Descriptive Data Analysis of Tuberculosis Surveillance Data, Sene East District, Ghana, 2020

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ABSTRACT

Introduction: On 20th February 2017, health officials in Nadowli-Kaleo District (NKD) of Ghana's Upper West Region received reports of an upsurge in the number of meningitis case-patients reporting to the district's health facilities. The number of cases had exceeded the alert but not epidemic threshold for meningitis for the district. We investigated to identify the aetiologic agent, determine the risk factors and implement control measures. **Methods:** We conducted an unmatched case-control study. A meningitis case-patient was any NKD resident with any of the following signs and symptoms: neck stiffness, convulsion, bulging fontanelle (infants), altered consciousness or other meningeal signs with or without fever, from 1st January to 30th March 2017. For each case-patient, 2 controls (neighbours of case-patients without meningitis signs and symptoms) were identified. Demographic and clinical data were obtained through records review and case-patient interviews. Cerebrospinal fluid (CSF) samples were collected for laboratory investigation. Significant risk factors were identified using multivariable logistic regression. **Results:** In all 67 case-patients comprising 35 (52.2%) males and two (3%) children aged < 5 years were identified. The median age of case-patients was 24 years (interquartile range: 15–46 years). Ten deaths were recorded (case fatality rate: 14.9%). Most affected age group was 15-24 years with 18 (26.9%) case-patients and an age-specific attack rate of 170.8/100000 population. Nadowli Central sub-district, the epicenter, recorded 14 (22.4%) cases. Dominant aetiologic agent was *Neisseria meningitidis* isolated from 17 (58.6%) of 29 culture-positive CSF samples. Compared to controls, meningitis case-patients had higher odds of living in single window rooms (adjusted odds ratio (aOR) =5.05; 95% confidence interval (CI) =1.35-11.66), or in rooms inhabited by more than two people (aOR=3.28, CI=1.57-7.73). **Conclusion:** *Neisseria meningitidis* caused the upsurge in meningitis cases in NKD, with the youth being the most affected age group. Living in poorly ventilated rooms and overcrowded rooms were risk factors. Prompt case-management and health education helped control the occurrence and prevented an outbreak.

KEYWORDS: Tuberculosis, case detection, Surveillance data analysis, Sene East, Bono East

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Introduction

Meningitis is the inflammation of the meninges of the brain and or spinal cord. Meningitis can result from many causes, both infectious and non-infectious agents. Meningitis caused by bacteria is an acute life-threatening condition that requires prompt recognition and treatment. The common respiratory pathogens causing bacterial meningitis are *Neisseria meningitidis, Streptococcus pneumonia*, and *Haemophilus influenza* [1]. They are spread from person to person by close contact with respiratory secretions.

Meningitis is still a major public health challenge especially along the African "meningitis belt". Epidemic bacterial meningitis is common along the African "meningitis belt" which is vast space of land that extends from Ethiopia in East Africa to Senegal in West Africa. It includes 26 countries where recurring epidemics results in incidence rates of greater than 1,000 cases per 100,000 population [2]. Globally, the mortality rates for meningitis are between 2% - 50% [3].

The five regions of Northern Ghana (Northern, North East, Savanna, Upper East and Upper west), some parts of the Oti and Bono East regions of Ghana fall within the African meningitis belt and are mostly affected [4] . On March 20, 2017, the Nadowli-Kaleo District (NKD) reported an upsurge in the number of reported meningitis cases. The district had exceeded its alert threshold on several occasions but had not hit the epidemic threshold. The Disease Surveillance Department of the Ghana Health Service sent a team of public health officials to the district to identify the etiological agent, determine the associated risk factors and to implement control measures.

Methods

Setting

Our investigation was conducted in the Nadowli-Kaleo District of the Upper West region. It is one of the thirteen administrative districts and municipalities in the region. It was carved out of the then Nadowli District in June 2012 under Legislative Instrument (L.I) 2101 with Nadowli as its capital. The Nadowli-Kaleo District is centrally located in the Upper West region of Ghana. It is bordered to the south by Wa Municipal, west by Burkina Faso, north by Jirapa and Lambussie-Karni Districts and to the east by the Daffiama-Bussie-Issa District Figure 1. The Nadowli-Kaleo District (NKD) lies within the African "meningitis belt". The district has an estimated population of 61,561 inhabitants and covers a land area of 1,132 Km2 according to the Ghana Statistical Service [5]. It´s largely a rural settlement with one hospital, 12 Health Centers and 14 Community Health Planning Services (CHPS) compounds [6].

Study Design

We used both descriptive and case control study designs for this investigation. We described the cases by person, place, and time. We employed a 1:2 un-matched community-based case control study. Our cases included all residence of NKD with confirmed Meningitis diagnosis during the outbreak and randomly selected neighborhood controls where the cases lived. The investigations were done between 20th and 31st March 2017.

Data collection

Descriptive Study

We engaged and interviewed health officials including the District Director of Health Services, District Disease Control and Surveillance Officers, the Hospital Management Team, Clinicians, and Laboratory staff to obtain first-hand information on the occurrence. We reviewed surveillance data, medical records, and the initial line-list generated by the district health team.

We used structured questionnaires to interview health officials and community leaders on the nature of the situation. We interviewed some of the case patients on admission in the wards. Data was abstracted on age, sex, signs and symptoms, date of illness onset, date of admission, date of discharge, treatments given and laboratory outcome. We visited some of the affected case-patients who had been treated and discharged. Based on the information gathered we defined a case of Meningitis as "Any person within NKD with any of the following: neck stiffness, convulsion, bulging fontanelle (infants), altered consciousness or other meningeal signs with or without fever, from 1st January to 30th March 2017".

We conducted active case search in the health facilities, by reviewing out-patient department, consulting room, admission and discharge registers as well as patient folders within the facility. We updated the line list with the new cases identified. We conducted active case search in the communities and interviewed case patients, their contacts and community members using an abridged semi-structured questionnaire that focused on socio-demographic and basic case history data.

Case Control Study

We conducted an unmatched case control study in the district using the entire population of NKD as the exposed population. Using the 'Statcalc' utility feature of Epi-InfoTM statistical software for calculating sample size when comparing proportions, we used a confidence level of 95% and power of 80%. The expected exposure frequency (living in poorly ventilated rooms) in controls of 30%, expected exposure frequency in cases of 60%, case to control ratio of 1:2 and an odds ratio of 3.5 (for a risk factor on which intervention would have a significant impact). We recruited and interviewed 31 cases and 62 controls.

Selection of Cases and Controls

The NKD hospital is the only referral facility in the district. We randomly selected case patients on admission in the hospital and those who had been discharged using the line list by generating random numbers in Microsoft Excel. We tracked those who had been discharged and interviewed them in their residences. We defined a control as any person within the NKD without any of the following: neck stiffness, convulsion, bulging fontanelle (infants), altered consciousness or other meningeal signs with or without fever, from 1st January to 30th March 2017 and who comes from same community and neighborhood of a case. We selected two controls for each case and interviewed them on the same day on which the case was interviewed. The first control was randomly selected from the same household as the case. The second control was selected by spinning a bottle in the center of the house of the case. We selected the immediate house to the direction of the top of the bottle and randomly selected the second control from that house. Random selection of controls was done by numbering all persons met in a household on pieces of paper, mixed them and one selected.

Assessment of surveillance and Laboratory activities

We assessed the district´s meningitis surveillance system by reviewing case detection and reporting to next level, data collection and analysis procedures and their epidemic response readiness using a structured questionnaire. We also assessed the NKD Hospital Laboratory´s capacity in terms of human resource capacity, CSF sample collection, storage, processing, analyses and transportation to the Zonal Public Health Reference Laboratory for further testing.

Conducted environmental assessment

We conducted environmental assessment of the district, with focus on housing structure and room ventilation, household population density as well as Water Sanitation and Hygiene (WASH) practices in the communities using a structured questionnaire.

Data management

Data was entered, cleaned, and analysed using Epi Info version 7. We performed a descriptive analysis of the data by person, place and time. Univariate analysis was done by expressing categorical variables as frequencies and relative frequencies. Continuous variable (age) was expressed as median and interquartile range as the appropriate measure of central tendency and dispersion. We calculated overall, age and sex specific attack rates by dividing the number of cases with baseline population estimates for the period. Case-fatality rate (CFR) was calculated by dividing the number of deaths by total numbers of suspected case. We drew an epidemic curve to depict the occurrence.

For analysis of the case-control data, we dichotomized qualitative exposure-variables and compared them among case patients and controls in bivariate analysis. We used Chi-Square test at 95% confidence level to identify potential risk factors for infection. We included all significant factors in a logistic regression model at 95% confidence level to identify the risk factors associated with meningitis-case status. An exposure was considered a risk factor if the odds of association with Meningitis-case status at 95% confidence interval was statistically significant for a p-value <0.05.

Ethical considerations

We sought permission from the Upper West Regional Health Directorate and the Nadowli-Kaleo District Health Directorate to carry out this study. Informed consent was sought from the participants before the interviews while mothers consented in the case of minors. We used coding to ensure the protection of participant confidentiality. We discussed the preliminary report with the Surveillance Unit of the Ghana Health Service, the Regional and District Health Directorates. The Ghana Health Service deemed this a public health emergency hence, no ethical approval was required locally for this study.

Results

Descriptive Statistics

The index case was a 79-year-old male from the Kulpieni village. He reported of neck stiffness and difficulty in breathing on the 2nd January, 2017. He had visited the Kulpieni Community Health Planning Services (CHPS) compound on 3rd January 2017 and was referred to the Nadowli-Kaleo District Hospital where a CSF sample was taken for laboratory investigation. He passed on in the evening of 3rd January, 2017. The results turn out positive for meningitis after he had passed on.

From January, 3rd through to 26th March, 2017, a total of 67 meningitis case-patients were recorded with an overall attack rate of 108.8/100,000 population. They were 10 mortalities giving a case fatality rate of 14.9%. The median age of the suspected cases was 24 years (Interquartile Range 15 - 46 years). About 3% (2/67) of the case-patients were under five years old. A higher proportion of the case-patients 18 (26.9%) were within age group 15- 24 years **Figure 2** formed majority of the cases, 35(52.2%) **Table 1**. The sex-specific attack was 121.7/100000 population for males and 97.5/100000 population for females. Age group 15-24years recorded the age-specific attack rate of 170.8/100000 population, this was followed by age group 45-54 years with an attack rate of 164.1/100000 population, children under five years has the least attack rate of 25.6/100000 population.

The outbreak affected 41 villages/communities in the Nadowli-Kaleo District and Daffiama-Bussie-Issah (DBI) an adjourning district. The Nadowli-Central recorded the highest proportion of cases 22.2% (14/67), Charipong 6.0% (4/67) cases with Tangasie, Papu, Kpazie, all recording 3(4.4%) cases each.

The date of symptoms onset in the district was on the 2nd of January, 2017 in Epi week 1 **Figure 3**. The district with an estimated population of 61,000, has an alert threshold of 5/100,000 population and an epidemic threshold of 10/100,000 population. The epi-curve had 2 notable peaks (Epi week 3 and Epi week 8). The district had exceeded the alert threshold in Epi week 3 and the interventions which included active case search, contact tracing started in Epi week 8. The outbreak had a propagated pattern of spread lasting 13 weeks. Following the intervention, the cases went down and by Epi week 15, there were no recorded cases. The incubation period of meningitis is 2- 10days, after the third Epi week when no cases were recorded, the upsurge in meningitis cases was brought under control.

Laboratory findings

The Nadowli-Kaleo district hospital laboratory performed latex agglutination and gram staining on all the samples after which the samples were referred to the Zonal Public Health Laboratory in Tamale for further testing and confirmation. The Gram staining reaction for most samples showed Gram Negative Cocci (GNC) mostly diplococci with the latex agglutination test revealing *Neisseria meningitides* as the causative organism for majority 58.6% (17/29) of the positive samples.

Our laboratory assessment revealed the lack of reagents and supplies for most of the laboratories in all eight health centers which also lacked qualified laboratory personnel. There was time lag in the transportation of samples to the referral laboratory for confirmation.

Case management

The clinical management of all the cases was done in the district hospital, which served as the referral center for all the health facilities in the district and also the adjourning district, Daffiama-Bussie-Issa District. The common sign and symptoms presented were headache 42(62.7%), fever 37 (55.2%), neck stiffness 21(31.3%), and altered consciousness 13 (19.4%). Intravenous (IV) Ceftriaxone, a broad-spectrum antibiotic for 5-7 days and dexamethasone were the drugs of choice used in the management of all the cases.

Surveillance and contact tracing

The district had adequate numbers of Disease Control Officers (DCO) and Nurses based on the Ghana Health Service staffing norms. With a simple and sensitive case definition, the health centers at the sub-district level easily picked up suspected cases and timely referred them to the district hospital, which had adequate capacity to diagnose and manage the cases.

Case based forms were forwarded to the DCO, who then created and updated the line list on a daily basis of all the cases in the district. The DCO updated the District Health Management team three times a week on situational report of meningitis in the district. The District Disease Control Officer performs routine analysis of the data by person, place and time by drawing spot maps and graphs to depict the situation.

There was an active contact tracing team led by a disease control officer and predominantly made up of Community Health Nurses and Community Health Volunteers. The contact tracing team line listed and traced 143 contacts. These contacts were monitored daily through phone calls and home visiting and frequently given education on the signs and symptoms of Meningitis. A total of eight (5.6%) of the contacts traced were infected with meningitis.

Environmental assessment

The environmental assessment revealed a general dry and windy environment, low humidity and high temperatures, with temperatures above 400C on somedays. Bushfires were rampant with the general vegetation and farmlands affected leaving the atmosphere dry and dusty. The houses in the affected communities were mostly built from mud with mostly thatch and corrugated roofing materials. Windows to most homes were single, small, and mostly covered with polythene material. Firewood was the main fuel used for cooking. On the average, the number of occupants per room was four, with a range of one person to seven persons per room. The classrooms of basic schools in the district were mostly full to capacity, with overcrowding observed in about 50% of the schools. The un-tarred nature of the roads in the communities also made the surrounding dusty.

Risk Factors for Meningitis infection

Our multiple logistic regression revealed that, compared to controls, meningitis case-patients had higher odds of living in single window rooms (adjusted odds ratio (aOR) =5.05; 95% confidence interval (CI) =1.35-11.66), or in rooms inhabited by more than two people (aOR=3.28, CI=1.57-7.73) **Table 2**.

Discussion

Northern Ghana continues to record focal outbreaks of meningitis annually despite the improvement in overall public health intervention. Our study revealed a high case fatality rate compared previously reported outbreaks in the country. Domo et al., reported a case fatality rate of 12.4% in the neighboring Jirapa Municipality in 2016 [7] whiles Letsa and his groups reported a case fatality rate of 9% in the middle belt (Brong-Ahafo Region) of Ghana [8]. It´s also slightly higher compared to the World Health Organisation´s estimates of one death in every 10 cases of bacterial meningitis [3].

Even though, the district had crossed the alert threshold of 5 cases per 100,000 population in several epidemic weeks, it did not get to the epidemic threshold of 10 cases per 100,000 population. For this reason, the district could not technically declare an outbreak even though there was an upsurge in the number of meningitis cases. The district epidemic response team responded promptly to the situation using their previous experiences and trainings in meningitis response. The district was therefore able to prevent an imminent outbreak of meningitis using the early warning signals and response actions. Because the Nadowli-Kaleo District lies in the African meningitis belt, seasonal epidemics are common.

Our finding showed males were more affected. This is supported by other works such as those by Domo and Kaburi who both found males to be more infected than females [7,9]. However, other works by Letsa and colleagues and also by Kwabama-Adams and his group have reported higher prevalence in females compared to males [8,10].

The most affected age group was 15-24 years, with close to fifty percent of those affected within the school going age. This trend in seen in other reports by Kwabama-Adams [10], who recorded most cases under 15 years, whiles Letsa and colleagues [8], recorded 10-19 years as the most affected. A high proportion of children within the school going age were affected even though there was a district wide vaccination campaign targeting Men A and Men C for all children below 15 years in 2012. The schools could have also been a possible source of infections giving the high number of children of school going age that were affected. Burman and his colleagues opines that adolescents and young adults mostly represent a significant proportion of meningitis case-patients because they often have the highest carriage rates and have characteristically low vaccination adherence[11].

The causative organism implicated in the upsurge of meningitis was predominantly, *Neisseria meningitides* (W135) followed by *Streptococcus pneumonia*. Neisseria meningitides has been implicated in number of outbreaks occurring in northern Ghana [9,12], however, Letsa et al., reported *Streptococcus pneumonia* as the predominant cause of the outbreak that occurred in the middle belt of Ghana in 2016 [8]. The mass vaccination in 2012 targeted Men A and C so *Neisseria meningitides* (W135) and *Streptococcus pneumonia* were not covered. This could explain why Neisseria meningitides, Streptococcus pneumonia strains are currently circulating in the region because they were not the target of the last mass meningitis vaccination exercise.

Sleeping in crowded and poorly ventilated rooms was found to significantly increase the odds of being infected with meningitis. Sleeping in a poorly ventilated room was found to have as much as 5 times increased odds of meningitis whiles overcrowding increased the odds of meningitis by over 3 times. Studies have shown consistent evidence that meningococcal disease has a direct relationship with poor housing conditions [13,14] and is further buttressed by the fact that poor housing conditions and overcrowded household makes one vulnerable to the outbreaks of meningitis [15-17].

Limitations associated with our study were that, because some of our case-patients were very young, they were unable to provide us with comprehensive clinical history of their condition. Again, the unmatched case-control design employed meant we were unable to control for confounding variables such as age differences and socio-economic status among respondents. Given that patients and controls had to recall their exposures likely introduce recall bias in responding to the questionnaire. To minimize this, we selected recent cases.

Public Health Actions taken

We sensitized community members, community and religious leaders and schools on the control and prevention, signs and symptoms of meningitis. We again sensitized health workers at the health facilities on meningitis record keeping, and infection prevention and control.

Conclusion

There was an upsurge in the number of meningitis cases in the Nadowli-Kaleo District of Ghana between January and April 2017. The youth were mostly affected. This upsurge was predominantly caused by *Neisseria meningitides* (W135). Living in poorly ventilated rooms and living in overcrowded rooms were factors associated with meningitis disease. Prompt case-management, contact tracing and health education helped in the control of the upsurge.

What is known about this topic

- The Upper West Region of Ghana falls within the African meningitis belt, this makes meningitis a major disease of public health concern in the region;
- Seasonal outbreaks of meningitis are common in the region and Northern Ghana generally;
- Capacities of public health officials in the region to be able to control meningitis outbreaks have been developed over time.

What this study adds

- A good surveillance system with appropriate early warning signals is effective in preventing meningitis outbreaks;
- The rapid increase in the number of meningitis cases was predominantly caused by *Neisseria meningitides* (W135);

- Poor housing conditions (overcrowding and poor ventilation) were risk factors for meningitis disease.

Competing interests

The authors declare no competing interests.

Authors' contributions

DKA, SOS, EK and GRI conceived the idea. GRI, DAB DAA, and DKA framed the design, conducted the investigation and performed statistical analysis. GRI, DAB and DKA drafted and revised the initial manuscript. GRI, DAA, DAB, DKA, SOS, EK edited and reviewed the manuscript. All the authors read and approved the final version of this manuscript.

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Figures

Figure 1: Trend of TB Case Notification Rate in the Sene East District 2015 to 2019

Figure 2: Age and sex distribution of TB cases in the Sene East District, 2015 to 2019

Figure 3: Cumulative TB case detection by sub districts in Sene East, 2015 to 2019

Figure 4: Number of cases recorded monthly in the Sene East District, 2015 to 2019

Figure 5: Trend of Treatment outcome of TB in the Sene East district, 2015 to 2018

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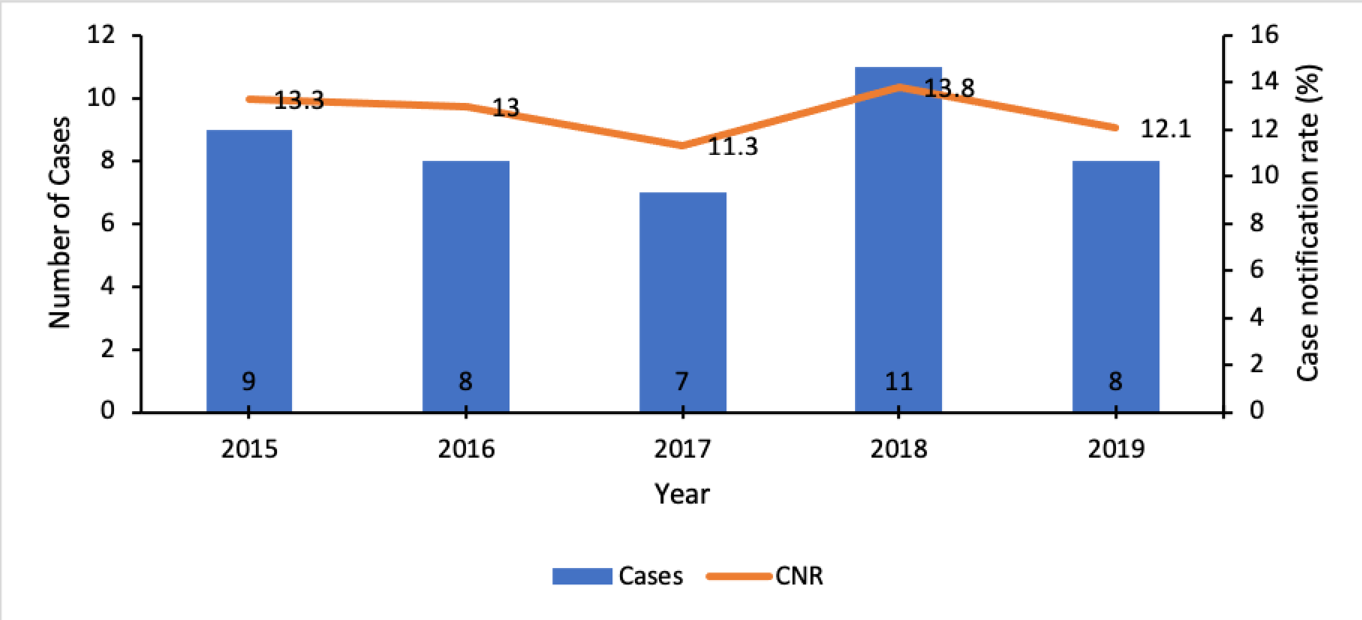

Figure 1: Trend of TB Case Notification Rate in the Sene East District 2015 to 2019

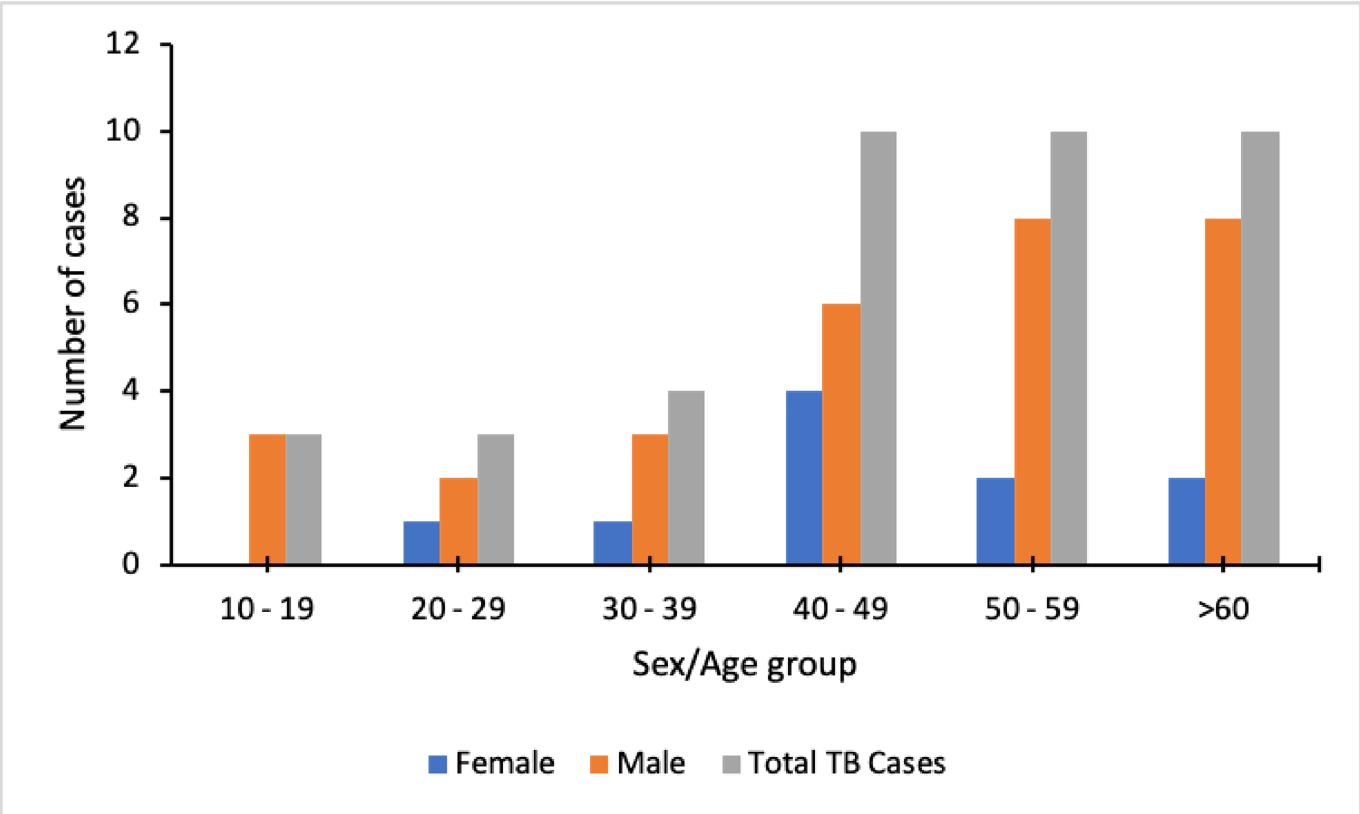

Figure 2: Age and sex distribution of TB cases in the Sene East District, 2015 to 2019

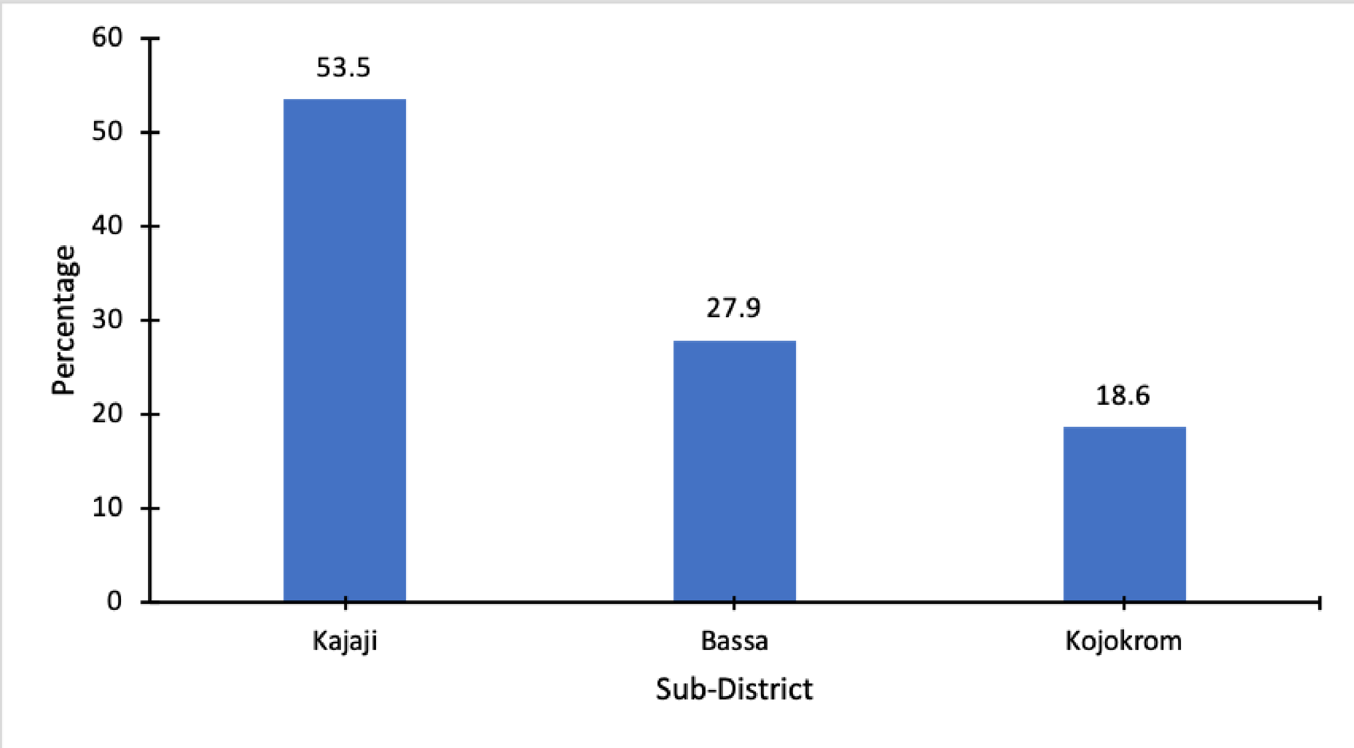

Figure 3: Cumulative TB case detection by sub districts in Sene East, 2015 to 2019

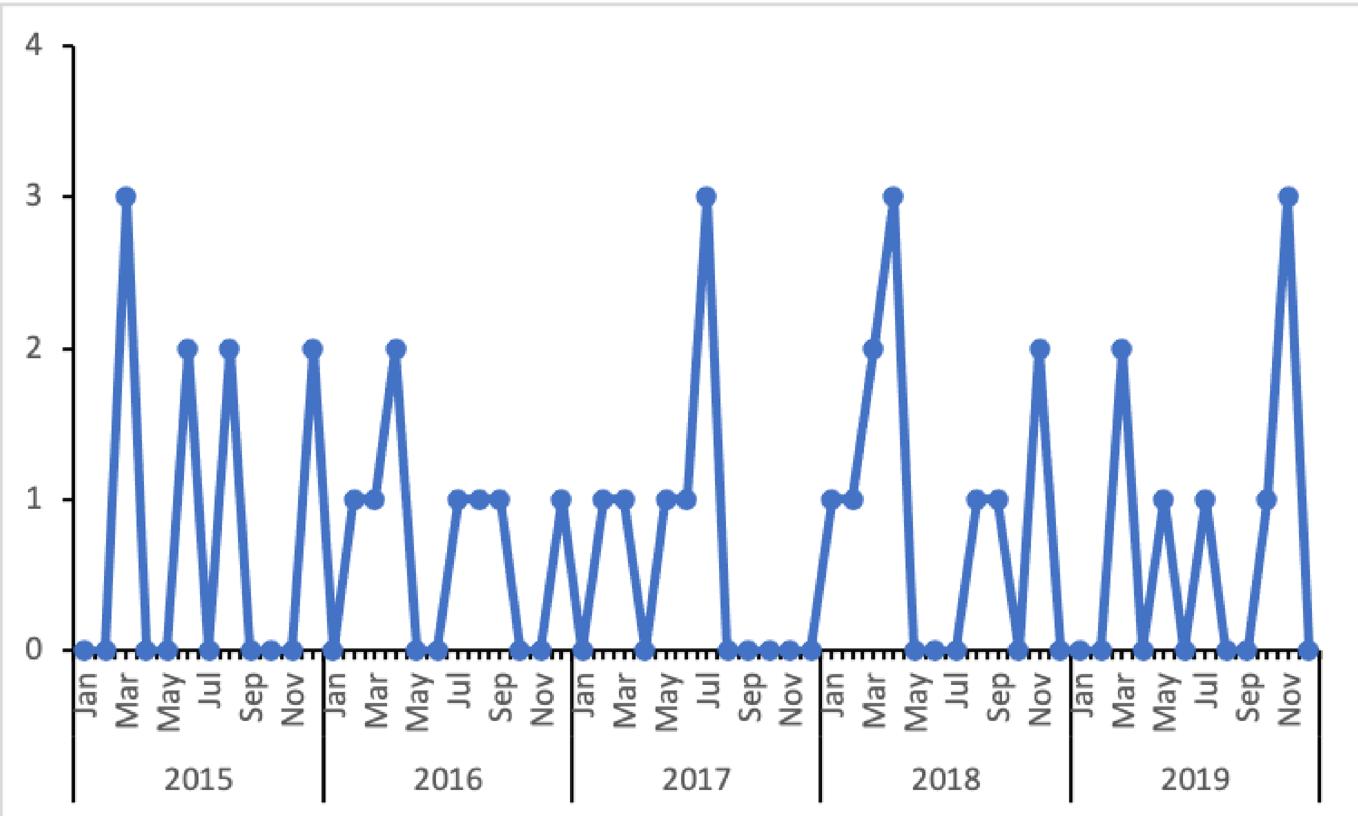

Figure 4: Number of cases recorded monthly in the Sene East District, 2015 to 2019

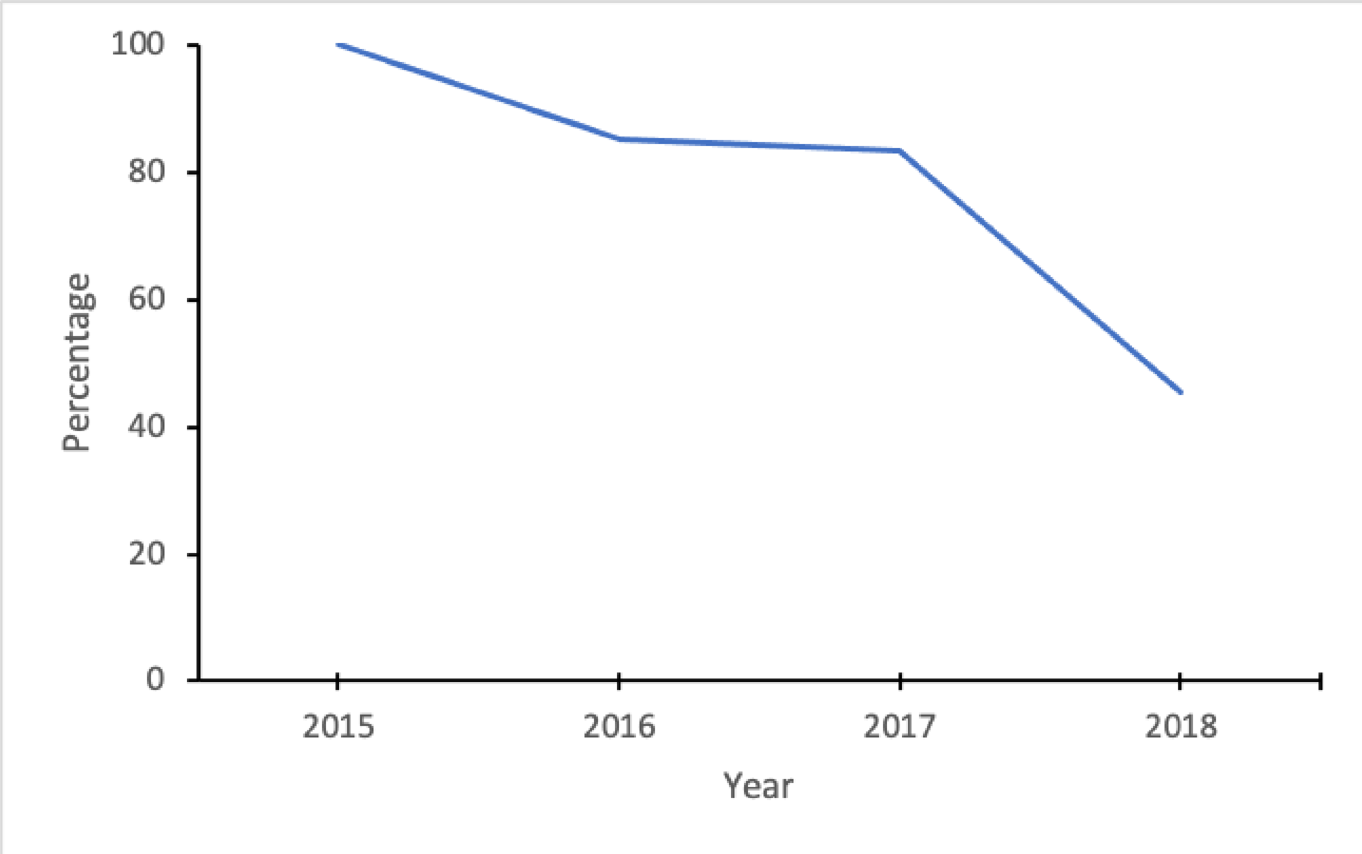

Figure 5: Trend of Treatment outcome of TB in the Sene East district, 2015 to 2018