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Evaluating Response Time in Zanzibar's Malaria Elimination Case-Based Surveillance–Response System

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Abstract. As countries transition toward malaria elimination, malaria programs rely on surveillance–response systems, which are often supported by web- and mobile phone–based reporting tools. Such surveillance–response systems are interventions for elimination, making it important to determine if they are operating optimally. A metric to measure this by is timeliness. This study used a mixed-methods approach to investigate the response time of Zanzibar's malaria elimination surveillance–response system, Malaria Case Notification (MCN). MCN conducts both passive and reactive case detection, supported by a mobile phone–based reporting tool called Coconut Surveillance. Using data obtained from RTI International and the Zanzibar Malaria Elimination Program (ZAMEP), analysis of summary statistics was conducted to investigate the association of response time with geography, and time series techniques were used to investigate trends in response time and its association with the number of reported cases. Results indicated that response time varied by the district in Zanzibar (0.6–6.05 days) and that it was not associated with calendar time or the number of reported cases. Survey responses and focus groups with a cadre of health workers, district malaria surveillance officers, shed light on operational challenges faced during case investigation, such as incomplete health records and transportation issues, which stem from deficiencies in aspects of ZAMEP's program management. These findings illustrate that timely response for malaria elimination depends on effective program management, despite the automation of web-based or mobile phone–based tools. For surveillance–response systems to work optimally, malaria programs should ensure that optimal management practices are in place.

INTRODUCTION

Between 2000 and 2015 there was marked progress in malaria control worldwide, with a 41% decrease in malaria incidence and a 62% decrease in malaria mortality.[1] As a result, malaria elimination, or zeroing the incidence of indigenous malaria cases in a specific geographic region, has become a stated objective.[2] In fact, 35 countries across the world have made formal commitments toward elimination.[3] However, the prospect of eliminating malaria is only feasible in countries that presently have a low malaria burden, are located near "the margins of malaria-endemic regions," and have the health system capacity to conduct a "relentless focus on surveillance and response."[4]

Key to malaria elimination is the interruption of its transmission, which requires rapid detection and treatment of all infected individuals early in the course of illness.[5] Infected individuals can become a source of the parasite if left untreated, so the quicker a surveillance system can identify cases, the faster response can be taken to halt onward transmission. Traditionally, malaria programs use passive case detection (PCD), which relies on health facilities to report cases they detect. However, at near-elimination levels, malaria is characterized by temporal and geographic micro-epidemiological variations[6] and the proportion of asymptomatic cases can be higher—especially in regions that have recently reduced transmission.[7] This renders PCD insufficient to aid malaria elimination, as it is unable to detect all malaria infections. As a result, malaria programs turn to reactive case detection (RACD) when pursuing malaria elimination, which involves case investigation of household members and/or surrounding households of a passively detected index case.[8] Secondary cases of malaria are more likely to be found in index case households or nearby households than in noncase households,[9–12] making RACD useful for targeting public health efforts.[13] Such surveillance–response systems produce spatiotemporal data in near-real time[14] to guide public health response and are considered an intervention during the elimination phase.[8] To facilitate rapid surveillance and response, in addition to making data more accessible, many malaria programs have incorporated novel information communication technologies into their surveillance–response systems.[15]

Zanzibar, an archipelago off the coast of Tanzania, with two major islands (Unguja and Pemba), is one region that is pursuing elimination.[16] The introduction and scale-up of interventions in 2004, supported by assistance from the Global Fund to Fight AIDS, Tuberculosis, and Malaria[17] and the U.S. Presidents Malaria Initiative (PMI),[18] reduced malaria prevalence from 35–40% in 1995[19] to 1% as of 2007.[20] Because of the low burden of malaria and the isolation of Zanzibar as an island, the government of Zanzibar conducted a malaria elimination feasibility assessment in 2009. The findings indicated that elimination was possible but would require a high coverage of interventions and a robust surveillance–response system.[19] As a result, the government of Zanzibar launched Malaria Case Notification (MCN) in 2012, a surveillance–response system that uses both PCD and RACD via a novel mobile-based reporting technology called Coconut Surveillance. Coconut Surveillance was developed by RTI International[21] with support provided by PMI's Tanzania Vector Scale-up Project (TVCSP).[22] Furthermore, Zanzibar shifted strategy from control to elimination by launching the Zanzibar Malaria Elimination Program (ZAMEP) in 2013, which has a goal of achieving malaria elimination by 2018.[23]

As an essential component of malaria elimination, surveillance–response systems should undergo periodic evaluations to assess their performance.[24] A vital metric is timeliness,

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which captures the length of time taken to collect, analyze, and disseminate data.[25] Despite its importance, timeliness has not been measured in a standardized manner and it is a relatively underdeveloped metric. Most of the studies investigating timeliness of surveillance have focused on simple measures, such as summary statistics of response time (i.e., median and interquartile range [IQR]), response time ranges, and proportion of cases reported within a preset time range.[26,27] A few other studies went beyond simple measures and investigated the relationship of timeliness with health system and surveillance–response system factors, geographic factors, and epidemiological factors.[28,29] To our knowledge, very few studies have investigated timeliness of malaria surveillance in a malaria eliminating country[30–32] or in a subnational elimination program.[33] These studies investigated the association of timeliness with health system factors and compared timeliness before and after the introduction of web-based and mobile phone–based reporting systems or the initiation of an elimination program. However, to our knowledge, none have investigated trends in surveillance timeliness of a mobile phone–based elimination program.

This study aimed to fill a gap in the surveillance timeliness literature by evaluating a subnational elimination program that has yet to be studied, Zanzibar's MCN system. Furthermore, it primarily focused the analysis on trends in timeliness after the mobile phone–based system was implemented and analyzed the association of timeliness with geographical and epidemiological factors. Investigating the trend in MCN's timeliness can assess if its ability to gather information and support decision-making for elimination has changed over time. This study also administered surveys and conducted focus groups to assess operational challenges faced during case investigation, which provided a more holistic understanding of timeliness.

MATERIALS AND METHODS

Study population. The study population comprised malaria case data from PCD at health facilities and RACD, or case investigation, between October 5, 2012, and July 31, 2014. In addition, a cadre of health workers called district malaria surveillance officers (DMSOs), who conduct case investigation, were provided paper-based surveys and asked to participate in focus group discussions to provide qualitative data on operational challenges faced during case investigation.

Study setting: MCN and response. All 150 government health facilities participate in MCN, a number which did not change throughout the study period. When a malaria case is passively detected at health facilities using a rapid diagnostic test (RDT) or blood slide microscopy, health-care workers record patient information in a malaria case register (MCR)[34] and report the case to ZAMEP using a mobile phone.[15] The primary RDT used in Zanzibar is the SD BIOLINE Malaria Ag P. f/Pan test (Chicago, IL).[34] These steps comprise the PCD component of MCN. RACD, or case investigation, is then conducted by DMSOs.

There are 20 DMSOs in Zanzibar, two per each of Zanzibar's 10 districts. Each DMSOs was provided a motorcycle by the TVCSP for transportation purposes and a tablet preloaded with Coconut Surveillance to record case information.[35] Cases reported by health facilities are automatically transferred to a DMSO's tablet if they are assigned to the same district in which the index case was reported. Once cases are transferred, DMSOs receive a case notification on Coconut Surveillance and commence RACD. DMSOs then review and collect case information at health facilities; travel to the index household to geo-locate the household; capture additional information, such as bed net usage; test all household members for malaria with RDTs; and treat those with positive results.[15,34] Data collected on their tablets are opportunistically synced to the cloud (the Coconut Surveillance server) to allow for near–real-time tracking of cases.[21] This process is to take place within 48 hours,[36] a benchmark which follows the World Health Organization (WHO) guidelines on case investigation during the elimination phase.[37] Once surveillance data are in the Coconut Surveillance server, ZAMEP can analyze them to determine if response activities are needed. Figure 1 depicts the process of case detection and reporting to case investigation.

Data sources. Data were obtained with permission from RTI International and ZAMEP, and included all case records in MCN from October 5, 2012, to July 31, 2014, which coincide with the middle of the low-transmission season in 2012 and the end of the high-transmission season in 2014. Although MCN captures both PCD and RACD data, analysis used only passively detected cases to analyze timeliness. The database covers a period of 634 days and 4,774 reported index cases. Malaria cases were not reported for 18 days during this time period, which was interpreted as zero cases detected for each day. The MCN case data are maintained at the patient level, and include a de-identified case identification (ID) number. Each case ID has a corresponding time stamp for every step of PCD (case reporting) and RACD (case notification, health facility follow-up, household follow-up, and complete household member testing) in addition to information on the patient, household size, health facility the case was detected at, and an identifier for the DMSO who was responsible for case investigation.

Using these data, *Response Time Per Case* was measured as the period of time (in days) from case reporting to when case investigation is finished (when all household members are tested). There was one observed case in which response time was less than zero, and it is not known why this occurred. This observation was excluded before data analysis. Similarly, there is a large peak in response time observed just after MCN was implemented (on November 5, 2012), which could be attributed to training and learning curves of DMSOs. The raw MCN case data, including both the number of reported cases and the average response time compressed to the daily level, can be seen in Figure 2. Note, high variability in average response time per day can be observed at a time when the number of reported cases is low. It is unclear why this occurred. Using the case records, additional variables were created to capture geographic and epidemiological factors (the district a case was reported in and the number of cases reported per day per district).

Ethics. The study protocol was approved by the Institutional Review Board at Duke University in North Carolina. The DMSOs provided written consent in Swahili to participate in the interviews and focus groups. Furthermore, all personal identifiers were removed from the datasets before analyses were undertaken.

Data analysis. *Quantitative analysis.* The quantitative analysis in this study was guided by three broad hypotheses. 1) *Response time per case varies by district*. Operational capacity to report and respond to cases is likely to be inconsistent across Zanzibar's districts. Measuring the variation of response time

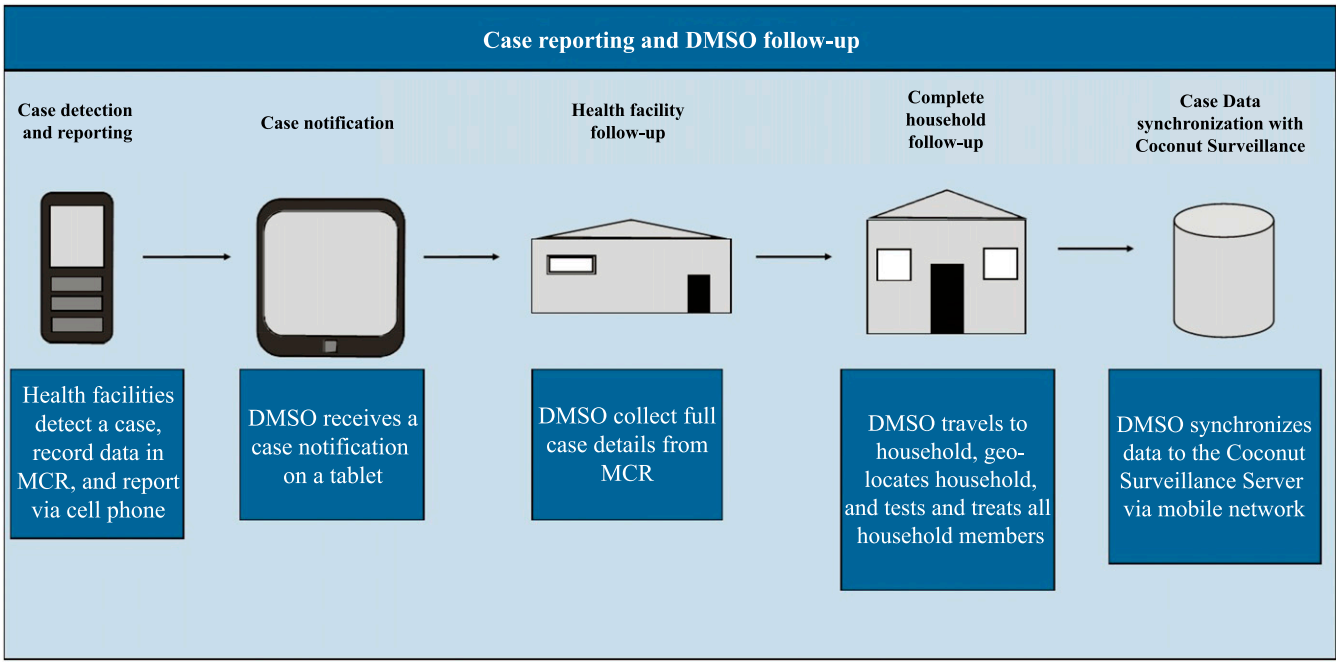

FIGURE 1. Case reporting and district malaria surveillance officer (DMSO) follow-up. MCR = malaria case record. This figure appears in color at www.ajtmh.org.

may identify districts that are lagging, which can be used to more efficiently target public health resources. 2) *Response time per case is negatively associated with calendar time—such that response time goes down (improves) over the course of the study period*. At the time of the study, MCN had been in operation for less than 2 years. For the purposes of supporting ZAMEP to achieve malaria elimination, it was expected that DMSOs would become more efficient as they became more experienced. 3) *Response time per case is positively associated with the number of reported cases*. As the number of reported cases increases, it was expected that DMSOs would take more time to respond. Identifying the degree to which this happens is an important operational measure of MCN's performance.

The first hypothesis was investigated by analyzing summary statistics (median reported cases, as well as the median and IQR of response time). The second and third hypotheses were analyzed by using time series techniques to characterize timeliness of case investigation over the study period, and to assess whether response time (*Response Time per Case*) varied by calendar time (*Time*) - both measured in days - and the number of reported cases (*Reported Cases*). Generalized linear models were fitted to the dependent variable, *Response Time Per Case*, hereafter referred to as response time. Fourier terms were also included in the model to account for potential periodicity in response time due to seasonal fluctuations in malaria transmission. In this study, the Fourier terms consisted of a sine and cosine function of *Time*. Table 1 summarizes the variables used to analyze response time. In addition to periodicity, there is likely to be short-term autocorrelation and correlation of response time by DMSO because the same DMSO is responsible for investigating multiple cases in the same district. As such, a general estimating equation (GEE) was used to account for these potential correlations in response time, with a log link, an exchangeable working correlation structure, and a negative binomial distribution to account for overdispersion in the outcome. Two models were used in the analysis. The first model investigated the association of calendar time with response time to understand linear trends in timeliness of MCN. The second model included a term for the number of reported cases to investigate the association of calendar time with response time, while controlling for the number of cases. Sensitivity analyses were conducted for both models by excluding the peak in response time on November 5, 2012. This peak was excluded in the modeling because its value stood far outside the surrounding temporal values for response time. Other peaks in the data were clustered together, whereas this peak was isolated.

Qualitative analysis. The second part of this study consisted of survey administration and focus group discussions with DMSOs to better understand the operational challenges faced during case investigation. All 20 DMSOs in Zanzibar were provided a survey with closed and open-ended questions that covered the topics of transportation, completeness and accuracy of data in MCRs at health facilities, household follow-up, and technological issues. Surveys were translated to Kiswahili before administration. Responses from 18 of the 20 DMSOs were received. The two surveys missing were from DMSOs in Unguja. Results were analyzed for global themes which were probed further during subsequent focus groups. Two separate focus groups were held with DMSOs in Unguja (on July 25, 2014) and Pemba (on July 26, 2014). In-depth notes were later evaluated for additional themes and details. The focus groups were conducted in Kiswahili with the assistance of a translator. All 20 DMSOs attended the focus groups.

RESULTS

Quantitative findings. *Variation of response time by district.* The median and IQR of response time in each district in Zanzibar, along with the median number of reported cases in each district, can be found in Table 2. A notable finding was that on average, the median response time is

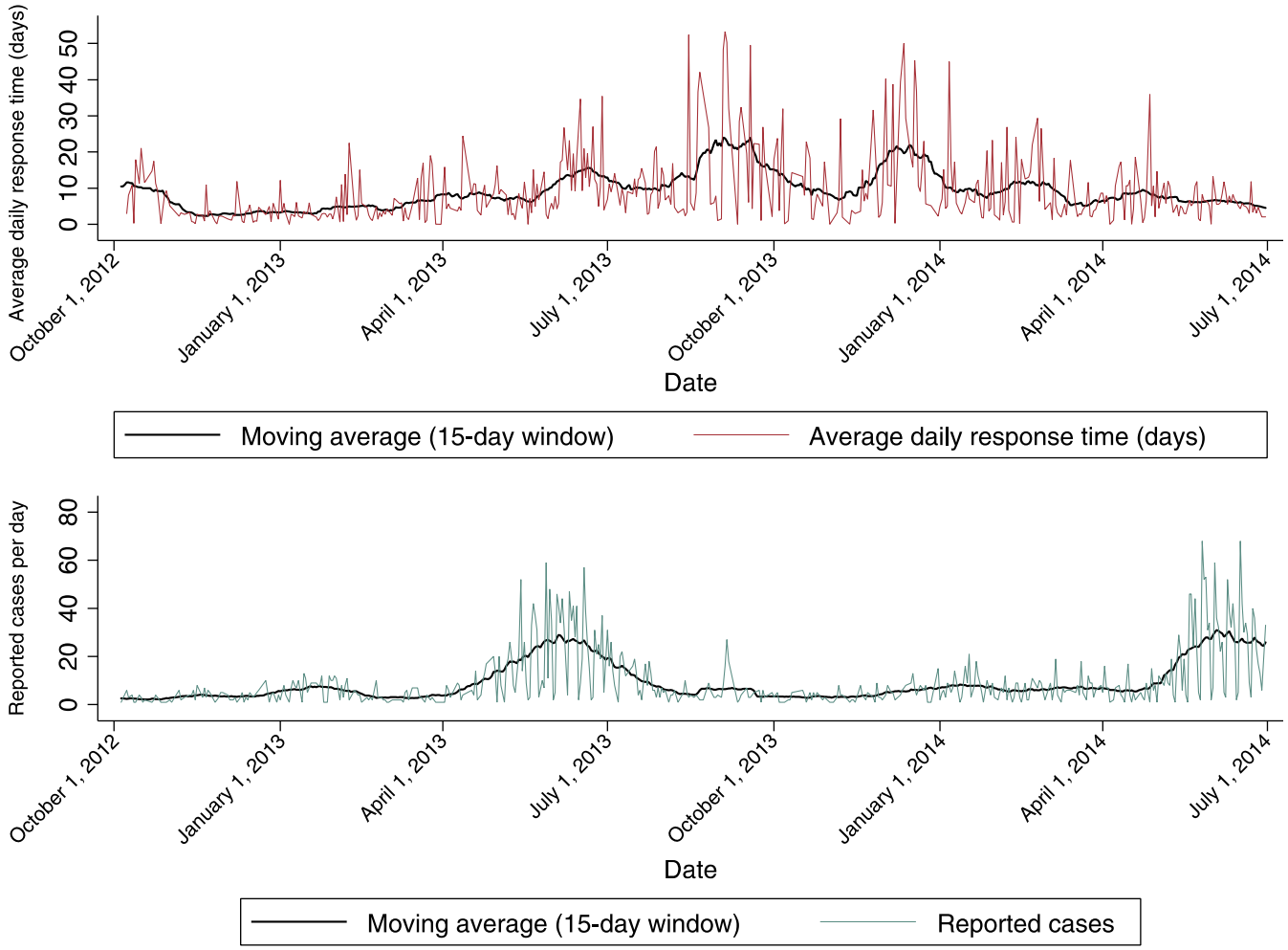

FIGURE 2. Average daily response time (days) and reported cases per day in MCN. Note: Peak seasons of malaria transmission occur between May and August. This figure appears in color at www.ajtmh.org.

higher in districts in Unguja than that in Pemba. Similarly, on average, the median number of passively reported cases is also higher in districts in Unguja than that in Pemba. Another finding to note is the high variability in the median response time across districts, ranging from 0.6 days (IQR: 0.03–0.07) in Wete District to 6.05 days (IQR: 1.33–15.24) in South District. Furthermore, there also seemed to be high variability in response time within districts. This is illustrated by large IQRs, with the spread of data being higher in districts in Unguja than of those in Pemba.

TABLE 1
Description of variables

Variable	Description
Response time	Overall response time from case reporting to complete household member follow-up for each case. Complete follow-up captures the amount of time it takes to capture case data on each household member, which often necessitates revisiting of households.
Time	Length of time MCN has been in place, measured in days
District	Administrative district of the health facility or hospital where the case was detected
Reported cases	Total number of cases reported within a district on the same day
Fourier terms	Sine and cosine functions of the time variable

Association of response time with time and reported cases. Results of the GEE models can be seen in Table 3. The first model indicated that there was no significant linear change in response time over calendar time after controlling for the seasonal effect. The results for the second model, which further controlled for the number of reported cases, also indicated that there was no significant linear change in response time. The association between the number of reported cases and response time was positive: 1.004 (95% confidence interval: 0.994–1.013), indicating that for each additional reported case, the response time increased by 0.004 days. However, this association was not statistically significant at the 0.05 level.

Qualitative findings. Survey responses and focus group discussions with DMSOs revealed that, across case investigation, DMSOs encountered operational challenges in four broad areas: missing and inaccurate information in MCRs, difficulty finding households and surprise and distrust on household follow-up, transportation and network connectivity

TABLE 2
Response time (days) and median reported cases per district

District	Median passive cases reported (per day)	Response time (median and IQR)				
		Median	25th percentile	75th percentile	IQR	IQR–median ratio
Districts in Unguja						
Central	6	6.04	2.17	10.49	8.32	1.38
North A	3	1.93	0.93	4.10	3.17	1.64
North B	4	5.88	2.06	12.44	10.38	1.77
South	5	6.05	1.33	15.24	13.91	2.30
Urban	3	4.95	1.96	11.18	9.22	1.86
West	5	5.00	2.25	9.29	7.04	1.41
Districts in Pemba						
Chake Chake	1	1.96	0.98	3.98	3.00	1.53
Micheweni	3	4.11	1.20	15.13	13.93	3.39
Mkoani	2	0.92	0.16	1.93	1.77	1.93
Wete	2	0.60	0.03	1.07	1.04	1.73

IQR = interquartile range. Administratively, Zanzibar is divided into 10 districts, six of which are in Unguja and four of which are in Pemba.

issues, and finally varied case prioritization. These challenges are summarized in Table 4.

Missing and inaccurate information in MCRs. A challenge DMSOs consistently reported was incomplete or inaccurate information found in MCRs at health facilities. DMSOs noted that contact information of the patient (phone number and address) was frequently missing from MCRs—a problem which impaired the DMSOs' abilities to conduct the household follow-up step. Some DMSOs hypothesized that this was because of a patient's inability to provide answers or an unwillingness to divulge personal information. It was posited by some DMSOs that incorrect information in a MCR and a patient's inability to provide certain information, such as their address, were due to their recently arriving in Zanzibar. However, other DMSOs theorized that health facilities failed to collect this information because of either being too busy or an overreliance on them to collect this information. In terms of the latter, it was perceived by DMSOs that health facility personnel considered the recording and reporting of cases to be the sole responsibility of DMSOs. In fact, DMSOs also reported that they would occasionally find cases in MCRs that were not reported to MCN. In such circumstances, DMSOs had to request health facility personnel to report the case to receive the case notification.

Difficulty finding the household and surprise and distrust on household follow-up. Because of missing information in MCRs, DMSOs often had difficulties locating index case households. However, even once they arrived for household follow-up, DMSOs encountered additional problems. One issue reported was that household members were surprised to see DMSOs or were not present—necessitating repeat follow-ups. Another issue reported was that household members often refused to be tested, fearing the use of needles or suspecting that the test was meant for HIV and not malaria.

Transportation and network connectivity issues. An overarching issue reported which affected the entire case investigation process was transportation issues. DMSOs primarily rely on the motorcycles provided by the TVCSP to travel to health facilities and households. However, fuel shortages in Zanzibar made it difficult for DMSOs to use them—necessitating the use of public transportation. Issues related to transportation were more commonly reported in Pemba. In both Unguja and Pemba, DMSOs reported that lack of reliable transportation became especially problematic when they faced a high number of reported cases or cases with large distances between them. Network connectivity issues were also reported, which delayed when DMSOs could send data to Coconut Surveillance. This was exemplified by the fact that DMSOs often had to travel 8–20 km (5–12 miles) to get a signal for opportunistic synchronization with the Coconut Surveillance server to occur.

Varied case prioritization. Finally, DMSOs revealed that their case prioritization often did not follow the order in which case notifications were received and that prioritization of cases varied. Whereas some would prioritize cases that were reported first, others would prioritize cases that were reported most recently. Meanwhile, other DMSOs would prioritize cases depending on their location.

TABLE 3
Modeling results for case response time

Variables	Model 1 IRR (95% CI)	Model 2 IRR (95% CI)
Time (days)	1.000 (0.999–1.000)	1.000 (0.999–1.000)
Sine (time)	0.924 (0.876–0.975)**	0.932 (0.881–0.986)*
Cosine (time)	1.591 (1.479–1.710)**	1.592 (1.480–1.713)**
Reported cases	–	1.004 (0.994–1.013)
Constant	7.987 (6.697–9.526)**	7.870 (6.579–9.414)**

CI = confidence interval; IRR = incidence rate ratios. Output presented are IRR, with values in parentheses being the 95% CI. Asterisks indicate that the variables are statistically significant: * = at the 0.05 level and ** = at the 0.01 level of significance. Note: constant here refers to the intercept, or the response time at the beginning of the time series.

DISCUSSION

Taken together, the quantitative findings and responses from DMSO surveys and focus groups illustrate the complexities of rapid reporting and case investigation for malaria elimination. In fact, case investigation in Zanzibar often did not occur within internationally agreed on standards. Over the course of the study period, the median response time ranged from 0.602 days to 6.05 days. Only within four of Zanzibar's 12 districts (Chake Chake, Mkoani, North A, and Wete) were DMSOs able to complete case investigation (follow-up to the household and testing of all household members) within WHO's 48-hour benchmark. This challenge, however, is not unique to Zanzibar and has been identified in other settings.[12,31] Incidentally, the districts in which case investigation was completed within 48 hours had some of the lowest numbers of reported cases, which could explain a faster response time. Furthermore, the IQR of response time in these districts

TABLE 4
Summary of challenges that DMOSs face during reactive case detection, categorized by case detection stage

Case detection and reporting	Health facility follow-up	Household follow-up	Case data synchronization
1. Incomplete and/or erroneous information collected in MCRs	1. Transportation delays	1. Transportation delays	1. Poor network connectivity delays when information is sent to the Coconut Surveillance server
2. Health facility personnel may not report all cases	2. Inconsistent prioritization of cases	2. Inconsistent prioritization of cases	
	3. DMSO requests health facility personnel to report cases found in MCRs	3. DMSOs have difficulty locating households because of missing or incorrect information in MCRs	
		4. DMSOs need to conduct repeat visits to test all household members	
		5. Household members suspect testing is for HIV	

DMSO = district malaria surveillance officer; MCR = malaria case record.

were also the lowest—illustrating the consistency of case investigation. For the remaining districts, however, median response times ranged from 4.11 days to 6.05 days and response time IQRs ranged from 7.04 days to 13.93 days. The varied nature of response time in Zanzibar showcases how operational challenges can impede case investigation despite the automation provided by mobile reporting, a finding noted in other studies on malaria eliminating countries.[12,38] In their responses to surveys and focus group discussions, DMSOs shed light on four broad program management challenges faced during case investigation that could impact timely case investigation and malaria elimination efforts: unclear definition and distinction of roles within ZAMEP, erroneous data provided by newcomers, transportation and network connectivity issues, and finally varied case prioritization.

Definition and distinction of roles in ZAMEP. Some DMOSs noted that health facility personnel seemed to be overly reliant on them to collect the information in MCRs. This was most evident by the occurrence of incomplete information and a failure to report cases. This lack of clear division of labor and distinction of roles between health facility personnel and DMSOs could explain why patients and family members were either surprised to see DMSOs or were not present during household follow-up. The latter issue has been previously reported in other studies.[10] Without health facility personnel collecting clear and full information and conveying to malaria patients that a follow-up will occur, delays in the household follow-up and household member testing can be inevitable. This speaks to the need for clearly defining and distinguishing roles of all parties involved in malaria case detection, reporting, and investigation. Assuring standard operating procedures (SOPs) and ensuring that all responsible parties understand program goals can make success more likely.[24,39,40] For health facility personnel, this could be facilitated by the introduction of an electronic platform on which cases can be recorded and reported to reduce the dual burden of paper records and electronic reporting.

Erroneous data provided by newcomers. Another frequent issue raised by DMSOs was the occurrence of erroneous information in MCRs. DMSOs reported this to be more pertinent among those who recently arrived in Zanzibar because of their not knowing the information. Collection of accurate information on all cases is vital for timely case investigation and elimination efforts. However, it can be more important for those who have recently arrived to understand the rate of imported cases. A prior study concluded that malaria infections in Zanzibar resulted from importation and subsequent transmission.[41] Furthermore, it is thought that prior resurgence events in Zanzibar have been caused in part by importation.[19] To minimize the risk to malaria elimination, all suspected imported cases need to be identified, classified, and appropriately targeted through focused strategies, such as border screening, or strengthening of broader elimination strategies, such as reducing local receptivity.[42]

Transportation and network connectivity issues. Transportation issues were another challenge raised by DMSOs. Although DMSOs were issued motorcycles by TVCSP, they reported to experience fuel shortages. As a result, they had to rely on public transportation, the schedule of which has been reported to be unreliable in other studies.[43] This obstacle could result in delays throughout case investigation. A similar issue DMSOs reported was poor network connectivity. Rather than causing a delay in reaching a health facility or a household, poor network connectivity required DMSOs to travel up to 5–10 miles to sync case data with Coconut Surveillance. This workaround could be hampered by unreliable transportation, thereby delaying when ZAMEP receives data to inform response efforts. Ameliorating these barriers will require ZAMEP to make use of TVCSP motorcycles more reliable, perhaps through fuel disbursements, and to use a more dependable mobile network.

Varied case prioritization. Although not a challenge related to case investigation, variations in case prioritization by DMSOs could impact response time. That DMSOs choose to investigate cases in an order that differed from the order in which they were reported by health facilities could explain why median response time varied between districts even when median number of reported cases was the same. For example, while both North A and Urban districts reported a median of three cases per day, their median response times were 1.93 days (IQR: 0.93–4.10) and 4.95 days (IQR: 1.96–11.18), respectively. Furthermore, differing case prioritization may explain the lack of association between response time and calendar time and between response time and the number of reported cases. A pattern of case prioritization by DMSOs should have been captured as the models addressed clustering of data by DMSOs through the use of an exchangeable correlation structure. However, if each DMSO was inconsistent in how he or she prioritized cases, then a lack of association could be explained. Another explanation for the heterogeneity of response times within and across districts could be variations in challenges DMSOs faced, as they were not universally raised. For example, DMSOs may have encountered more challenges during RACD in the Urban district than in North A district. In addition, if DMSOs encountered

health facilities with differing case-recording practices in the same district, a high variance in the response time could theoretically occur.

The introduction of malaria interventions in Zanzibar has brought malaria prevalence down to elimination levels, a feat that is being supported by Coconut Surveillance and DMSOs. ZAMEP's surveillance–response system demonstrates key aspects of effective program management for malaria elimination, such as system-wide access to data and specialist teams intervening on each case.[39] Furthermore, its strategy to screen only household members during RACD has been found to be efficient in terms of cost per case detected and the numbers of secondary cases identified.[44] However, as ZAMEP continues down its path to elimination, it will need to address deficiencies identified in its program management: unclear distinction of roles, inconsistent implementation of SOPs for case reporting and investigation, and suboptimal anticipation of threats to elimination—specifically case importation, unreliable transportation for case investigation, and an undependable mobile network.

In the long-term, Zanzibar will need to maintain its political commitment toward elimination. As prevalence levels decrease and remain low for long periods of time, complacency can set it and interventions can be relaxed—a trend that is associated with more than 90% of resurgence events.[45] A component of this will entail keeping health workers motivated even as cases become increasingly rare.[46] Similarly, communication strategies and community engagement activities could remind the population of the threat of malaria and make them aware of case investigation.

Limitations. Although this study does have some actionable results for ZAMEP, it is not without its limitations. First, forcing a fixed sinusoidal wave form to the data may have oversimplified the complex patterning of response time over calendar time. Furthermore, the data analyzed were also of a relatively short duration and included some missing values. Adequately accounting for periodic trends with just 2 years of data is difficult. Had additional years of data been available for use, longer term trends in response time could have been more clearly estimated. Other data limitations for the quantitative analysis were uncovered during the interviews and focus groups with DMSOs. This included the occurrence of missing or incorrect information in MCRs, which the analysis could not control for. Furthermore, the distances DMSOs traveled and varied case prioritization could also not be controlled for. Thus, variables that may have influenced the modeling of response time were not captured. In addition, DMSOs reported they would occasionally have to request health facility personnel to report a case if they found one in the MCR that was not activated on their tablets. It is not known how often this occurred. As response time was measured as the time between health facility reporting and when all household members are tested, this issue could have made some of the response times artificially low. Last, the focus group discussions with DMSOs were not transcribed and as a result were not coded. Had focus group discussions been recorded and transcribed, additional details lost during note taking could have been analyzed.

Conclusion. The study's findings indicate that mobile reporting tools are not a panacea for rapid case detection and investigation. Although Coconut Surveillance allowed for near-real collection and sending of case data to ZAMEP, quantitative and qualitative findings illustrated that operational challenges hampered this process. As ZAMEP progresses toward elimination, it should strengthen aspects of its program management identified in the article: clear division of labor and distinction of roles, consistent implementation of SOPs, a more stringent focus on imported cases, the provision of reliable transportation for case investigation, and the use of a dependable mobile network for synchronization of data. These findings are relevant to other countries as they embark on their own elimination goals. To make full use of a surveillance–response system, malaria programs should ensure that optimal management practices are in place.

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