You cannot find what you are not looking for! Detecting malaria outbreaks in Uganda: A Case Study

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Abstract

Malaria is the leading cause of morbidity and mortality in Uganda, with nearly half of the population becoming infected in any given year. Uganda relies on analyzing high-quality surveillance data to help detect outbreaks, determine which areas or population groups are most affected, and help target resources to where they are most needed.

In March 2019, over 300 health facilities from different districts in Uganda reported substantially higher malaria cases than usual. In 13 districts, health facilities reported that the number of malaria cases was so high that they were experiencing stockouts of antimalarial drugs. Although seasonal increases in cases had been expected, districts reported that the number of cases being identified were overwhelming the capacity of the health facilities.

Uganda's National Malaria Control Division tasked a team of epidemiologists to investigate this unprecedented increase in malaria cases. National Malaria Control Division were interested in how malaria epidemiology had been changing in recent years, and whether they had missed something that would have predicted the situation they were facing in 2019.

This case study describes the steps taken to conduct descriptive analyse of routine malaria surveillance data and demonstrates how to detect malaria outbreaks using historical data. It is useful for training Field Epidemiologists and public health officers involved in analysis of surveillance data.

Key words: Case-Study, Malaria, Surveillance, data, analysis, outbreak, detection, Uganda

Participant guide: Distribute to students

Learning Objectives

After completing this case study, the participant should be able to:

- ❑ Discuss the importance of routinely analyzing disease surveillance data.
- ❑ Conduct a descriptive analysis of surveillance data.
- ❑ Interpret the findings of descriptive analysis of surveillance data.
- ❑ Describe the importance of malaria normal channels in detecting malaria outbreaks.
- ❑ Draw a malaria normal channel.
- ❑ Interpret a malaria normal channel.

This case study is based on analysis of malaria surveillance data conducted by FETP residents in Uganda's Ministry of Health in 2019.

This case study was developed by Benon Kwesiga, Phoebe Nabunya, Daniel Kadobera, Steven Kabwama, Lilian Bulage, Alex Ario and Julie Harris in 2019.

Do not read this page aloud

How to use this case study: Case studies in applied epidemiology allow students to practice applying epidemiologic skills in the classroom to address real-world public health problems. The case studies are used as a vital component of an applied epidemiology curriculum, rather than as stand-alone tools. They are ideally suited to reinforcing principles and skills already covered in a lecture or in background reading.

This case study has a facilitator guide and a participant guide. Each facilitator should review the Facilitator Guide, gain familiarity with the outbreak and investigation on which the case study is based, review the epidemiologic principles being taught, and think of examples in the facilitator's own experience to further illustrate the points.

Ideally, participants receive the case study one part at a time during the case study session. However, if the case study is distributed in whole, participants should be asked not to look ahead.

During the case study session, one or two instructors facilitate the case study for 8 to 20 students in a classroom or conference room. The facilitator should hand out Part I and direct a participant to read one paragraph out loud, then progressing around the room and giving each participant a chance to read. Reading out loud and in turns has two advantages. First, all participants engage in the process and overcome any inhibitions by having her/his voice heard. Second, it keeps all participants progressing through the case study at the same speed.

After a participant reads a question, the facilitator will direct participants to answer the question by perform calculations, construct graphs, or engage in a discussion of the answer. Sometimes, the facilitator can split the class to play different roles or take different sides in answering the question. As a result, participants learn from each other, not just from the facilitator.

After the questions have been answered, the facilitator hands out the next part. At the end of the case study, the facilitator should direct a participant to read the objectives once again on page 1 to review and ensure that the objectives have been met.

Target audience: Trainees in Field Epidemiology and Laboratory Training Programs (FELTPs), public health students, public health workers who may participate in routine analysis of surveillance data, and others who are interested in this topic.

Prerequisites: For this case study, participants should have received instruction or conducted readings in:

- *Public health surveillance and analysis of surveillance data*
- *Using disease thresholds to detect outbreaks.*

Materials needed:

- Flip charts, marker set: One per 8-10 participants.
- Laptop computers: With Microsoft Office Suite pre-installed.
- Projector, projection screen (or substitutes), and LASER pointer.

Level of case study: *Frontline, Intermediate, and advanced*, (e.g., Intermediate, i.e., participants should have background in analyzing public health surveillance data).

Time required: *Provide expected duration* (e.g., approximately 3 hours)

Language: English

Part I

According to the Uganda National Malaria Operational Plan, Malaria is the leading cause of death in Uganda, with nearly half of the population becoming infected in any given year [1]. Uganda, like many malaria-affected countries, relies on having high-quality surveillance data to help determine which areas or population groups are most affected, and help target resources to the places where they are most needed [2].

In March 2019, over 300 health facilities from different districts in Uganda reported to their District Health Officers (DHOs) that they were seeing substantially more malaria cases than usual. In 13 districts, facilities reported that the number of malaria cases was so high that they were experiencing stockouts of antimalarial drugs. Although seasonal increases in cases had been expected, DHOs reported that the number of cases being identified were overwhelming the capacity of the facilities.

While multiple teams were deployed to the field to investigate, the National Malaria Control Program (NMCP) tasked a team of epidemiologists, including two Field Epidemiology Training Program (FETP) residents, to analyze malaria surveillance data. NMCP were interested in how malaria epidemiology had been changing in recent years, and whether they had missed something that would have predicted the situation they were facing in 2019. In addition, they had been carrying out multiple interventions over the past few years and wanted to evaluate the effects of those interventions over time.

Question 1: Without using jargon, define what is meant by 'public health surveillance.'

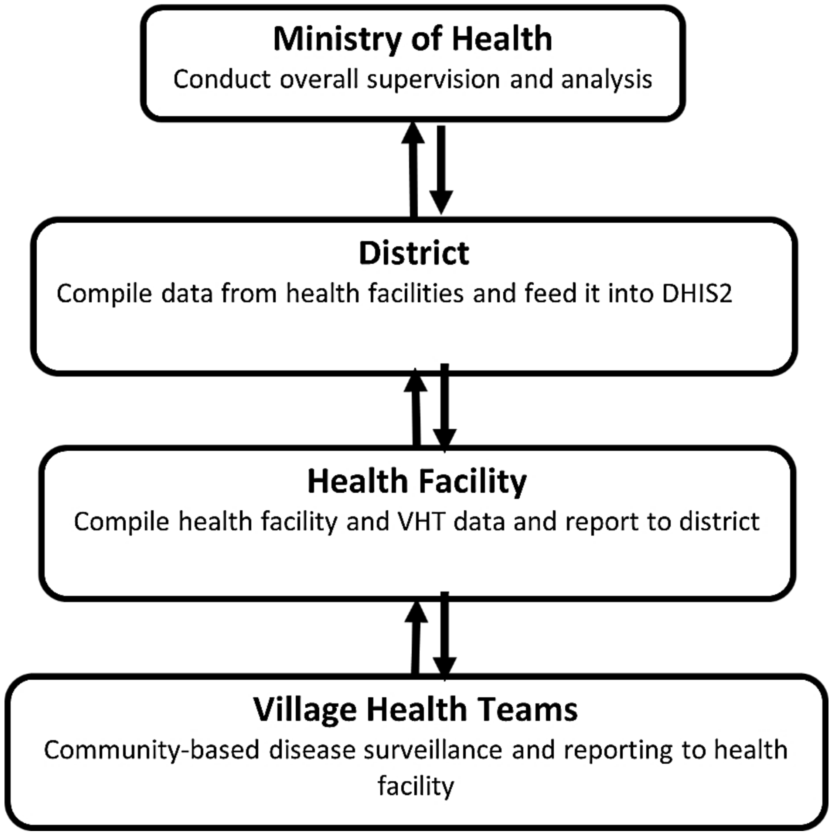
Question 2: Why do we collect and analyze public health surveillance data?

In 2019, Uganda utilized the Health Management Information System (HMIS) to conduct malaria surveillance [3]. In this system, malaria patient data from clinical records were first collected by health facility records officers and transferred to HMIS registers. Health facility records officers then aggregated data in the registers into HMIS paper forms and submitted these forms to the District Surveillance Focal Person (DSFP). The DSFP entered these data from the paper records into the District Health Information System (DHIS2) electronic database. The DHIS2 could then be accessed by the Ministry of Health (Figure 1). Both the MoH and districts were expected to analyze the malaria data in HMIS every week, to facilitate the rapid identification of unusual patterns of disease.

In the Uganda malaria surveillance system, a malaria case was defined as a positive test using either malaria Rapid Diagnostic Test (RDT) or microscopy. All suspected malaria cases in Uganda were tested for confirmation; clinically diagnosed cases without confirmation were not reported.

Question 3: What is a surveillance system case definition? Why is it important?

Figure 1: Flow of data in Uganda's Health Management Information Surveillance System



<u>Question 4</u>: The system above uses passive surveillance to detect cases of malaria. What does this mean? What are the advantages and disadvantages of this type of surveillance?

Part II

The NMCD had asked the residents to investigate possible changes in malaria epidemiology in recent years. The team decided to start their analysis by looking at overall, age-specific, and sex-specific malaria incidence rates over time. To do this, the team reviewed surveillance data for all 120 districts. The team decided to analyze data from 2014-2018, as the most recent comprehensive surveillance analysis had covered 2010 to 2013, and it was too early in the year to look at all the 2019 data.

In total during 2014-2018, 54,493,812 malaria cases and 17,574 deaths were reported in Uganda. Use the data provided in the tables and figures below to answer the following questions.

Table 1. ***Table of malaria incidence rates by age and sex in Uganda, 2014-2018***

Year	Characteristic	Category	Cases	Population	Incidence
2014	**Age**	<5 years	407,660	6,177,203	66
		>5 years	972,009	27,964,098	35
	Sex	Male	575,466	17,060,832	34
		Female	804,202	17,573,818	46
	Total		1,379,669	34,634,650	40
2015	**Age**	<5 years	337,758	6,292,000	54
		>5 years	779,768	29,200,100	27
	Sex	Male	468,419	17,344,000	27
		Female	649,107	18,158,100	36
	Total		1,117,527	35,502,100	31
2016	**Age**	<5 years	324,280	6,468,700	50
		>5 years	768,443	30,092,000	26
	Sex	Male	459,972	17,926,900	26
		Female	632,751	18,725,800	34
	Total		1,092,724	36,652,700	30
2017	**Age**	<5 years	284,527	6,672,400	43
		>5 years	795,932	31,001,400	26
	Sex	Male	454,795	18,527,900	25
		Female	625,665	19,311,000	32
	Total		1,080,460	37,838,900	29
2018	**Age**	<5 years	209,458	6,893,800	
		>5 years	569,541	31,929,300	
	Sex	Male	322,864	19,146,800	
		Female	456,136	19,912,200	
	Total		779,000	39,059,000	

Question 5: What is an incidence rate? Why is incidence used to describe malaria (as opposed to prevalence)?

<u>Question 6</u>: Calculate and fill in the missing incidence rates for 2018 in Table 1 above.

Time-series data, such as the data shown above, can be presented in tables. However, they are often presented in graphs for ease of interpretation. To facilitate interpretation of the data in their table, the team decided to create a line graph to look at the age- and sex-specific incidence rates over time.

<u>Question 7</u>: Using the Microsoft excel dataset provided ***(Monthly malaria incidence rates and CFR)***, calculate and draw a graph of the age-specific incidence rates from 2014 to 2018. Interpret the graph.

Seeing the changes in disease incidence, the team wondered if there were also changes in case-fatality rates over time. The case-fatality rate is used to measure the severity of a disease in a population or in its subgroups. Comparing the case-fatality rate to a standard or to other settings can provide inferences about the quality of care available or the need for additional interventions in specific subgroups.

The team calculated the case-fatality rates for malaria, stratified by age and sex, in Table 2.

Table 2. Malaria cases, deaths, and case-fatality rates by age and sex in Uganda, 2014-2018

Year	Characteristic	Category	Cases	Deaths	CFR
2014	**Age**	<5 years	4,076,601	1,320	3.2
		>5 years	9,720,091	998	1.0
	Sex	Male	5,754,666	1,394	2.4
		Female	8,042,026	1,432	1.8
	Total		13,796,692	5,144	3.7
2015	**Age**	<5 years	3,377,590	1,254	3.7
		>5 years	7,797,684	1,097	1.4
	Sex	Male	4,684,197	971	2.1
		Female	6,491,077	1,074	1.7
	Total		11,175,274	2,045	1.8
2016	**Age**	<5 years	3,242,807	1,563	4.8
		>5 years	7,684,434	1,834	2.4
	Sex	Male	4,599,723	1,749	3.8
		Female	6,327,518	2,601	4.1
	Total		10,927,241	4,350	4.0
2017	**Age**	<5 years	2,845,276	2,187	7.7
		>5 years	7,959,328	1,547	1.9

	Sex	Male	4,547,951	1,678	3.7
		Female	6,256,653	1,956	3.1
	Total		10,804,604	3,634	3.4
2018	**Age**	<5 years	2,094,585	1,324	
		>5 years	5,695,416	1,037	
	Sex	Male	3,228,640	1,092	
		Female	4,561,361	1,309	
	Total		7,790,001	2,401	

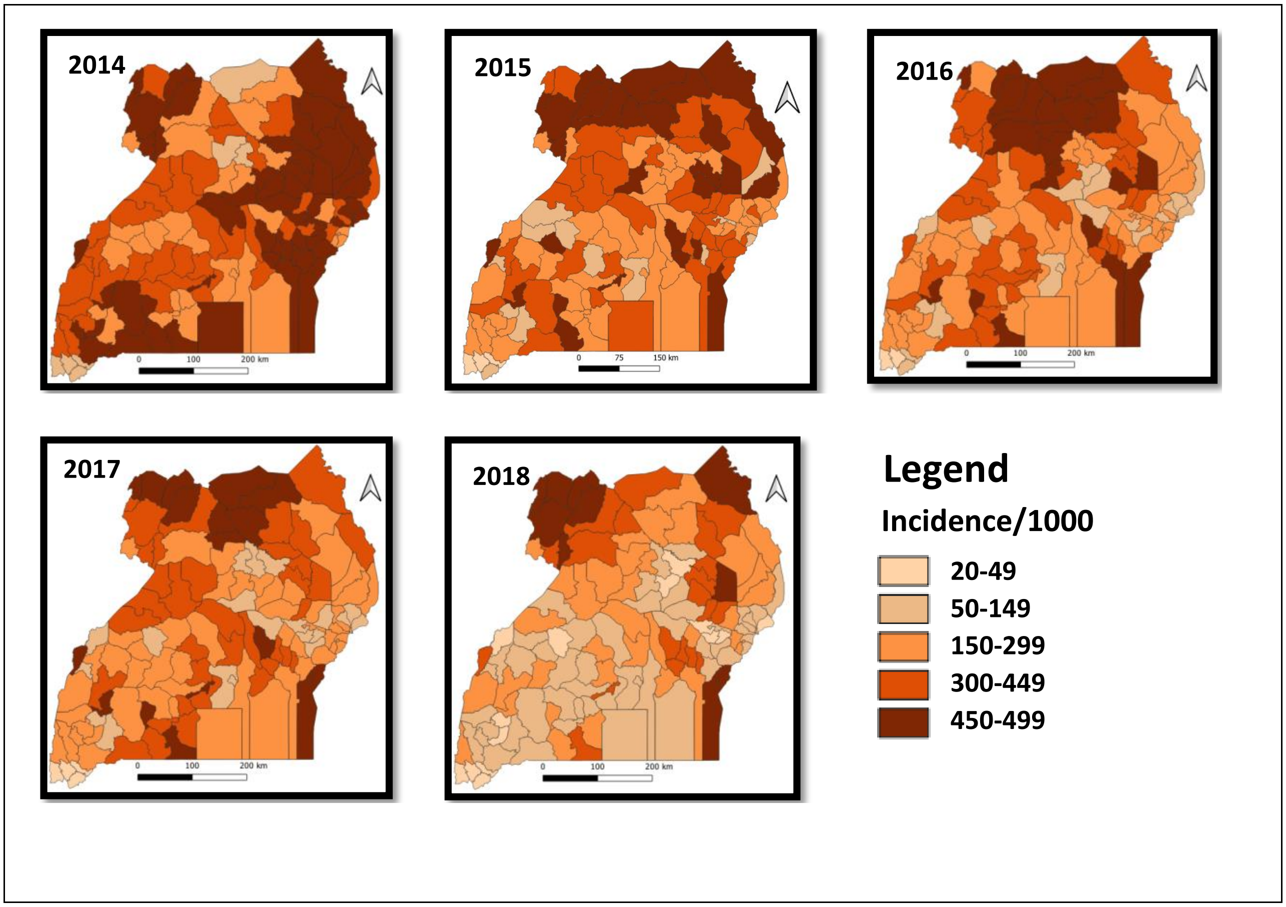
<u>Question 8</u>: Calculate the missing case-fatality rates for 2018 in Table 2.

<u>Question 9</u>: Using the Microsoft excel dataset provided ***(Monthly malaria incidence rates and CFR)***, calculate and draw a graph of the age-specific case fatality rate from 2014 to 2018. Interpret the findings.

Question 10: When calculating the case-fatality rate, why do we use cases (instead of the whole population) as the denominator?

The team next wanted to understand the geographic distribution of reported cases of malaria, as well as trends over time. Using QGIS mapping software, they drew maps of district malaria incidence rates for each year from 2014 to 2018 (Figure 2) [4].

Figure 2. Maps showing changes in the distribution of malaria incidence in Uganda districts 2014-2018



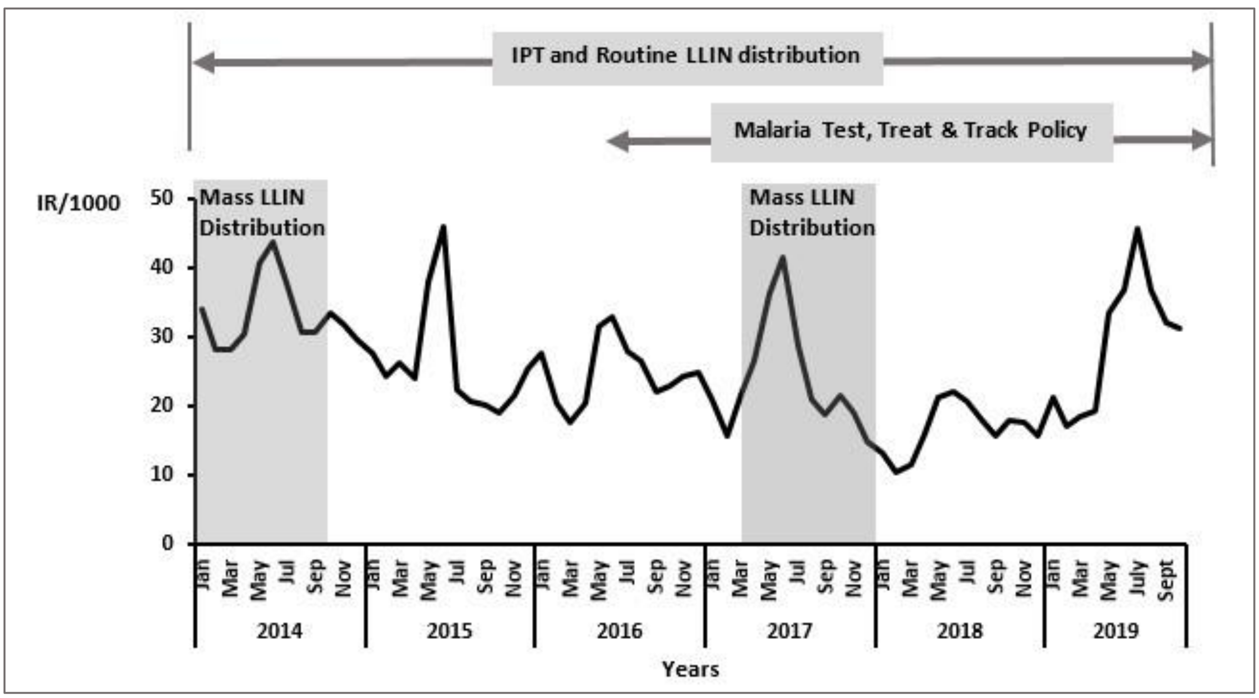
Question 11: What changes in malaria incidence are occurring over time? Are there regional variations?

Part III

The team noted that malaria incidence had declined overall during the evaluation period. It seemed surprising to them that they would see a continual decline through 2018 only to be facing apparent increases in 2019. They wondered if there might have been some failure in the malaria interventions that had been implemented across the country throughout this time period. These included widespread campaigns to provide long-lasting insecticide-treated bed nets (LLINs) and implementation of the Malaria 'Test, Treat and Track' policy (testing of all suspected malaria cases and treating only confirmed cases, rather than presumptive antimalarial treatment for all persons with febrile illness) and intermittent preventive therapy (IPT) for pregnant women.

To take a closer look at the effect of these interventions on malaria cases, the FETP residents plotted a graph of national malaria incidence and marked the dates when key malaria control interventions were initiated during the analysis period (Figure 3).

Figure 3: Graph of monthly malaria incidence rate (IR) and period of key malaria control measures in Uganda 2014-2018



Question 12: Describe the patterns and trend of malaria cases shown in the graph.

Question 13: How might NMCD use the above analysis of surveillance data to help them design control measures?

Part IV

In addition to using surveillance data to project needs and plan future interventions, routine analysis of surveillance data is often conducted to ensure prompt detection of and response to outbreaks [5]. NMCD had asked the team to conduct analysis of surveillance data to understand historical trends. Now, they also wanted to know if the situations that were being reported in the districts represented outbreaks, or normal seasonal increases.

In malaria-endemic areas, a common method for detecting outbreaks is by plotting a malaria normal channel. This method was recommended by World Health Organization (WHO) and adopted by malaria-endemic countries, including Uganda in 2011 [6]. It uses historical data to determine malaria epidemic thresholds, or 'expected' numbers of cases in each area over a given time period. These thresholds are then compared to current surveillance data so that active investigation and response can be initiated when the number of current cases exceeds the 'normal channel' upper threshold.

The 'expected' number of cases used to develop malaria normal channels are based on malaria data from the most complete recent 5 years in each district, excluding outlier years (such as years with large outbreaks). These data are then used to determine the range of expected cases for the year of the suspected outbreak (2019).

You have been provided a dataset of malaria cases in Mbale. (**Malaria normal channel data for Mbale District.xls**). Use it to answer the following questions.

<u>Question 14</u>: Use the Microsoft excel dataset provided with this case study (**Malaria normal channel data for Mbale District.xls**) and the step-by-step instructions provided below to draw a malaria normal channel for Mbale District.

Steps to follow when drawing a malaria normal channel.

1. Obtain weekly data on confirmed malaria cases for the most recent 5 years from the malaria surveillance system.
2. Using a spreadsheet program such as Microsoft Excel, tabulate the confirmed malaria cases for each of the 52 weeks in a year for the most recent complete 5 years (Example in figure 4).

   Figure 4: Example showing how to organize weekly malaria data in columns of years while drawing a malaria normal channel

Weeks	2014	2015	2016	2017	2018
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

3. Derive the 25th percentile using the PERCENTILE function in Microsoft Excel. If the cases are in cells A1-A5, the Percentile is generated by typing in the target cell **=PERCENTILE (A1:E1, 0.25)**.
4. Derive the 75th percentile by typing **=PERCENTILE (A1:E1, 0.75)**. Refer to example in figure 5.

Figure 5: Example showing how to organize columns for weeks, lower and upper percentiles, and 2019 cases while drawing a malaria normal channel

Weeks	Lower Limit (25th percentile)	Upper limit (75th percentile)	2019 cases
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

5. Plot the percentiles for each week.
6. The area between the 25th and the 75th Percentiles is the expected malaria cases (normal channel).
7. Plot the 2019 cases on the same graph.

Question 15: Interpret the malaria normal channel.

Question 16: In a few sentences, summarize the main findings from the descriptive analyses and normal channels graphs developed in this case study.

Conclusion

The 2019 malaria outbreaks in Uganda affected most of the districts in the country. Late detection of the outbreaks was a direct result of failure to analyze surveillance data, both at the district level and at the national level. Interviews with surveillance staff revealed that, although normal channels were supposed to be developed and compared with surveillance data on a weekly basis, it was not being done, for a multitude of reasons including poor motivation, lack of supervision, and poor accountability from many supervisors.

When these outbreaks were detected, National Rapid Response Teams (NRRTs), including FETP residents, were deployed in the affected districts to support the districts in investigating and controlling the outbreaks. The investigations generally revealed prolonged mosquito breeding in the affected areas. This was worsened by inadequate malaria preventive measures. Interventions included frequent draining of water harvesting containers, increasing coverage for LLINs and larviciding breeding sites. Investigators noted that the delay in identifying cases had created a situation that could partially reverse the effect of the interventions implemented over the last few years, as the mosquito population overall had been allowed to expand while interventions were delayed. To avoid late detection of future malaria outbreaks, the NMCD retrained all district malaria focal persons on how to use malaria normal channels to promptly detect malaria outbreaks in their districts. NMCD also improved and maintained the supervision of districts to ensure that this practice was maintained.

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Competing interest

The authors declare they had no competing interest

Author's contributions

BK - Led the writing process after collecting data and drafted the case study. LB, DK, ARA, SNK and JRH were involved in the development and writing of the various drafts of the case study. All authors read and gave approval to the final case study for use and publication.

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Disclaimer

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