# Delayed Outbreak Detection: A Wake-Up Call to Evaluate a Surveillance System

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**Abstract**

During May, 83 of the 120 districts in Uganda had reported malaria cases above the upper limit of the normal channel. Across all districts, cases had exceeded malaria normal channel upper limits for an average of six months. Yet no alarms had been raised!

Starting in 2000, Uganda adopted the World Health Organization (WHO) Integrated Disease Surveillance and Response (IDSR) strategy for disease reporting, including for malaria. Even early on, however, it was unclear how effectively IDSR and DHIS2 were being used in Uganda. Outbreaks were consistently detected late, but the underlying cause of the late detection was unclear. Suspecting there might be gaps in the surveillance system that were not immediately obvious, the Uganda FETP was asked to evaluate the malaria surveillance system in Uganda.

This case study teaches trainees in Field Epidemiology and Laboratory Training Programs, public health students, public health workers who may participate in evaluation of public health surveillance systems, and others who are interested in this topic on reasons, steps, and attributes and uses the surveillance evaluation approach to identify gaps and facilitates discussion of practical solutions for improving a public health surveillance system.

**Key words:** Case Study, Malaria, Surveillance system evaluation, Outbreak detection, Uganda

**Participant guide: Distribute to students**

## Learning Objectives

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

- Describe reasons for conducting a public health surveillance system evaluation
- Discuss the steps of conducting a public health surveillance system evaluation
- Discuss the attributes of a public health surveillance system
- Use the surveillance evaluation approach to identify gaps in a public health surveillance system
- Discuss practical solutions for improving a public health surveillance system

*This case study includes some elements that are based on actual historical events in Uganda, but it is not based on real data.*

**Do not read this 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 the 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 once again read the objectives on page 1 to review and ensure that the objectives have been met.

**Prerequisites:** For this case study, participants should have received lectures or conducted readings in *public health surveillance and public health system evaluations.*

**Target audience:** Trainees in the Uganda Field Epidemiology Training Program / Public Health Fellowship Program, other Field Epidemiology and Laboratory Training Programs (FELTPs), public health students, public health workers who may participate in evaluation of public health surveillance systems, and others who are interested in this topic.

**Level of case study:** *Advanced*
**Time required:** Approximately 12 hours
**Language:** English

**Part I**

In June 2019, an epidemiologist looking at Uganda's malaria surveillance data noted what seemed to be an excess of cases in Zombo District in May; the number of cases was nearly twice as high as would have been expected. As the epidemiologist looked further back in the data, it became clear that not only were case counts higher than expected in May, but they had been higher than expected for many months - since November 2018. He was surprised; how had this gone unnoticed for so long?

As he proceeded to analyze data from other districts, he saw that many other districts were also reporting case counts above the number expected, based on the malaria normal channels *(these are line graphs illustrating the minimum and maximum number of malaria cases expected in a given period of time).* In fact, during May, 83 of the 120 districts in Uganda had reported cases above the upper limit of the normal channel. Across all districts, cases had exceeded malaria normal channel upper limits for an average of six months. Yet no alarms had been raised!

When the epidemiologist shared this with the National Malaria Control Division (NMCD), they were frustrated. Districts were supposed to analyze their own data and alert the NMCD if they detected an outbreak, yet it appeared that no one had been analyzing their data for a long time. This was not the first time this had happened. In fact, this seemed to be the norm, rather than the exception: malaria outbreaks were often missed or reported to NCMD late. Although teams were always deployed to investigate the outbreaks, the responses came too late to make a difference. Their surveillance system was clearly not being used well.

**Question 1: What is public health surveillance? What are the reasons that we conduct public health surveillance?**

**Question 2: What are some reasons that outbreaks may be missed or detected late?**

**Part II**

Uganda is located in East Africa. The topography ranges from the high-altitude Rwenzori Mountains in the west to the low-lying Sudanese plains in the north. Malaria is endemic in approximately 95% of the country, where transmission is perennial (year-round) with peaks after the rainy season (April-May), and during October-November. The year-round temperatures, which range between 16-36°C, and consistent high humidity provide optimal conditions for *Anopheles* mosquito breeding and the resulting malaria transmission[1].

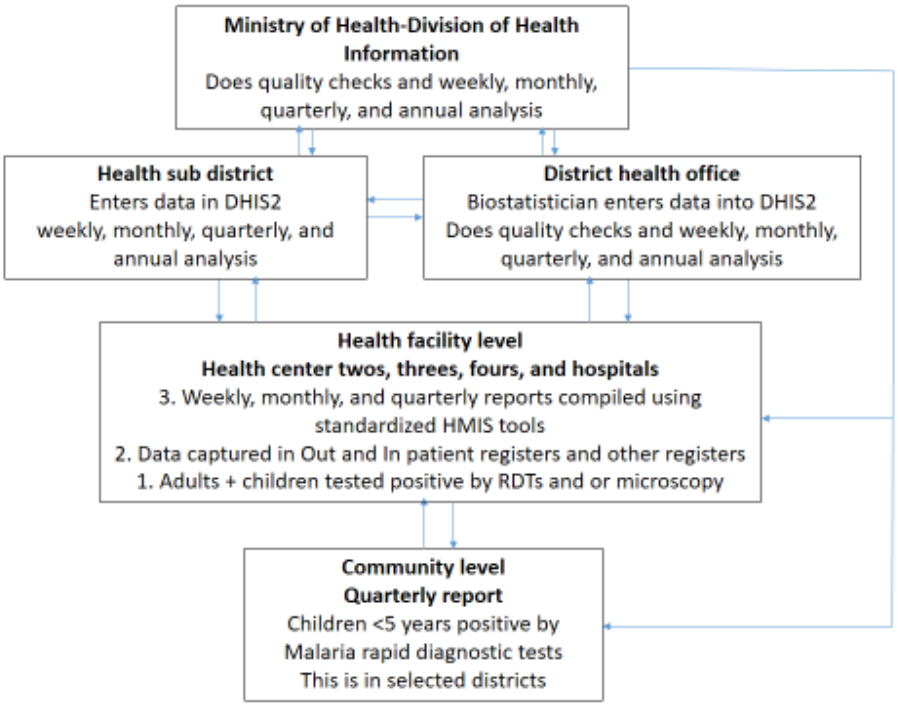
The Malaria Control Unit in Uganda was established by the MoH in 1995, charged with establishing an efficient malaria surveillance system that could provide reliable estimates of the disease burden nationwide. However, after three years in service, reliable malaria disease estimates were still not available. In 1998, a health minister asked in a meeting, "*Why does everyone report that malaria is the leading cause of morbidity and mortality in Uganda, yet there is no evidence to support that claim?*" The need for better data was seen as most urgent for detection of malaria outbreaks in the highlands of Uganda, where outbreaks were almost always detected late or were missed entirely[2].

**Question 3: If you were responsible for developing a malaria surveillance system, what key features would the system have?**

Starting in 2000, Uganda adopted the World Health Organization (WHO) Integrated Disease Surveillance and Response (IDSR) strategy for disease reporting, including for malaria[3]. IDSR uses an open-source platform called District Health Information System 2 (DHIS2) for reporting, analysis, and dissemination of health data[4]. Even early on, however, it was unclear how effectively IDSR and DHIS2 were being used in Uganda. Outbreaks were consistently detected late, but the underlying cause of the late detection was unclear. Suspecting there might be gaps in the surveillance system that were not immediately obvious, the Uganda FETP was asked to evaluate the malaria surveillance system in Uganda. Steps to evaluating a surveillance system are shown in Appendix I[5,6].

On July 1, 2019, the FETP fellow assigned to the evaluation began by drawing a diagram of the existing malaria surveillance system. This is a critical first step in surveillance system evaluations, to understand how information passes from the patient up to the highest level of reporting.

**Figure 1: Flow diagram illustrating the Malaria Public Health Surveillance System**



**Part III**

Surveillance system evaluations comprise two parts: a descriptive section and a quantitative section. In the descriptive section, the evaluator describes the public health importance of the disease or event under surveillance, the purpose and operations of the surveillance system including the planned uses of the data from the system among other components, and the resources (human, material, and financial) used to operate the system. In the quantitative section, the evaluator collects data on the attributes of the surveillance system through record reviews/audits and interviews with the users of the system. All surveillance systems should be evaluated periodically to ensure that they serve a useful public health function and meet their intended objectives[5].

To gain some background about the malaria surveillance system, its history, original purpose, and resources used to operate it, the fellow conducted interviews with people involved in the system. She used the data collected to build Table 1.

**Table 1: Characteristics of the Uganda Malaria surveillance system**

| Characteristic | Information |
|---|---|
| Public health importance of malaria in Uganda | Malaria is the most frequently reported disease at both public and private health facilities in Uganda. In Uganda, malaria is highly endemic, with >95% of the country having year-round transmission. In 2017, 14.5 million cases were reported in Uganda. Malaria has a significant negative impact on the economy of Uganda due to loss of workdays, decreased productivity, and decreased school attendance. A single episode of malaria costs a family USD$9 on average. A poor family in a malaria-endemic area may spend up to 25% of the household income on malaria prevention and treatment. Investors may be wary of committing finances in countries with high malaria rates, leading to a loss in funding opportunities. |
| Purpose and operations of the surveillance system | The malaria surveillance system was set up to (1) identify the areas or population groups most affected by malaria; 2) identify trends in cases and deaths that require additional intervention, e.g. epidemics; and 3) assess the impact of malaria control measures. It is intended to ensure regular collection, collation, analysis, and reporting of malaria data. All districts are asked to promptly report weekly, monthly, and quarterly malaria reports of the following: numbers of suspected malaria cases, cases receiving a diagnostic test, and the number of confirmed malaria cases, inpatients, and deaths from all public and private health facilities. |
| Resources used to operate the surveillance system | In total, 4,800 health facilities reported malaria data to the MoH in 2019. Since 2010, one community health worker in each village has been responsible for diagnosis using malaria rapid diagnostic kits and management of cases under the Integrated Community Case Management (iCCM) program for malaria, pneumonia, and diarrhea. Each health facility had at least one records officer who performed day-to-day collection and reporting of data, which took 30% of the time for each of the records officers. At each of the reporting levels, there were standard reporting tools used for the different reporting periods (weekly, monthly, and quarterly). Approximately 60% of the health facilities had computers to facilitate reporting. All the data were housed in DHIS2, requiring airtime and internet to transmit the data. |

**Question 5**: **Why is it important to describe the surveillance system in this way before continuing with the evaluation?**

The FETP fellow organized a stakeholders' engagement meeting to discuss her planned surveillance system evaluation. She invited healthcare workers from health facilities at various levels, district and subdistrict in-charges, technical staff from the NMCD, district biostatisticians, implementing partners, and donors supporting the surveillance system. She planned to ask the stakeholders if they could confirm the data flow she had shown in her diagram, and also discuss perceived challenges to the system.

**Question 6**: **What are some challenges that surveillance systems face?**

**Part IV**

Of the 20 persons invited to the stakeholders' meeting, only eight were able to attend. Despite the limited attendance, stakeholders reported more challenges than the fellow had expected. Stakeholders told the fellow that neither reporting nor analysis of data were done with any regularity, and that there were problems with data quality across all sites. Stakeholders also reported that although some districts have community level testing and managing of malaria among children, data generated at that level is only reported to the health facility level on quarterly basis, making it irrelevant for prompt outbreak detection. Stakeholders also noted that, although private health facilities saw many cases of malaria, they rarely reported these cases into the national system. This presented problems to obtaining accurate data, as more than half of the population visited only private facilities. They also complained that there was rarely enough money allocated to the districts from the national level to pay community health workers to detect or report malaria cases. Some stakeholders also mentioned poor coordination between the NMCD and partners, as well as a lack of a data quality monitoring system.

The Assistant Commissioner cautioned the FETP fellow that, with the limited resources available for her evaluation, her activity should have a focus. He suggested that she narrow the purpose of the evaluation by identifying (i) what specific questions should be answered, (ii) who should receive the information and implement recommendations, and (iii) what standards would be used to assess the performance of the surveillance system.

**Question 7: What are some possible purposes for the evaluation?**

**Question 8: Who in Uganda should ultimately be responsible for receiving the malaria surveillance system evaluation report and implementing the suggested changes?**

Stakeholders stated that the original primary objective of the surveillance system had been to detect outbreaks, and the system was failing to do that. However, when the stakeholders were asked about the root causes of the failure to detect outbreaks in a timely manner, they were uncertain. The root causes of the problems remained unknown.

| **Question 9: How could the fellow gather information on the root causes of the delays in detecting malaria outbreaks?** |
|---|
| |

Stakeholders suggested that the evaluation should focus on the following:

**Table 2: Purpose of the evaluation and the questions it should address**

| | |
|---|---|
| **Purpose of evaluation** | Identify why outbreaks are being detected late and make recommendations to address this issue. |
| **Question 1** | Are the data at each step of data collection complete? |
| **Question 2** | What is/are the major bottleneck(s) to transmission of surveillance data up the chain in a timely manner? |
| **Question 3** | Are there knowledge gaps among the surveillance staff about how to identify malaria outbreaks (such as developing normal channels, plotting graphs, are they reviewing surveillance data as often as they should do, etc.)? |

The fellow reviewed these objectives and determined that, to address them, she would need to gather evidence regarding the different attributes of the system. Check the detailed notes on the attributes of a surveillance system in Appendix II.

**Part V**

Due to her limited resources, the FETP Fellow decided to focus her surveillance system evaluation on data from a single region. To determine where to focus, she began by conducting simple analysis of the national data. Since the primary purpose of the evaluation was to understand why outbreaks were being reported late, she began by focusing on timeliness and completeness of data, two attributes that seemed like they could have an impact on late reporting.

In a surveillance system evaluation, *timeliness* can be defined as the proportion of reports received within the expected time. In practice, evaluations of timeliness should be framed as the time it takes between each step of reporting from the lowest to the highest level. *Completeness* is more complicated, and can refer to *variable completeness* (the proportion of a specific variable that is filled in across all reports), *form completeness* (the proportion of all forms that are filled completely), or *site completeness* (how many of the reports from a particular reporting site are actually reported to the next level in a given time period). There may also be variations on this, depending on the needs of the surveillance[5,6].

To identify why outbreaks weren't getting reported, the FETP fellow decided that the most important things to focus on would be:

(i) timeliness at each step of reporting (identifying the proportion of weekly reports submitted by their due date in the past six months)
(ii) form completeness
(iii) site completeness

She calculated these values by district and site, in hopes of identifying a single district and site with the poorest reporting characteristics. Because the malaria normal channel for detection of outbreaks is plotted using the weekly health facility reports and community-level reports to the health facility level were made on a quarterly basis, the fellow decided to skip the community-level report. A quick analysis of DHIS2 data from January-June 2019 by District yielded the findings in Table 3.

**Table 3: Districts performance as per number of reports submitted and timeliness in reporting, January-June 2019**

| Variable | District A | | | District B | | | District C | | |
|---|---|---|---|---|---|---|---|---|---|
| | Site A | Site B | Site C | Site D | Site E | Site F | Site G | Site H | Site I |
| **Timeliness**: Percentage of weekly reports submitted on a timely basis in the last six months (January-June 2019)-Healthy facility level to MoH (DHIS2) using mTrac | 20% | 25% | 30% | 70% | 75% | 95% | 65% | 67% | 80% |
| **Form completeness**: Percentage of weekly reports with no missing required information | 50% | 40% | 20% | 80% | 95% | 100% | 93% | 89% | 96% |
| **Site completeness**: Percentage of weekly reports from all sites reported to MoH in the last six months (January-June 2019) | 20% | 25% | 30% | 80% | 70% | 100% | 80% | 70% | 95% |

***Note:*** *mTrac is a government-led initiative to digitize the sending of Health Management Information System (HMIS) data via mobile phones. The focus of mTrac is to speed up the transfer of HMIS Weekly Surveillance Reports (covering disease outbreaks and medicines), provide a mechanism for community members to report on service delivery challenges, and empower District Health Teams by providing timely information for action*[7,8]*.*

**Question 10: Based on the rapid analysis, which district and/or which sites should she consider in conducting her evaluation?**

**Question 11: What are the advantages to choosing only a small number of sites for a surveillance evaluation? What are the disadvantages?**

**Part VI**

Based on the findings of rapid analysis of the malaria surveillance data in DHIS2, the FETP Fellow focused on District A for the evaluation. Initially, she wanted to know about the sensitivity of the system. In surveillance system evaluations, 'sensitivity' refers to the ability of the system to detect cases that occur in the community or at health facilities[5,6]. Under certain circumstances, the surveillance system may not capture true cases of disease that occur in the community or at facilities. An infected person (i.e., a 'true case') may not seek medical attention; the person may seek medical care but not be tested for the illness; the person may be tested but the test may not detect the disease; the disease may be detected but the person in charge of reporting it may not fill out a case reporting form; the case reporting form may be filled in but not submitted to the surveillance system; the case may be submitted to the system but not submitted up the chain to the next level.

In practice, detecting cases among persons who do not seek medical care, who do not receive appropriate testing, or who are tested but receive a false negative result is extremely difficult and requires a special study. The fellow noted that she had neither the time nor the resources for that activity. However, understanding the ability of the surveillance system's end-user (in this case, the Ministry of Health) to capture cases that are diagnosed and recorded in patient records is possible with the use of *audits.* Audits involve detailed review of health facility clinical and laboratory records (the 'source data') to identify all the cases recorded over a specific time period, and comparing the number of cases recorded to the number reported at the next level, and so on up the chain of reporting[5,6].

The fellow traveled to District A to visit Health Facilities A, B, and C and conduct an audit. Her source data was the laboratory and outpatient registers from January-June 2019. To help her organize her data, she made an Excel file with columns for all the cases she identified in the laboratory register each month, all the cases identified in the outpatient, inpatient, and ANC department registers, and all the cases in the hard copy of the weekly report from each facility, as well as the number of confirmed cases captured in DHIS2. In addition, to evaluate whether or not the facility was reporting their cases, she added a column to show the proportion of weekly reports submitted from that facility to DHIS2 using mTrac. The details are shown in Table 4.

**Table 4: Numbers of confirmed malaria cases captured at the different reporting stages and reporting rates**

| Facility | Health Facility Name/Month | Cases in Laboratory Register | Cases in Department Registers* | Cases in Hard Copy of Weekly Report | Cases Captured in DHIS2 | % of Weekly Reports Submitted to DHIS2 using MTRAC | Sensitivity (%) |
|---|---|---|---|---|---|---|---|
| Facility A | January | 300 | 300 | 300 | 220 | 75% | 73 |
| | February | 358 | 358 | 254 | 254 | 100% | |
| | March | 397 | 397 | 323 | 323 | 100% | |
| | April | 400 | 380 | 340 | 340 | 100% | |
| | May | 447 | 447 | 351 | 252 | 75% | |
| | June | 500 | 409 | 409 | 313 | 75% | |
| Facility B | January | 350 | 350 | 255 | 255 | 100% | |
| | February | 400 | 400 | 359 | 359 | 100% | |
| | March | 450 | 450 | 426 | 426 | 100% | |
| | April | 600 | 600 | 519 | 400 | 100% | |
| | May | 725 | 725 | 657 | 550 | 75% | |
| | June | 750 | 745 | 650 | 300 | 50% | |
| Facility C | January | 453 | 453 | 412 | 412 | 100% | |
| | February | 500 | 500 | 420 | 420 | 100% | |
| | March | 447 | 447 | 339 | 339 | 100% | |
| | April | 601 | 601 | 513 | 513 | 100% | |
| | May | 735 | 686 | 671 | 671 | 100% | |
| | June | 816 | 816 | 816 | 816 | 100% | |

*Because patients seen in the IPD were often seen in the OPD and ANC first, the fellow had to first go through the data and remove duplicate reports of malaria cases from the department cases.

**Question 12: For Health Facility A, the sensitivity of the system during the month of January (defined as the ability of DHIS2 to identify cases that occurred and were diagnosed at Facility A) was 73% (220/300*100). At what point during the reporting chain was the surveillance system losing the cases that were occurring at Facility A?**

**Question 13: Using the same definition for sensitivity as in Question 13, calculate the sensitivity of the system for the other facilities and months.**

| Facility | Health Facility Name/Month | Cases in Laboratory Register | Cases in Department Registers* | Cases in Hard Copy of Weekly Report | Cases Captured in DHIS2 | % of Weekly Reports Submitted to DHIS2 using MTRAC | Sensitivity (%) |
|---|---|---|---|---|---|---|---|
| Facility A | January | 300 | 300 | 300 | 220 | 75% | 73 |
| | February | 358 | 358 | 254 | 254 | 100% | |
| | March | 397 | 397 | 323 | 323 | 100% | |
| | April | 400 | 380 | 340 | 340 | 100% | |
| | May | 447 | 447 | 351 | 252 | 75% | |
| | June | 500 | 409 | 409 | 313 | 75% | |
| Facility B | January | 350 | 350 | 255 | 255 | 100% | |
| | February | 400 | 400 | 359 | 359 | 100% | |
| | March | 450 | 450 | 426 | 426 | 100% | |
| | April | 600 | 600 | 519 | 400 | 100% | |
| | May | 725 | 725 | 657 | 550 | 75% | |
| | June | 750 | 745 | 650 | 300 | 50% | |
| Facility C | January | 453 | 453 | 412 | 412 | 100% | |
| | February | 500 | 500 | 420 | 420 | 100% | |
| | March | 447 | 447 | 339 | 339 | 100% | |
| | April | 601 | 601 | 513 | 513 | 100% | |
| | May | 735 | 686 | 671 | 671 | 100% | |
| | June | 816 | 816 | 816 | 816 | 100% | |

The FETP fellow reviewed Tables 3 and 4 and noted that both timeliness and completeness appeared to be a problem across all sites. Sometimes cases identified in the facilities weren't included in the hard copy weekly reports and sometimes the cases in the weekly reports weren't included in DHIS2.

While it is tempting to blame lack of completeness of surveillance data on laziness or indifference, it more often reflects overworked staff, staff turnover, inadequate training, insufficient resources for reporting, supervisory apathy, technological problems, or other challenges. To identify challenges that might lead to incomplete data, the fellow decided to also evaluate acceptability and simplicity of the surveillance system. Acceptability and simplicity of surveillance systems may be affected by a number of factors as highlighted in Appendix 1[5]. In contrast, the fellow thought that positive predictive value and stability were less likely to be associated with reporting delays or incomplete data.

**Question 14: What actions could you take that could help you assess acceptability and simplicity as they relate to the malaria surveillance system?**

## Part VII

On July 18, the Fellow called four people: the community health workers' coordinator, a records officer at the health sub-district, the District Biostatistician, and the NMCD epidemiologist. She asked if she could visit and discuss the surveillance system with them, focusing on the questions about the simplicity and acceptability of the system. Several days later, she traveled back to District A to conduct the interviews.

The key informants all agreed that the data reporting structure was well defined. They told her that there was a designated records officer at each level of the system whose job it was to report cases. They also shared with her the standardized reporting tools at their levels of the system, and all agreed that they were clear and well-understood. All informants said they reported to the MoH, but they also mentioned that some facilities and districts had to report to implementing partners at the same time, which put a burden on them.

Other information collected from focus group participants included the following:

- Staff generally were very willing to participate in the malaria surveillance system. However, they collectively noted work overload, specifically around disease reporting. Specifically, due to the large number of diseases the records officer was reporting, he noted that he sometimes skipped facilities or records when he was under a tight deadline
- Many private health facilities felt that, because they did not receive government funding, they should not have to report cases to the surveillance system.
- Many community health workers did not see routine reporting as part of their job description and felt they should be compensated additionally for reporting cases.
- Participants reported that the data they did report were not sufficiently utilized to identify problems, including outbreak detection.
- The biostatistician noted that drawing of malaria normal channels was not routinely being done at the Ministry of Health, by the districts, or by the health sub-districts, despite knowledge on the part of biostatisticians on how to draw them.
- He further noted that, because it was not a routine performance indicator – that is, because staff were not evaluated based on the drawing of malaria normal channels – and because they were rarely demanded, it was not viewed as a priority activity.
- The health sub-district records officer reported that his sole responsibility was to ensure that data is entered into DHIS2 and also prepare the quarterly performance reports to be shared with the District Health Officer and the Chief administrative officer. He further said that he had heard about the malaria normal channels for detection of outbreaks but didn't know how to create them.

**Question 15: Based on the above information, does the surveillance system seem simple to you? Does it seem acceptable?**

**Question 16: How might the above-described challenges affect the malaria surveillance data, in terms of number of cases reported in the system?**

**Question 17: Given the additional information provided by the key informants, what factors might be contributing to the delay in detection of the malaria outbreaks in Uganda? For each factor, how would you intervene to ensure prompt detection and response to the outbreaks?**

| Factor | Proposed intervention |
|---|---|
| | |
| | |
| | |
| | |
| | |
| | |

## Conclusion

Without high-quality data, all of the human and material efforts that contribute to the collection, organization, and analysis of surveillance data are useless. The evaluation of surveillance systems can provide critical data that can ultimately improve the quality of data and enable informed decision-making. The malaria surveillance system evaluation revealed major gaps in the surveillance system, both in terms of motivation to collect case data, transfer of case data up the chain of reporting, and incomplete reporting from all facilities. Even when data were available, outbreaks were frequently undetected due to lack of data analysis, which were in part due to the lack of demand from higher levels as well as a lack of knowledge about how to make malaria normal channels.

Following the evaluation, the Ministry of Health conducted a refresher training on use of surveillance data for decision-making, including outbreak detection. The training targeted District Biostatisticians, District Health Officers, District Health Management Information System Focal Persons, District Surveillance Focal Persons, and In-charges of large volume health facilities and covered public health surveillance in general, malaria data extraction from DHIS2, descriptive data analysis, and drawing of malaria normal channels to identify outbreaks. Performance indicators were added to District Biostatistician job evaluations for both drawing malaria normal channels and timely reporting. The Assistant Commissioner NMCD assigned an epidemiologist to be in charge of analyzing surveillance data on a weekly basis, and to follow up with districts to ensure that they were following through with activities. As of 2020, malaria outbreaks continue to be reported in Uganda in multiple hotspots, and malaria surveillance continues to undergo system evaluation

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## Further reading

1. Delays in Global Disease Outbreak Responses: Lessons from H1N1, Ebola, and Zika, 2018, Steven J. Hoffman and Sarah L. Silverberg
2. Drivers of earlier infectious disease outbreak detection: a systematic literature review, 2016, Panel Lindsay Steele, Emma Orefuwa, Petra Dickmann

## Competing interest

The authors declare they had no competing interest

## Author's contributions

LB-Collected the data and information, LB-Led the writing process and drafted the case study; DK, BK, SNK, and ARA participated the case study development workshop and the writing process. JRH facilitated the case study development workshop, writing, and revision of many drafts. All authors read and gave approval to the final case study for use and publication.

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## Disclaimer

The contents of this case study are the sole responsibility of the authors and do not necessarily represent the official views of the US Centers for Disease Control and Prevention/the Agency for Toxic Substances and Disease Registry, the US Department of Health and Human Services, Makerere University School of Public Health, African Field Epidemiology Network or the Uganda Ministry of Health.

## Appendices

## Appendix I: Broad steps of a public health surveillance system evaluation

| Component | Description |
|---|---|
| Engage the Stakeholders in the Evaluation | At a meeting, stakeholders are presented with the plan for evaluation and are asked to provide input to ensure that the evaluation addresses appropriate questions, assesses pertinent attributes, and that its findings will be useful. Stakeholders can be defined as persons or organizations who use the surveillance data for the promotion of healthy lifestyles and the prevention and control of disease, injury, or adverse exposures. Stakeholders who might be interested in defining questions to be addressed by the surveillance system evaluation and subsequently using the findings from it include public health practitioners, health-care providers, data providers and users, representatives of affected communities, governments at the local, state, and federal levels, and professional and private nonprofit organizations. |
| Describe the Surveillance System to be Evaluated | This involves describing the public health importance of the disease or event under surveillance, the purpose and operations of the surveillance system, and the resources used to operate the system. Multiple sources of information might be needed here, including consultations with a variety of stakeholders involved with the system, checking reported descriptions of the system against direct observations. |
| Focus the evaluation design | This step is done to ensure that the limited resources most control programs are faced with including time and money are utilized efficiently. This involves articulating the specific purpose of the evaluation; the stakeholders who will receive the results and recommendations (the intended users); considering what will be done with the information generated; specifying the questions that will be answered by the evaluation; and defining standards for assessing the performance of the system. |
| Gather Credible Evidence Regarding the Performance of the Surveillance System | This facilitates the identification of gaps in surveillance system functioning. The evidence of the system's performance must be viewed as credible; and the gathered evidence must be reliable, valid, and informative for its intended use. The system's performance must be assessed based on some or all of its attributes (usefulness, simplicity, flexibility, data quality (data completeness and validity), acceptability, sensitivity, representativeness, positive predictive value, timeliness, and stability. There are many potential sources of evidence regarding the system's performance, including comparisons of source data to data in the surveillance system through audits of source data, consultations with physicians, epidemiologists, statisticians, and other persons participating in the system. It is critical here to gather enough data to defend conclusions about the surveillance system's function and recommendations for its improvement. |
| Justify and State Conclusions, and Make Recommendations | Conclusions from the evaluation are justified through appropriate analysis, synthesis, interpretation, and judgement of the gathered evidence regarding the performance of the public health surveillance system. Because the stakeholders must agree that the conclusions are justified before they will use findings from the evaluation with confidence, the gathered evidence should be linked to their pre-defined standards for assessing the system's performance. In addition, the conclusions should state whether the surveillance system is addressing an important public health problem and is meeting its specified objectives. Since needs change and systems change, a system that was once useful and met its objectives may no longer be doing these things. Recommendations may be made about modifications to a surveillance system. Before recommending modifications to a system, the evaluation should consider the cost implications. In some instances, conclusions from the evaluation indicate that the most appropriate recommendation is to discontinue the public health surveillance system; however, this type of recommendation should be considered carefully before it is issued. The cost of renewing a system that has been discontinued could be substantially |

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| | greater than the cost of maintaining it. The stakeholders in the evaluation should consider relevant public health and other consequences of discontinuing a surveillance system. |
| Ensure Use of Evaluation Findings and Share Lessons Learned | We make deliberate efforts to ensure that the findings from a public health surveillance system evaluation are used and disseminated appropriately. When conclusions from the evaluation and recommendations are made, follow-up might be necessary to remind intended users of their planned uses and to prevent lessons learned from becoming lost or ignored. Strategies for communicating the findings from the evaluation and recommendations should be tailored to relevant audiences, including persons who provided data used for the evaluation. |

## Appendix II: Attributes of surveillance systems

**Usefulness:** Usefulness implies that surveillance results are used for public health action. Assessing usefulness consists in taking inventory of actions that have been taken in conjunction with the surveillance system. A public health surveillance system is useful if it contributes to the prevention and control of adverse health-related events, including an improved understanding of the public health implications of such events. A public health surveillance system can also be useful if it helps to determine that an adverse health-related event previously thought to be irrelevant is actually important. In addition, data from a surveillance system can be useful in contributing to performance measures, including health indicators that are used in needs assessments and accountability systems

**Simplicity:** The simplicity of a public health surveillance system refers to both its structure and ease of operation. Surveillance systems should be as simple as possible while still meeting their objectives.
Simplicity might be affected by the amount and type of data necessary to establish that the case definition has been met; amount and type of other data collected; number of organizations receiving case reports; integration with other systems; method of collecting the data and time spent on collecting data; amount of follow-up necessary to update data on the case; time spent on transferring, entering, editing, storing, and backing up data; methods for analyzing and disseminating the data, including time spent on preparing the data for dissemination; training requirements; and time spent on maintaining the system.

**Flexibility:** A flexible public health surveillance system can adapt to changing information needs or operating conditions with little additional time, personnel, or allocated funds. Flexible systems can accommodate, for example, new health-related events, changes in case definitions or technology, and variations in funding or reporting sources. In addition, systems that use standard data formats (e.g., in electronic data interchange) can be easily integrated with other systems and thus might be considered flexible.

**Acceptability:** Acceptability reflects the willingness of persons and organisations to participate in the surveillance system. Acceptability is influenced substantially by the time and efforts required to complete and submit reports or perform other surveillance tasks. Acceptability is linked to completeness of report forms and timeliness of data reporting. Quantitative measures of acceptability can include: subject or agency participation rate (if high, how quickly it was achieved?); interview completion rates and question refusal rates (if the system involves interviews); and physician, laboratory, or hospital/facility reporting rate.

**Data quality:** Data quality reflects the completeness and validity of the data recorded in the public health surveillance system. Examining the percentage of “unknown” or “blank” responses to items on surveillance forms is a straightforward and easy measure of data quality. Data of high quality will have low percentages of such responses.

**Completeness** can be considered as having two separate dimensions: Internal completeness refers to whether there are missing and/or unknown data fields in a surveillance database and can be defined as 'the number of completed data fields out of the total number of data fields' (unknown and missing items should be included in the denominator). External completeness relates to whether the data available to the surveillance system reflect the true number of cases affected by a given condition. External completeness applies to the reporting process only and is equivalent to 'sensitivity of reporting' as described below. It can be a way to estimate underreporting of surveillance data but is does not measure under-ascertainment.

**Sensitivity:** The sensitivity of a surveillance system can be considered on two levels. First, at the level of case reporting, sensitivity refers to the proportion of cases of a disease (or other health-related event) detected by the surveillance system. Second, sensitivity can refer to the ability to detect outbreaks, including the ability to monitor changes in the number of cases over time.

**Positive predictive value:** Positive predictive value (PPV) is the proportion of reported cases that actually have the health-related event under surveillance. In assessing PPV, primary emphasis is placed on the confirmation of cases reported through the surveillance system. The effect of PPV on the use of public health resources can be considered on two levels. At the level of case detection, PPV affects the amount of resources used for case investigations. A surveillance system with low PPV, and therefore frequent “false-positive” case reports, would lead to misdirected resources. At the level of outbreak (or epidemic) detection, a high rate of erroneous case reports might trigger an inappropriate outbreak investigation. Therefore, the proportion of epidemics identified by the surveillance system that are true epidemics can be used to assess this attribute.

**Representativeness:** A public health surveillance system that is representative accurately describes the occurrence of a health-related event over time and its distribution in the population by place and person.
**Timeliness:** Timeliness reflects the speed between steps in a public health surveillance system. The time interval linking any two of these steps can be examined. The interval usually considered first is the amount of time between the onset of a health-related event and the reporting of that event to the public health agency responsible for instituting control and prevention measures**.**

**Stability:** Stability refers to the reliability (i.e., the ability to collect, manage, and provide data properly without failure) and availability (the ability to be operational when it is needed) of the public health surveillance system. Some of the measures of system stability might be: the number of unscheduled outages and down times for the system’s computer; the costs involved with any repair of the system’s computer, including parts, service, and amount of time required for the repair; the percentage of time the system is operating fully; the desired and actual amount of time required for the system to collect or receive data; the desired and actual amount of time required for the system to manage the data, including transfer, entry, editing, storage, and back-up of data; and the desired and actual amount of time required for the system to release data. A lack of dedicated resources might affect the stability of a public health surveillance system. For example, workforce shortages can threaten reliability and availability.