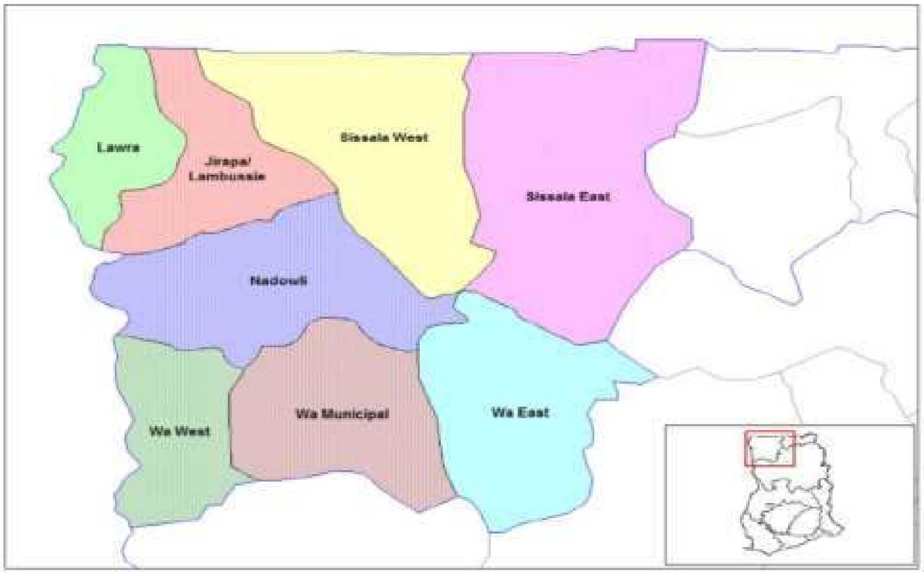

Fig. 1. Map of the upper west region of Ghana 11

epidemiological features of this outbreak. Specifically, we set out to; describe the geographic distribution of all bacterial meningitis cases across the districts in the Upper West region throughout the outbreak, characterize the trend of cases with epidemic weeks in the hardest hit districts, describe the host range age and sex distribution of all cases and provide an overview of the reactive mass vaccination campaign following the outbreak.

1.1 Study Site

The Upper West Region shares borders to the east with the Upper East Region, to the south with the Northern Region as shown in Fig. 1. The region covers a geographical area of 18,476 square kilometers, which is about 12.7% of the total land area of Ghana [10,11]. The region is located in the Guinea Savannah belt. The climate of the Upper West Region follows a general pattern identified with the three northern regions in Ghana. It has a single rainy season from April to September, with average annual rainfall of about 115 mm [11]. This is followed by harmattan, a prolonged dry season characterized by cold and hazy weather from early November to March, and an intense hot weather that ends only with the onset of early rainfall in April. The rather harsh climatic condition makes the region prone to meningitis disease almost to endemic proportions and hence its occurrence in the African 'meningitis belt' [1,11].

2. METHODS

The line list of all suspected cases of bacterial meningitis by district between December 2015 and April 2016 from the Upper West Region was obtained from the Ghana Health Service's Disease Surveillance Department. Secondly, information on the coverage of the reactive vaccination campaign by district in the Upper West Region following the bacterial meningitis outbreak was also obtained. Variables such as age, sex, district of residence, district of reportage, health facility reported, date seen at health facility, date of onset, laboratory results and outcome, were all extracted from the data and was used for all descriptive analysis. Analysis was done based on set aims and objectives, all data was double entered into the Microsoft excel software spread sheet and later converted to fit the used statistical software. ArcGIS 10.3.1 (Environmental Systems Research Institute (ESRI) software was used to display the geographic distribution of all suspected and confirmed cases of bacterial meningitis across the districts of the Upper West region throughout the outbreak. STATA'14 statistical software package (Stata Corp.2007. Stata Statistical Software. Release 14. StataCorp LP, College Station, TX, USA) was used for all descriptive analysis (univariate and bivariate analysis).

3. RESULTS

A total of 560 suspected cases of bacterial meningitis were recorded from the Upper West region throughout the outbreak with 89 cases laboratory confirmed by culture to be cases of bacterial meningitis. *Neisseria meningitidis (Serogroup Nm W)* formed the majority with 63 cases recorded, representing 70% of all cases. Nadowli-Kaleo, Jirapa and Wa West recorded the highest suspected cases as seen in Table 1. In Fig. 6 as well it is observed that the highest number of suspected cases between weeks 1 and 7 were recorded in the aforementioned 3 districts. The Jirapa and Nadowli districts recorded the highest number of laboratory confirmed Nm W cases as seen in Fig. 7. From Table 2, age groups 6-14 years and 45 years and above recorded the highest number of Nm W cases with 12 deaths identified. The sex distribution of cases was almost equal with males recording 31 and females 32. Though majority of NmW cases recorded were within the ages 15 years and above, there was no significant association between age group and laboratory result ($p > 0.05$) as shown in Table 3. The cases were as well monitored using alert and epidemic thresholds, in Jirapa, from week 1, the number of cases crossed the alert threshold and further increased to cross the epidemic threshold in week 4 as seen in Fig. 2. In Nadowli/Kaleo district, the number of suspected meningitis cases increased and crossed the alert threshold in week 4 and then crossed the epidemic threshold in week 5 as observed in Fig. 3. In Nandom, the number of meningitis cases increased and crossed the alert threshold in week 4 and the epidemic threshold in week 5 as seen in Fig. 5. Among all the cases confirmed between week 1 and 7, the predominant causative organism was Neisseria *meningitidis* (Nm W). In, Lawra the number of meningitis cases increased and crossed the alert threshold in week 3 and remained well below the epidemic threshold as observed in Fig. 4. A request for vaccines to undertake a reactive vaccination campaign was made to ICG. The request covered Jirapa, Nadowli/Kaleo, Nandom and Lawra districts. Lawra and Nandom were included to prevent international spread to Burkina Faso. The request for three districts was approved excluding Lawra. The reactive vaccination undertaken in the three districts are seen in Table 5. A total of 150,250 doses of Meningococcal ACW vaccines were received and administered to persons between ages 2-29 years of age as observed in Table 4, 139,700 out of the received vaccines were used with a waste rate of 2.9 recorded and a target coverage of 98.4% achieved.

Table 1. Summary distribution of suspected & confirmed meningitis cases across the Upper West Region of Ghana

District	Number of cases	Confirmed cases		
		H. influenzae	***N. meningitidis***	***S. pneumoniae***
Wa Municipal	33	0	0	1
Lawra	29	0	3	1
Jirapa	198	1	21	9
Nadowli-Kaleo	119	1	11	4
Wa West	81	0	15	6
Nandom	31	0	8	1
Wa East	21	0	4	1
Daffiama Bussie Issa	29	0	1	1
Sissala West	5	0	0	0
Lambuddie Kani	12	0	0	0
Sissala East	2	0	0	0
Total	560	2	63	24

Table 2. Host Distribution of suspected bacterial Meningitis cases by age group, sex and outcome

Organism	Age group (years)				Sex		Outcome	
	0-5	**6-14**	**15-44**	**45>**	**Male**	**Female**	**Alive**	**Dead**
H. influenzae	0	0	2	0	1	1	2	0
N. meningitis	1	6	28	28	31	32	57	6
S. pneumoniae	0	1	15	8	11	13	18	6

Table 3. Test for association between variables of all cases

Variables	Chi square/Fisher's exact test for association
Age group vs. Outcome	Fisher's exact =0.233
Outcome vs PCR	Fisher's exact =0.092
Case status vs Outcome	Pearson chi square =22.352, p-value =0.000
Sex vs Outcome	Pearson chi square = 2.964, p-value = 0.085

Univariate analysis was carried out using STATA statistical software package (StataCorp.2007. Stata statistical Software. Release 12. StataCorp LP, College Station, TX, USA).

Table 4. Population break down by sub district [11]

Name of district	Total population	2-29-year age group population
Jirapa	98,971	62,352
Nandom	50,698	31,940
Nadowli-Kaleo	69,190	43,590

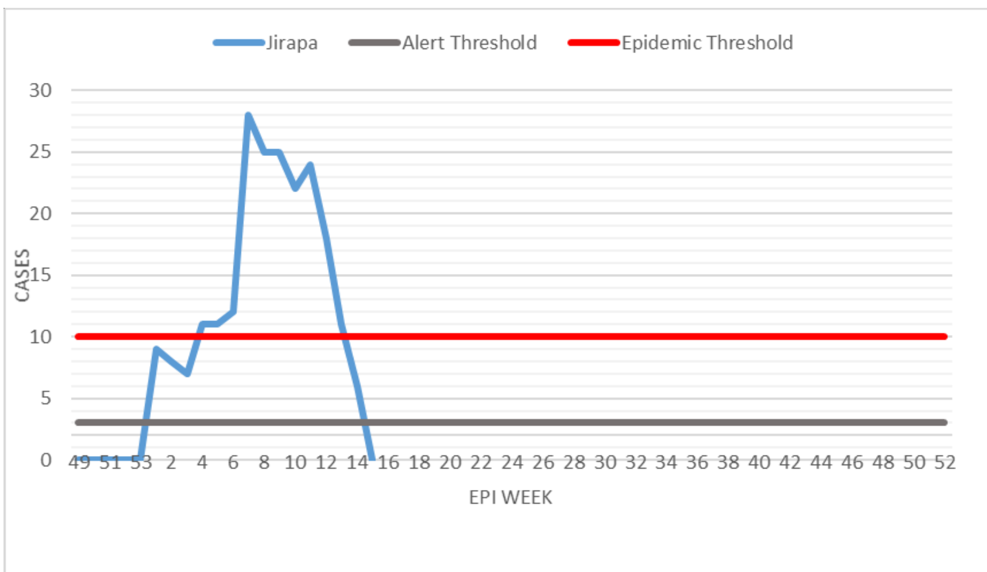

Fig. 2. Meningitis monitoring chart for Jirapa district 2016 epidemiological season

Table 5. Reactive vaccination coverage by sub districts by the three districts for THE meningitis ACW 135 vaccines march 2016

List teams or sub districts or districts	Population for 2016	Target population (63%*C) (2-29 years)	Total vaccinated	Doses of Men ACW vaccines received	Doses of Men ACW vaccines used	Number of AEFI cases identified	% coverage of 2-29 years
Upper West	218,862	137,883	135,679	150250	139700	7	98.4
Jirapa	98,971	62,352	57,916	70050	63570	2	92.9
Nandom	50,698	31,940	32,878	31920	30710	3	102.9
Nadowli Kaleo	69,193	43,592	44,885	48280	45420	2	103.0

Key; AEFI -Adverse Event Following Immunization, Men ACW – meningitis ACW vaccines

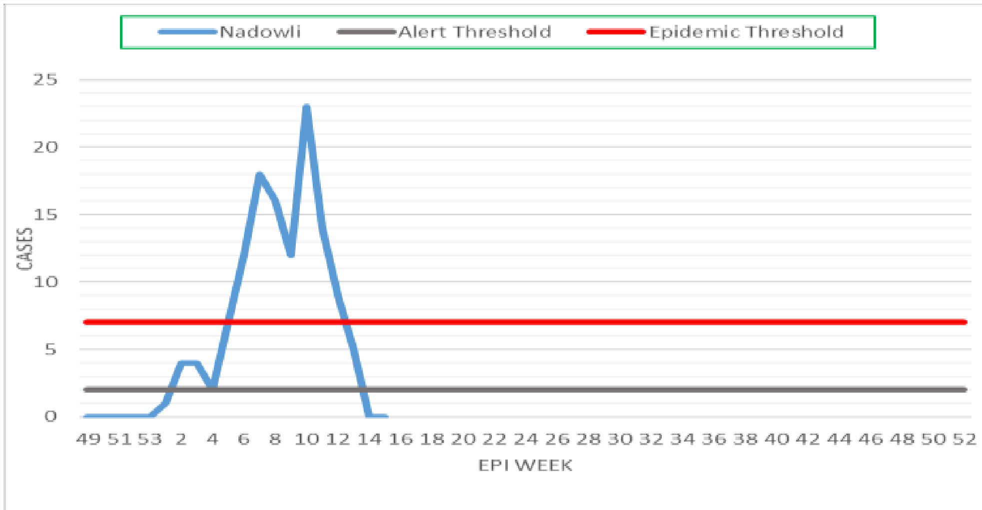

Fig. 3. Meningitis monitoring chart for Nadowli/Kaleo 2016 epidemiological season

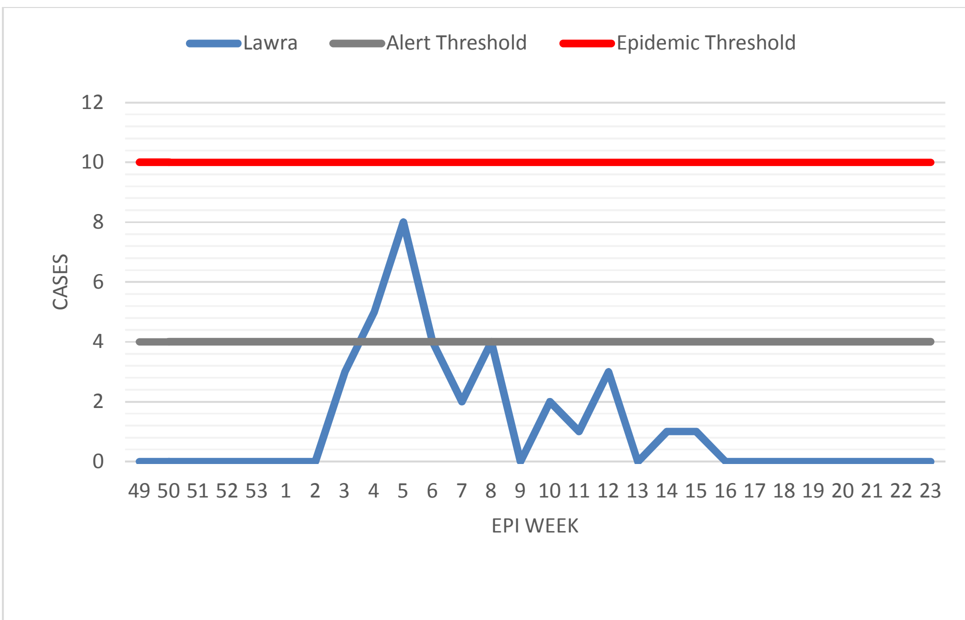

Fig. 4. Meningitis monitoring chart for Lawra district 2016 epidemiological season

4. DISCUSSION

Meningococcal serogroup W has been known to be the cause of various isolated outbreaks of bacterial meningitis for a long time and has been recently linked with a number of outbreaks in Ghana [2,4,12,13]. This particular bacterial meningitis outbreak hit various parts of Ghana's Northern and Brong Ahafo region. A study on the epidemiological dynamics of a bacterial meningitis outbreak in two districts in northern Ghana revealed that even though two outbreaks due to pneumococcal and meningococcal meningitis were identified, majority of cases were due to meningococcal serogroup W [12]. Seventy percent of all confirmed bacterial meningitis cases were Nm W supporting the fact that the Nm W strain of meningococcal meningitis should be prioritized. The public health importance of this particular form of bacterial meningitis cannot be over emphasized and has been noted in previous literature conducted not just in Ghana but in Burkina Faso and other African countries that occur in the African 'meningitis belt' [14–17].

Jirapa and Nadowli districts which recorded the highest number of suspected cases and confirmed cases happen to be two of the highly-populated areas in the Upper West region of Ghana [18,19]. Further evidence of the high population of Jirapa and Nadowli can be observed in Table 4 of the results section where the age category 2- 29 years happened to be higher in these two districts than in Nandom. The direct relationship between overcrowding

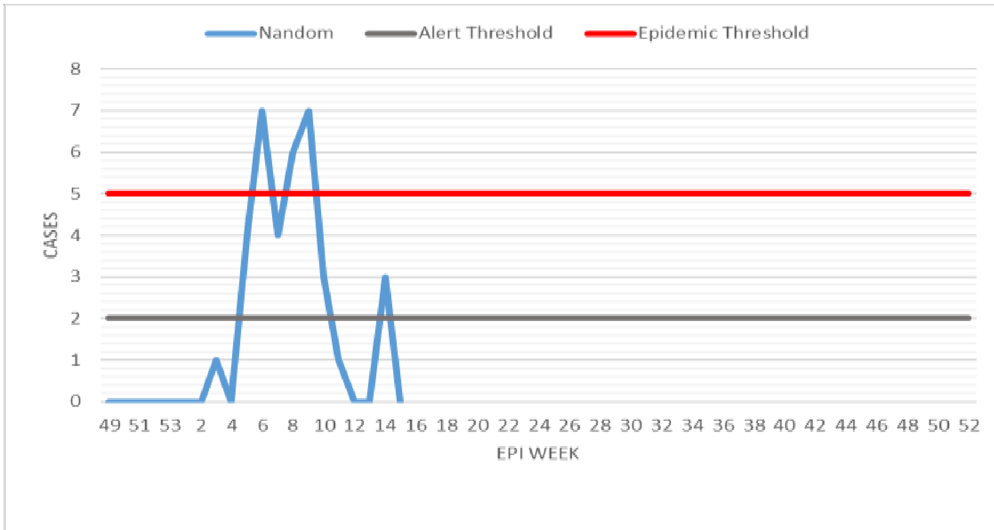

Fig. 5. Meningitis monitoring chart for Nandom 2016 epidemiological season

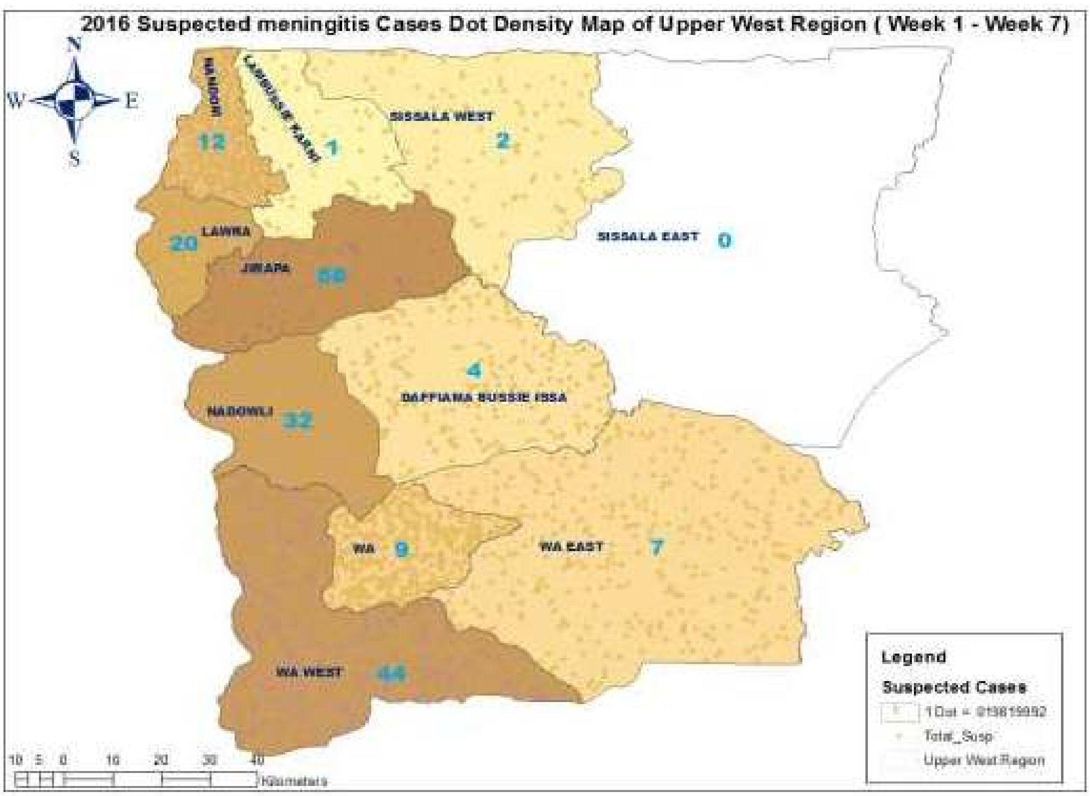

Fig. 6. Suspected meningitis cases from Upper West Region, Weeks 1-7

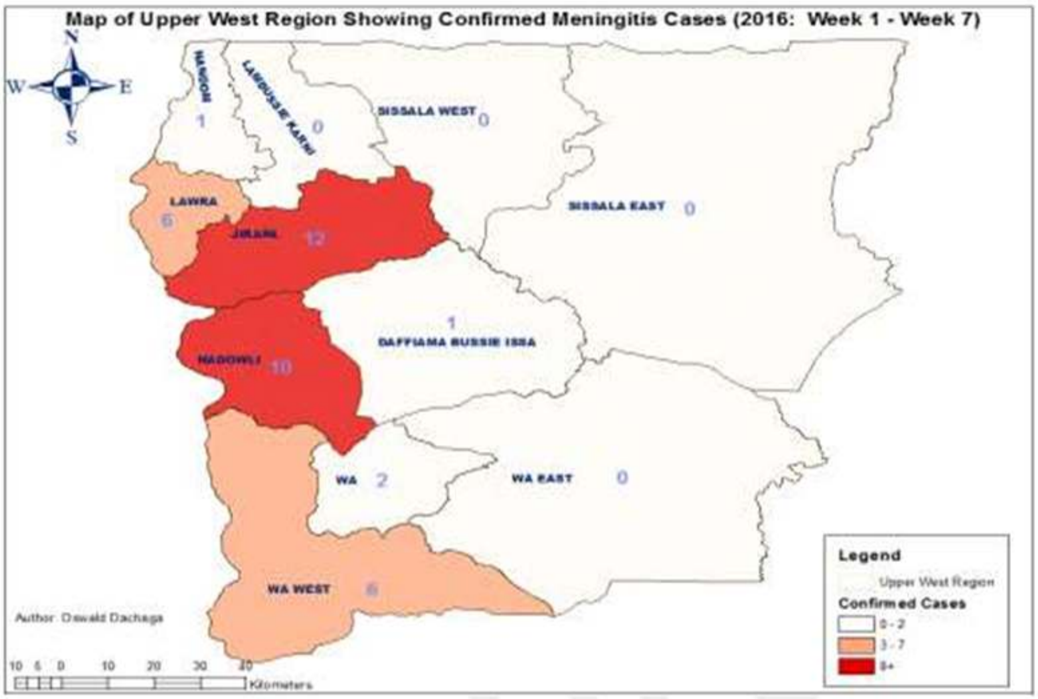

Fig. 7. Confirmed meningitis cases from upper west region, Weeks 1-7

and the spread of various communicable disease like meningitis has been properly documented in a number of publications [20–22], meningitis transmissibility in these two districts though not conclusive is most likely to be higher than in lowly populated and less crowded areas in the Upper West that were affected by the outbreak. Other probable explanations to the geographical distribution of the cases in the Upper west region can be attributed to disparities in urbanization, social behavior and certain socio-economic factors. Jirapa and Nadowli are some of the notable urban areas within the Upper West region and hence most likely to experience overcrowding due to high socio-economic activities, this development has a potential of causing an outbreak. To further buttress the issue of population and overcrowding, Jirapa and Nadowli had more of their suspected cases confirmed as cases of Nm W than any other district between week 1 and 7 of the outbreak, this can be observed in Figs. 6 and 7. The Wa West district which happens to be one of the urbanized districts in the region recorded high numbers of suspected cases (44 suspected cases of Nm W) but only had a few of those cases laboratory confirmed to be meningococcal meningitis (6 confirmed cases of Nm W).

A number of independent risk factors for meningococcal disease have been identified, previous studies have mentioned females and persons 60 years and above as individuals at risk of contracting meningitis [22]. The host age distribution of meningitis with respect to this outbreak identified age categories 15-44 years and 45 years and above recording the highest number of suspected cases for *Neisseria meningitidis* and even pneumococcal meningitis. These results were a bit different from a recent study which reported age group 6-14 years reporting majority of cases of Nm W [12]. Other studies have reported outbreaks among non-infant children and adults in the Brong-Ahafo region of Ghana between December 2015 and April 2016, though the dominant pathogen was *Streptococcus pneumoniae* [6]. The sex distribution of Nm W cases was virtually equal which explains the absence of any significant association between sex and laboratory result ($p > 0.05$, Fisher's exact = 0.375) as observed in Tables 2 and 3 in the results section. Most studies on risk factors for meningococcal disease have highlighted factors like socioeconomic level, climate and environment, urbanization level, geographical localization, upper respiratory tract or viral Infections, social behavior, demography and recreational spaces as the cause of the spread of meningococcal meningitis. Other risk factors like age and gender have been marginalized especially with respect to studies in Africa [21].

Between week 1 and week 7 of the outbreak Jirapa and Nadowli districts happened to be the hardest hit districts with respect to Nm W displayed in Figs. 2 and 3 respectively. Nadowli/Kaleo district, had suspected meningitis cases increase and cross the alert threshold in week 4 and then cross the epidemic threshold in week 7 as observed in Fig. 3. In Jirapa, from week 1, the number of cases crossed the alert threshold and further increased to cross the epidemic threshold in week 4 as seen in Figure 2. Notably, the cases peaked in the 7th week of the outbreak for Jirapa district and in week 10 for the Nadowli district. Jirapa has previously recorded an outbreak of meningococcal disease in 2010 and the occurrence of this very outbreak further emphasizes the endemic nature of the disease in the district. The response actions such as strengthening surveillance and reporting, capacity building of health staff and village volunteers, reactivation of the districts and regional epidemic committees and intensive public education on the signs and symptoms of meningitis and the need for early health care seeking behavior can help effectively mitigate the effects of any other potential outbreak [3,5,23–25]. Cases in Lawra and in Nandom over the course of the outbreak only crossed alert thresholds in week 3 and week 5 respectively. In both districts cases remained below the epidemic threshold especially for Lawra which explains the exclusion of Lawra from the subsequent vaccination exercise.

Preventive vaccination using Nm A has actually reduced the incidence of meningitis in Ghana since it was the dominant pathogen causing outbreaks. Establishing the outbreak in these districts led to a request for vaccines from ICG. There was an apparent delay in the request for vaccines mainly due to the delay in laboratory confirmation. A minimum number of the causative pathogens is required for a successful vaccine request and that could not be met with the low confirmation. The final request covered Jirapa, Nadowli/Kaleo, Nandom and Lawra districts. Lawra and Nandom were included to prevent international spread to Burkina Faso, a boundary country. The request for three districts was approved but Lawra was exempted because the number of cases only crossed alert threshold but not the epidemic threshold as shown in Fig 4. A total of 150,250 doses of Meningococcal ACW vaccines were received and administered to persons between ages 2-29 years of age as observed in Table 4. A coverage of 98.4% was achieved as seen in Table 5. The vaccination was carried out four weeks after the detection that cases crossed the epidemic threshold in the aforementioned three eligible districts. Studies have reported that, accelerating time to vaccination could prevent more cases per event than lowering the threshold. Once the meningitis epidemic threshold is crossed, it is of critical importance that vaccination campaigns, where appropriate, are initiated rapidly [26]. The study by Trotter et al. cited that using 2014 price estimates from the ICG, with a 6-week interval from crossing an epidemic threshold to population protection from vaccination, the vaccine cost per case prevented (including operational costs) ranged from US$ 31,200 to US$ 13,700 with ACW polysaccharide vaccine, depending on the threshold tested. The corresponding Nervous Necrosis Virus (NNV) to prevent a case varied from $11,600 to $4300. If the interval is shortened to 4 weeks, costs per case prevented ranged from US$ 10,600 to US$ 8600 (NNV 3700–2800) [26]. Thus, achieving the shortest possible response time improved the cost-effectiveness of the intervention, regardless of the threshold selected. The emphasis on timeliness of response is echoed in two recent papers that analyzed outbreaks of NmA disease in northern Nigeria [27] and NmW disease in Burkina Faso [28].

5. CONCLUSION

Neisseria meningitidis serogroup Nm W is increasingly becoming a major cause of bacterial meningitis and there is the need to institute effective measures to mitigate its effects. The highly populated Jirapa, Nadowli- Kaleo and Wa West districts recorded the highest number of suspected and confirmed cases. There is evidence that association exists between overcrowding and ease of spread of meningitis and therefore enhanced surveillance needs to be maintained in such highly populated districts particularly during the meningitis season. Surveillance should as well be intensified at the sub-district level to enhance better identification and detection of cases. Again, with other studies identifying that low meningitis thresholds improve timely detection of epidemics, it is important that areas like the Jirapa, Nadowli-Kaleo, Lawra, Wa West and Nandom districts have alert and epidemic thresholds reviewed with increasing population size to facilitate better detection and combat of outbreaks. The subsequent reactive vaccination campaign that was carried out in response to the outbreak was done 4 weeks after the epidemic threshold was crossed, in subsequent outbreaks it is recommended that once the meningitis epidemic threshold is crossed, it is of critical importance that vaccination campaigns, where appropriate be initiated rapidly.

CONSENT

As per international standard or university standard, patient's written consent has been collected and preserved by the authors

ETHICAL APPROVAL

Approval for access to existing data on cases of bacterial meningitis during the outbreak was obtained from the Disease Surveillance Department of the Ghana Health Service.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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