Determinants of rapid diagnostic test result use and malaria treatment decision making in the Democratic Republic of the Congo

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Acronyms

DRC	Democratic Republic of the Congo
FGD	Focus group discussion
HMIS	Health Management Information System
IT	*Infirmier Titulaire* (Nurse Administrator)
ITA	*Infirmier Titulaire Adjoint* (Assistant Nurse Administrator)
KII	Key Informant Interview
PNLP	*Programme National de Lutte contre le Paludisme* (National Malaria Control Program)
RDT	Rapid Diagnostic Test (for malaria)
SSI	Semi-structured interview
TPR	Test Positivity Rate (for malaria RDTs)
WHO	World Health Organization

Executive Summary

Introduction

Since 2010, the World Health Organization (WHO) has recommended that all suspected malaria cases be confirmed by methods that detect parasites such as microscopy or rapid diagnostic tests (RDT). Between 2016 and 2019, automated Deki readers, which transmit their interpretation of the RDT result to a cloud database in real time, were deployed in 183 health facilities in two provinces (Haut Katanga and Lualaba) in the DRC. They found that the average annual test positivity rate (TPR) reported via the national Health Management Information System (HMIS) was 30% higher than data collected via Deki readers (53.8% HMIS vs. 23.6% Deki readers). A follow-up study conducted by Measure Malaria also showed discrepancies between the TPR reported by the health facility in the HMIS and the TPR reported by the Deki readers. To understand the discrepancy, the current study examines provider behavior from the time a patient presents with fever, to patient assessment, treatment decisions, and, finally, reporting of results.

Methods

The study applied qualitative methods to explore factors influencing providers' decisions in managing malaria cases, how they record data in the health register, and how health register data are synthesized for monthly reporting in the HMIS. The unit of study was the health center or health post. Health centers and health posts were sampled based on preliminary results from the Measure Malaria study, with the criteria that they must have an operational Deki reader and have submitted at least 10 interpretable RDT results each month from April to June 2022. They were divided into four groups according to patterns of discrepancy between the Deki TPR and the HMIS. At each health facility, the supervisor and up to three other staff members were invited to participate in a semi-structured, mixed-methods interview. A separate instrument was used for supervisors, which included a clinic overview and a clinic mapping module. Other staff were separated into two categories: providers responsible for patient care and staff responsible for operating the Deki readers to capture RDT results and share them with the cloud database. Focus group discussions were also held with community members in the health areas served by the health facilities included in the study. Key informant interviews (KIIs) were conducted with malaria technical officers at the zonal, provincial, and national levels. KIIs were also conducted with the chief medical officers of the central health office in the four selected health zones.

Results

Patient assessment

There are three methods a provider can use to diagnose malaria: clinical diagnosis based on symptoms, RDT, and thick smear microscopy. If RDTs are available at lower-level health clinics, all patients presenting with fever should be diagnosed with an RDT, according to national policy. Study findings show that if the RDT result is positive, the provider will prescribe an antimalarial treatment. However, if

the RDT result is negative, providers in the study had to decide whether they were confident in the result, whether to use microscopy to confirm the RDT result, or if they will make their own assessment based on their experience with the symptoms.

Treatment decision making

When faced with a negative RDT result, providers, particularly in groups showing high discordance between the HMIS and the Deki readers, offered many reasons to provide antimalarials anyway, to perform microscopy to confirm malaria, or to treat the symptoms and have the patient return a few days later to repeat the RDT. Overall, there was little confidence in the negative RDT result, with recourse to microscopy being a common response. Providers in all groups indicated that a negative RDT result did not necessarily rule out malaria. A provider may decide to prescribe antimalarials if he or she perceives the case as "poorly treated" malaria or if the patient has already taken antimalarials or even antipyretics. Providers also felt that the RDT could give false negatives early in infection or if the malaria strain was not captured by the RDT.

Communication of results

Respondents provided many explanations as to why the Deki reader data may not be accurate, why the HMIS may have errors, and why the two data sources may be different. Staff responsible for using the Deki readers had concerns about availability of trained staff as well as lack of electricity and internet or network connectivity. Respondents also cited patients bypassing the consultation and going directly to the laboratory, delays in data transfer or counting errors, confusion about what to record in the register, and forms or registers being out of stock, as well as the lack of a column to record microscopy, as possible explanations for discrepancies. Stock-outs of RDTs and financial incentives also affect reporting.

Discussion and Conclusions

Deviations from prescribed policies are prevalent in health centers and health posts, from 1) patient assessment, which is inconsistently performed with RDTs and may be based on symptoms alone or on microscopy (either alone or in conjunction with an RDT), to 2) treatment decisions, which often do not respect RDT results, especially when they are negative, and 3) reporting, where a variety of factors influence whether cases are reported regularly and correctly.

Recommendations

1. Train providers (not just supervisors) on the appropriate use of RDTs, including a module on resolving misconceptions about RDT negativity and recording cases,
2. Ensure consistent use of RDTs and address the use of microscopy,
3. Work with pharmacists and traditional healers to refer clients to health facilities for testing to reduce self-medication,
4. Develop mass media/interpersonal communication content on pre-treatment testing,
5. Better communication for providers around seasonality and its effect on RDT results,

6. Communication around alternative diseases targeting the community and providers, emphasizing the importance of not missing typhoid or other diseases,
7. Testimonials from respected providers who adhere to RDT results,
8. Discussion of the HMIS data shared each month,
9. Advocacy with providers and supervisors on the importance of data accuracy, including assurance that seasonality will be considered when budgeting for resources to alleviate concerns that lower TPR in the dry season will result in fewer resources.

Introduction

Reporting of results from malaria rapid diagnostic tests: Discrepancies between routine reporting through HMIS and Deki readers

Malaria is a serious public health problem in the Democratic Republic of Congo (DRC); in 2018 the country represented 11% of all malaria cases globally (WHO World Malaria Report, 2018). Since 2010, the World Health Organization (WHO) has recommended that all suspected malaria cases be confirmed through methods that detect parasites such as microscopy or a rapid diagnostic test (RDT) performed on a finger prick blood sample. RDTs offer a simple, inexpensive, and reliable option (Bruxvoort et al, 2017), and are typically used by health centers and health posts in DRC. Basing malaria treatment decisions on RDT results has several benefits, including reducing unnecessary prescribing of antimalarials. This in turn reduces expenditures on antimalarials and may slow the spread of resistance to these medications. It also identifies RDT negative patients, who may require other diagnostic steps, and different treatments.

RDT results provide data that inform the test positivity rate (TPR), calculated based on the number of RDTs with a positive result (indicating detection of malaria parasites) out of all RDTs performed (Kigozi et al., 2019). RDT results can be interpreted visually and reported by health care providers, but in recent years mobile applications have been developed to provide automated interpretation of RDTs by digital image analysis software. One of these applications is the Deki Reader (shown at left), a battery-operated device with a touch screen that can transmit its interpretation of the RDT result along with an image of the RDT to a cloud database in real time. If a health facility has a Deki reader, the data automatically transmitted to the cloud database can be used to calculate monthly average TPR, based on the number of positive results out of the number of tests read per month.

Between 2016 and 2019, Deki Readers were deployed in 183 health facilities across two provinces (Haut Katanga and Lualaba) in DRC. They found the average annual TPR in routine reporting

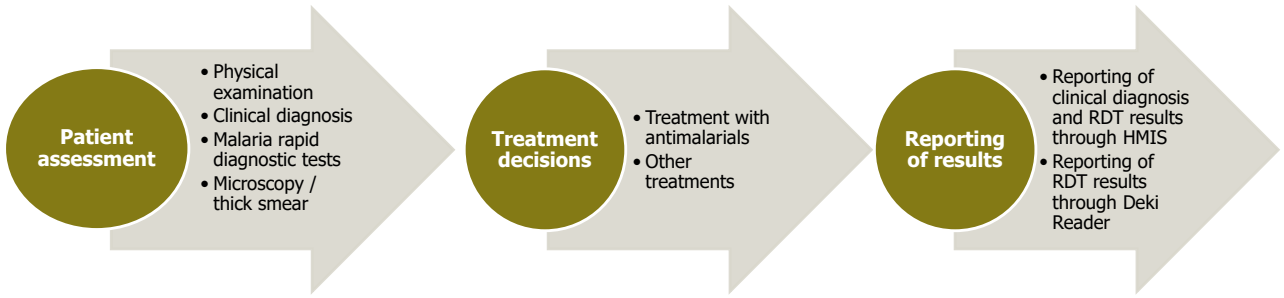
through the Health Management Information System (HMIS) was 30 percentage points higher than in the data collected via the Deki Readers (53.8% HMIS vs. 23.6% Deki readers). A follow-up study by Measure Malaria also showed discrepancies between the TPR reported by the health facility into the HMIS versus the TPR reported through Deki readers.

The HMIS data did not exhibit the expected seasonal variation in occurrence of malaria cases reflecting higher transmission in the rainy season, and lower transmission in the dry season. The Deki readers, however, did exhibit this seasonal variation. The most extreme difference reported between HMIS and Deki reader TPRs occurred in the low malaria transmission season, when the HMIS indicated substantial continued malaria transmission, whereas the Deki reader data indicated much lower transmission.

Reporting of RDT results in the health facility context

Individual behaviors of health care providers in health centers and health posts cannot be studied in isolation. The justification for this study is primarily to examine how Deki readers are being incorporated into clinical practice, and reasons for discrepancies in data reporting between the HMIS and Deki readers. However, to understand this discrepancy we must examine the entire chain of events in health care facilities after a patient presents with fever, starting with patient assessment, then treatment decisions, and finally reporting of results. The preceding steps of patient assessment and treatment decisions can affect when and how results are reported. The three steps are illustrated in Figure 1 below.

Figure 1. Sequence of provider behaviors after a patient presents with fever at a health center or health post.



Patient assessment and treatment decisions

RDT results are intended to guide malaria treatment decisions. Patients with positive results receive antimalarials, while patients with negative results do not receive antimalarial treatments. However, a number of studies have demonstrated that patients with negative RDT results commonly receive antimalarial treatments. This in turn can result in overuse of expensive treatments, and also favor the emergence of resistance to these treatments. Findings from prior studies shed light on reasons that patients with negative RDT results nevertheless receive antimalarial treatments:

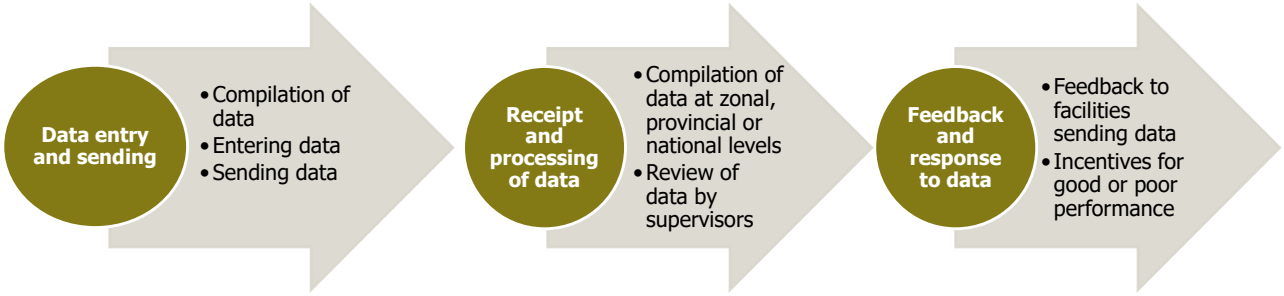
1. Patient assessment: Health workers often lack proficiency in differential diagnosis and identifying alternate treatments (Burchett et al., 2017). If providers are not confident in their ability to make alternate diagnoses in the presence of a negative RDT, they may prefer to treat for malaria rather than not treating at all.
2. Treatment decisions: Health workers may not have confidence in RDT results and may rely more on their clinical expertise and other factors to ascertain if a patient's symptoms constitute malaria (Altaras et al., 2016; Diggle et al., 2014; Johansson et al., 2016). They may also feel that when a patient comes to the health center or health post, the provider is obliged to provide treatment (Beisel et al., 2016; Johansson et al., 2016). Providers may also fear missing a case of malaria, particularly in children (Mokulu et al., 2018). Providers may be concerned that the risk of not treating for malaria is too great and may consider potential disease severity and client challenges to care-seeking as reasons to err on the side of antimalarial treatment to prevent a client becoming sicker and potentially needing to return to the facility (Altaras et al., 2016; Beisel et al., 2016; Burchett et al., 2017; Johansson et al., 2016).

The Measure Malaria study findings raise questions about the degree to which healthcare providers rely on RDT results when making malaria case management decisions for their patients (versus relying primarily on clinical presentation and clinical intuition), and which other factors influence provider decisions about malaria case management.

Reporting of results

The third step in Figure 1, reporting of results, itself can be broken down into multiple steps, as illustrated in Figure 2.

Figure 2. General steps in reporting of results in a HMIS.



1. Data entry and sending: In the first step, data are entered, compiled, and sent from the health care facility. Compilation may happen in paper forms or registers, or with a smartphone app. Data are then sent, either in paper reports or by emailing a report or uploading data to a server. Previous research has shown that providers may only record positive RDT results in the patient register (Mokuolu et al., 2018), or data may be lost between the patient register and the monthly totals reported into the HMIS (Breakthrough ACTION DRC, 2021). More generally, any time that data are either compiled, or transferred from one format to another in a HMIS, there is potential for introduction of inaccuracies and miscalculations. This has been demonstrated for

both community-based HMIS (Mitsunaga et al. 2015; Regeru et al. 2020) and facility-based HMIS (Nshimyiryo et al. 2020; Feng et al., 2021).

2. Receipt and processing of data: At the zonal, provincial, or national levels, data are then compiled and reviewed by supervisors.
3. Feedback and response to data: Finally, feedback is provided to the health care facilities that submitted the data. Supervisors may provide feedback through phone calls, routine meetings, or supervisory visits. In the context of a system of performance-based financing, there may be financial incentives for good performance. A further possible incentive is increased provision of medications and supplies to health care facilities, based on the number of patients seen or treated.

In DRC, differences in TPR reported through HMIS or Deki readers have considerable implications for malaria surveillance data and decision-making by supervisors and program managers about malaria prevention and treatment activities. The Measure Malaria study findings identify differences in TPR based on HMIS versus Deki Reader data, and raise concerns about how health care providers in health facility record and report data.

Methods

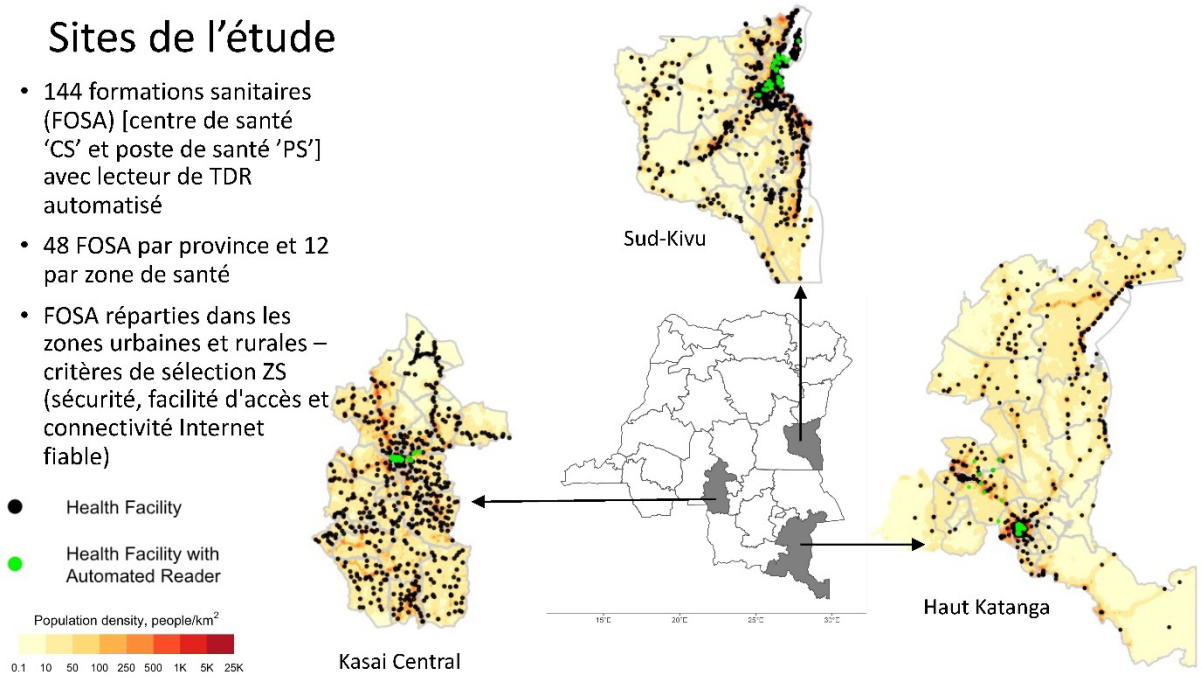
Study design

This qualitative study was situated within the 12-month parent study, "Assessment of malaria rapid diagnostic test readers for measuring sub-national test positivity rates and improving surveillance data quality", conducted by the Measure Malaria program that began in December 2021. In health centers and health posts participating in the Measure Malaria study, two distinct systems of reporting and compiling data were in place:

1. The existing system for reporting malaria diagnoses and results of rapid diagnostic tests through the national Health Management Information System (HMIS),
2. A parallel system for reading and uploading RDT results to a cloud server through Deki readers.

The study piloted the automated testing and reporting for malaria through Deki readers in health centers and health posts, which receive most patients with suspected malaria cases in DRC. Objectives of the Measure Malaria study included assessing patterns of discrepancy in TPR between RDT and Deki Reader by geography, level of malaria endemicity, seasonality, and health facility characteristics. While the Measure Malaria study was implemented in 144 health facilities across three provinces of DRC: Kasai Central, Haut Katanga and Sud-Kivu, as shown in Figure 4, this qualitative study was implemented in the two of the three study provinces for which HMIS data indicate the highest TPR for malaria RDTs: Kasai Central and Haut Katanga.

Figure 3. Location of provinces and health care facilities for Measure Malaria study



This qualitative study (referred to as the Breakthrough ACTION DRC study) complements the Measure Malaria study by seeking to understand why there are disparities in TPR as recorded by the Deki readers reported by health facility personnel through the HMIS. The study applied qualitative methods to explore factors that influence providers' decisions in malaria case management, how they record data in the health register, and how the data in the health registers are synthesized for monthly reporting into the HMIS.

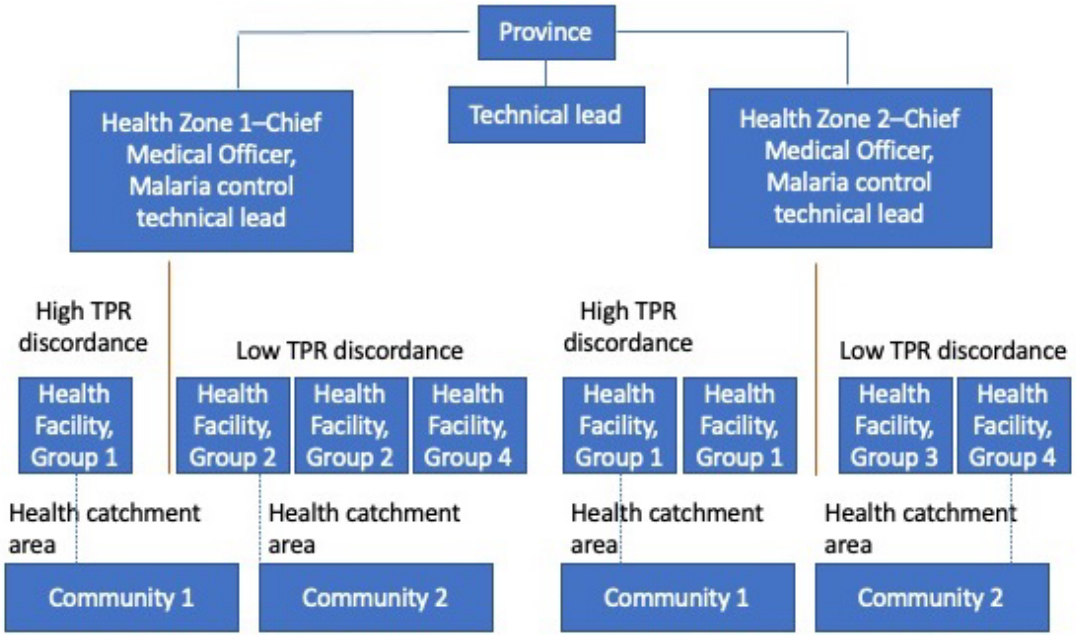
Table 1. Objectives and scope of the two studies

PROJECT	OBJECTIVE	TIMELINE	PROVINCES	# OF SITES
Measure Malaria – Quantitative	Determine the degree of discordance in TPR between data obtained from Deki readers compared to what is reported through national HMIS	December 2021-December 2022	Kasai Central, Haut Katanga, Sud Kivu	144
Breakthrough ACTION - Qualitative	Examine treatment practices for malaria in response to RDT test results Explain reasons for disparities in TPR reported by Deki readers when compared to HMIS data	August 2022	Kasai Central, Haut Katanga	16

Research methods

This qualitative study took place across two provinces and 16 health catchment areas: four health catchment areas from each of two health zones per province (Figure 4). The unit of data collection was the health center or health post serving the health catchment area, although key informant interviews were also conducted at the central health office in each zone, the provincial health department, and with national-level technical leads at the National Malaria Control Program (PNLP). The health centers and health posts were sampled based on preliminary results from the Measure Malaria study, with the criteria that they must have an operational Deki reader and have submitted at least 10 interpretable RDT results each month from April to June 2022.

Figure 4. Sampling Structure for a single province

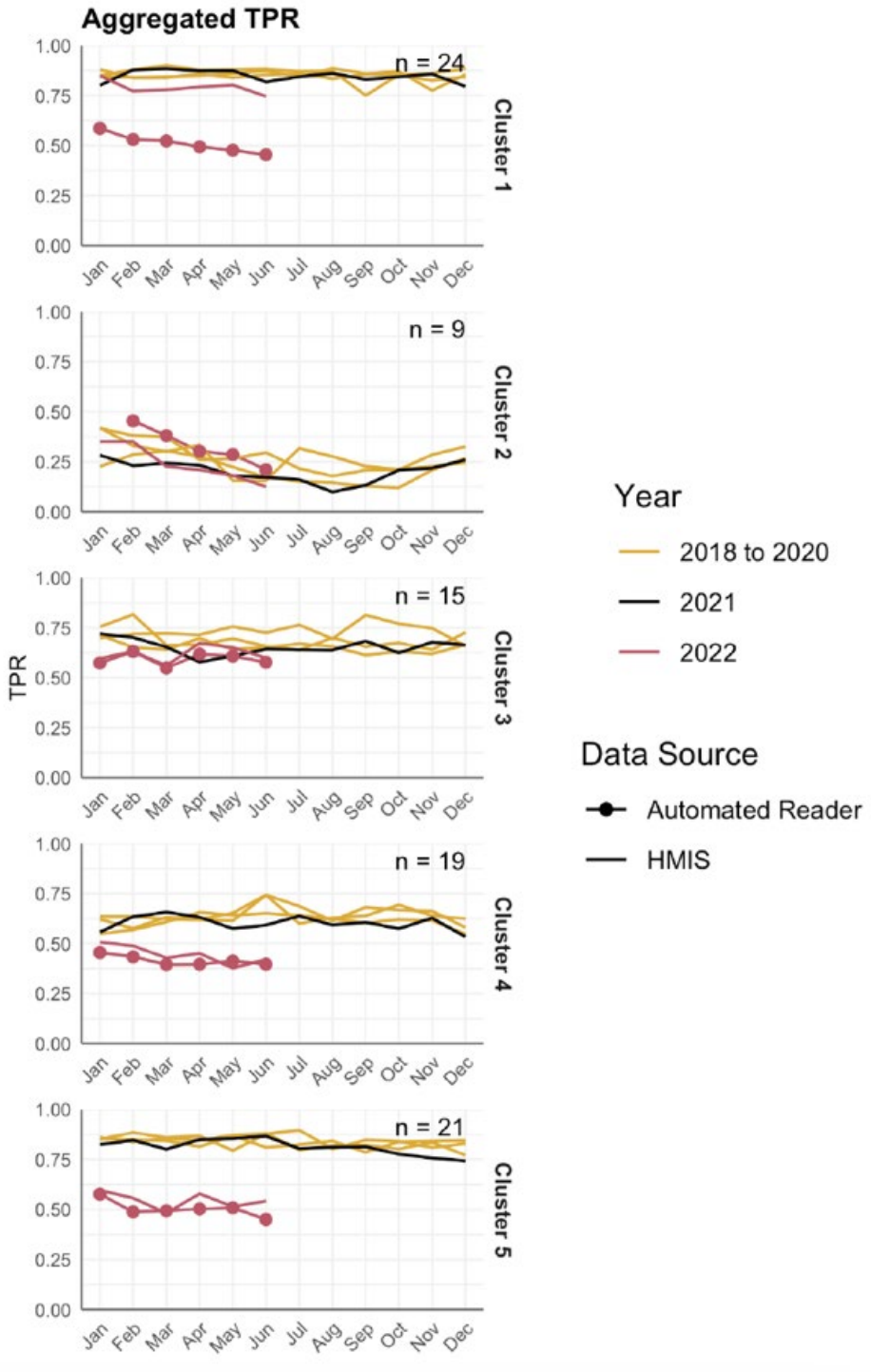


Based on the data submitted by 88 health facilities, Measure Malaria researchers identified four distinct groups for describing trends in TPR discordance:

1. High pre-study and current HMIS TPR, low Deki TPR (cluster 1)
2. Low pre-study and current HMIS TPR, low Deki TPR (cluster 2)
3. High pre-study and current HMIS TPR, high Deki TPR (cluster 3)
4. High pre-study HMIS TPR, low current HMIS TPR, low Deki TPR (clusters 4 and 5)

Pre-study HMIS refers to data collected from the years 2018 to 2021, while current HMIS refers to data from January to June 2022. Deki readers were introduced into health facilities in December 2021, and thus the TPR from the Deki readers refers to the same period as the current HMIS TPR. Figure 5 shows aggregated data from 88 health facilities with sufficient Deki reader entries to be eligible for inclusion. Clusters 4 and 5 have been combined (cluster 4). From the 88 facilities, a sample of 16 facilities were selected for qualitative data collection. Across the four health zones, six facilities were selected from group 1, two from group 2, and four each from groups 3 and 4.

Figure 5. Trends in TPR discordance via Measure Malaria



The Breakthrough ACTION DRC qualitative study applied several data collection methods (Table 2):

1. Key informant interviews (KII) with national and provincial level staff who set guidelines for malaria control;

2. Key informant interviews (KII) with health zone level Chief medical officers and health zone level supervisors who oversee health service provision;
3. Semi-structured interviews (SSI), including a clinic overview and mapping exercise, with health area supervisors who supervise malaria control activities within health centers and health posts, respectively, and may synthesize data to report into HMIS;
4. Semi-structured interviews (SSI) with (a) healthcare providers who manage the diagnosis and treatment for clients suspected of having malaria (e.g., presenting with symptoms such as fever, fatigue, vomiting or fast heart rate) and record client data in health register forms and (b) health facility personnel responsible for operating the Deki readers;
5. Focus group discussions (FGD) with community members living in health areas near a health facility sampled in the study, who have visited the local health center or health post for care for themselves or a child under 5 years.

Quantitative data to complement the qualitative data were collected using a tablet-based survey configured in ODK. There were four tablet-based surveys; the first two were administered to the facility supervisor and asked about a.) personnel, training, supervision, case management, and provider capacity, and b.) the facility itself, including patient flow, equipment, and capacity. The other two quantitative forms were administered to the healthcare providers responsible for management of suspected malaria cases and the staff responsible for using the Deki reader.

Study participants

The unit of study for this research was the health center or health post. At each health facility, the supervisor and up to three other personnel were invited to participate in a semi-structured, mixed methods interview. A separate instrument was used for the supervisors, which included a clinic overview and clinic mapping module. The other personnel were separated into two categories: providers responsible for case management of patients with possible malaria and staff members responsible for operating the Deki readers to capture RDT results and share them with the cloud database. Focus group discussions were held with community members in the health catchment areas served by the health facilities included in the study. Community members were eligible to participate in focus group discussions if they had visited the health facility for concerns about malaria (including having symptoms such as fever, fatigue, vomiting or fast heart rate) to seek care for themselves or for a child 5 years or younger. Focus groups were conducted separately for men and women who had visited the health facility for their own care, as well as with parents or caregivers of children 5 years or younger. Key informant interviews (KII) were conducted with malaria technical leads at the zonal, provincial, and national level. KIIs were also conducted with the Chief Medical Officers at the central health bureau in each of the four selected health zones.

Table 2. Data collection methods and sample frames

METHOD	MAIN OBJECTIVES	POPULATION	N
Key Informant Interviews	• Understand national and subnational guidelines and policies, • Understand training and supervision provided, • Capture challenges to adhering to guidelines and training requirements, • Capture challenges to reporting and perceptions of data quality	• Technical leads at the PNLP (national level) (2) • Technical leads at the DPS (provincial level) (2) • Chief Medical Officers at the health zone level (4) • Malaria technical leads at the health zone level (4)	12
Semi-structured interviews	• Provide health facility context, including number, distribution, and level of training of staff, available equipment, and patient flow, • Understand processes for training and supervision, • Understand processes for data recording and reporting, • Capture perceptions of provider knowledge and competencies, as well as adherence to RDT results, • Capture perceptions of data quality	• Health facility supervisors	16
	• Understand provider perceptions of malaria risk and factors affecting case management decisions, including testing, treatment, and recording of results, • Understand provider self-efficacy to make alternative diagnoses, • Understand the role of the Deki reader in the facility and how TPR data are interpreted	• Health providers responsible for malaria case management • Health facility personnel responsible for operating the Deki reader	48
Focus group discussions	• Understand community knowledge about malaria, including perceptions of risk and severity, • Understand factors that influence decisions about treatment-seeking, • Capture community expectations and experiences with malaria case management at the health facility,	• Men and women who have visited the health center for fever or other malaria-associated symptoms in the 6 months prior to the study • Parents who have sought care for their children <5 years for fever or other malaria-	144

	including community understanding of different diagnostic measures	associated symptoms in the 6 months prior to the study	
Total			**220**

Data collection

Data collection for this study took place from August 17 – August 26, 2022. All data collectors (6) and supervisors were trained in human-subjects research. Given the ongoing COVID-19 pandemic, precautions were taken including masking and a short assessment of potential COVID-19 symptoms and exposure. The data collector training took place in-person at Breakthrough ACTION's office in Kinshasa, and project staff accompanied the local research firm, ALMA Research Services, for a pre-test of the instruments in both study provinces. Breakthrough ACTION DRC staff, ALMA leadership, and representatives from the PNLP provided supportive supervision to data collectors in each of the regions. Data collection teams were made up of three data collectors, including one supervisor who was responsible for tracking daily activities and providing updates to the research coordinators. Semi-structured and key informant interviews were done one-on-one, while focus groups had a facilitator, a note-taker, and a third member of the team present to support and manage the audio recorder to ensure recording quality. Semi-structured interviews included both open-ended and closed-ended sections. For closed-ended questions, data collectors used a tablet-based ODK questionnaire. All interviews and focus group discussions were audio recorded. The data collection teams worked concurrently in the two provinces and coordinated with local community health workers to recruit participants for the focus group discussions. Data collection teams met with local health authorities to facilitate introductions to the health facility supervisors and personnel.

A number of challenges arose during data collection. Appointments arranged with key informants were postponed due to training or other activities. In one health zone, data collection coincided with a health facility supervisor training that made conducting interviews logistically complicated, although all interviews were eventually conducted. The long distances between health centers were also a challenge. In smaller facilities, it was difficult to recruit three personnel who fit the criteria, requiring data collectors to make multiple visits to the same site. Where health care facilities were short-staffed, it took longer to arrange a time to interview providers. Finally, air travel to the sites was difficult, and resulted in the field teams spending days in the field waiting for the next available flight after finishing the data collection.

Data analysis

Data analysis of quantitative data from the tablet-based portion of the semi-structured interviews was analyzed using SPSS. Audio recordings of qualitative data were transcribed in French and reviewed by "expert transcribers" prior to approval. Qualitative transcripts were analyzed by module rather than by transcript, in either Atlas.ti or Microsoft Word and Excel.

Results

Overview

Participants were selected according to the sampling frame. During the pretest of study instruments it became clear that many of the health providers responsible for case management and treatment were unfamiliar with the purpose and use of the Deki readers, and as such a subset of facility-based personnel were selected to respond directly to questions about the use and utility of the Deki readers. The final sample size is presented in Table 3.

Table 3. Study participants

PARTICIPANT	NATIONAL LEVEL (KINSHASA)	BY HEALTH CENTER	PROVINCIAL LEVEL	TOTAL
Technical leads at National Malaria Control Program (Instrument 1)	2	-	1	4
Chief Medical Officer (Instrument1)			2	4
Malaria control technical lead at the central health bureau (Instrument 1)	-	-	2	4
Health facility supervisor (Instruments 2 and 3)	-	1	8	16
Health providers responsible for consultations and treatment for fever or other malaria-related symptoms (Instrument 4a)	-	2	16	32
Staff responsible for maintaining and entering RDTs into the Deki reader (Instrument 4b)	-	1	8	16
Men (18-49 years) who visited the health facility for malaria-related symptoms in the past 6 months	-	-	24	48
Women (18-49 years) who visited the health facility for malaria-related symptoms in the past 6 months	-	-	24	48
Parents or caregivers who visited the health facility for malaria-related symptoms of a child under 5 years in the past 6 months	-	-	24	48
Total participants				**220**

#1 - Patient assessment

The patient assessment sets the stage for subsequent treatment decisions and reporting of results. Here we examined the organization of care in through health centers and health posts, flow of patients, procedures for patients presenting with fever, factors affecting the decision to refer a patient for a rapid diagnostic test or a thick smear for microscopy, and training on assessment and care for patients presenting with fever.

Facility mapping questionnaire

The facility-mapping questionnaire revealed that in 15 out of 16 facilities, all patients had their temperature taken regardless of their complaint. All supervisors said that any patient presenting with fever would be tested for malaria using either RDT or microscopy, although 3 said there were exceptions. Half of the supervisors (8 out of 16) said that there were cases in which a patient presenting without fever would be tested for malaria. Nine of the 16 health facilities stated that they had the capacity to perform thick-smear microscopy to diagnose malaria, in addition to RDTs, despite lower-level health facilities not being authorized to perform microscopy according to national directives. In these facilities, the slides were read by the lab technician. Time to results for microscopy ranged from 45 minutes to two hours. Four of the nine facility supervisors stated that at times both RDTs and microscopy would be used for the same patient. A quarter of the facilities reported stockouts of RDTs, with most of those reporting stockouts at least twice a year. Nine out of the 16 facilities had electricity, and only six had running water. Two of the 16 facilities had Wi-Fi or internet. A quarter of the facilities did not have ACT in stock.

Most patients visit the facility from 8am-12pm on weekdays. Six of the facilities noted that at times patients would bypass the provider consultation and go directly to the laboratory for malaria testing, meaning that these results may only be reported in the laboratory register and not in the patient register. Two of the 16 facility supervisors said that patients could receive a diagnosis prior to the test results being available. Results were recorded in the register either during the consultation (8 facilities) or at the end of the day (8 facilities). RDT results were entered into the Deki readers either during the consultation (11 facilities) or at the end of the day (5 facilities).

Supervisor and Provider questionnaires

Supervisors were also asked about trainings they had taken or organized, and the supervision that they provide and receive. Thirteen of the supervisors were trained on the use and reporting of RDT

results, and ten had organized a training on the use of RDTs, while 12 had organized a training on the recording of RDT results. At nine facilities, supervisors reported that all providers had participated in a training on the use of RDTs. However, when the providers were interviewed, only six out of 32 (18.8%) reported having been trained on the use of RDTs. Asked if another staff member had attended a training on RDT use, most providers cited the IT or supervisor (Table 4). These other staff members were likely to pass on what they learned in the training to respondents through informal conversation (34.5%), during a presentation at a staff meeting (27.6%), or via an internal training (20.7%) (Table 5). Roughly one third (11 out of 32) providers had been trained or counseled on case management of alternate (non-malaria) fevers.

Table 4. Provider questionnaire: Has someone else from your health facility participated in a training on the use of RDTs? (n=32)

	Frequency	Percent
No	3	9.4
Yes, the supervisor	1	3.1
Yes, head nurse / infirmier titulaire (IT)	20	62.5
Yes, other nurse	2	6.3
Yes, other	6	18.8
Total	32	100.0

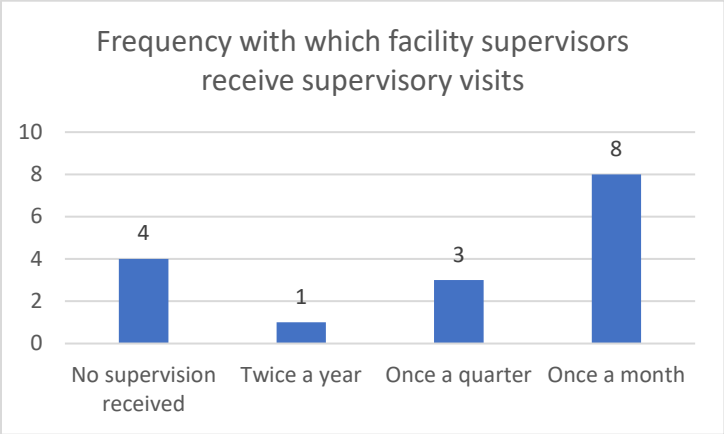
Table 5. Provider questionnaire: At facilities where only a subset of providers had received training, did they share this training with other staff members?

	Frequency	Percent
No	3	10.3
Yes, internal training	6	20.7
Yes, presentation during a staff meeting	8	27.6
Yes, informal conversation	10	34.5
Yes, other	1	3.4
Don’t know	1	3.4
Total	29	100.0

Providers who had not had the opportunity to participate in a training on the use of RDTs instead learned how to use them through internal trainings (34.6%), one-on-one teaching by another provider (26.9%), or through observation (11.5%).

Most facility supervisors (12 of 16) received some supervision from the health zone level in the past year, with half of supervisors interviewed reporting they received supervision once a month (Figure 7). Thirteen of the supervisors stated that the providers at their facility received supervisory visits once a month. All 16 facility supervisors did observations of provider consultations at their facility, with 11 saying they observed consultations each day and 4 saying they observed consultations every week.

Figure 6. Supervisor questionnaire: Frequency of supervisory visits on the use of RDTs and reporting of RDT results (n=16)



Supervisors were asked whether guidelines around when to use RDTs were available at their facility. Nine of 16 supervisors stated that these guidelines were available, but only three supervisors were able to show the interviewer guidelines on malaria case management and diagnosis. Nevertheless, eight of the nine stated that the health providers they supervised knew what the guidelines say about when to use the RDT. When asked, half of the supervisors stated that RDTs should be performed for all patients with fever, five that they should be performed for all patients with a clinical diagnosis or suspected cases based on symptoms, and two supervisors did not know what the guidelines said. Of the nine supervisors who indicated that guidelines were available, most stated that they covered how to record RDT results, how to report malaria cases in the HMIS, and therapeutic protocols for positive and negative RDTs (Table 6). Twelve of 16 supervisors said that the health providers at their facility knew what the guidelines said about recording RDT results.

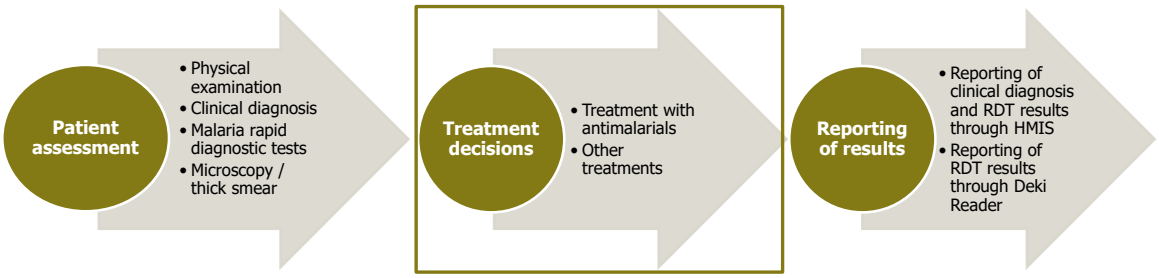
Table 6. Supervisor questionnaire: Scope of available guidelines (N=16)

	Yes	No	Don't know	No guidelines available	**Total**
The guidelines cover how to record RDT results	7	1	1	7	**16**
The guidelines cover how to report malaria cases in the HMIS	7	1	1	7	**16**
The guidelines cover the therapeutic protocol for cases where the RDT is positive	7	1	1	7	**16**
The guidelines cover the therapeutic protocol for cases where the RDT is negative	6	2	1	7	**16**

All supervisors stated that they observed the health providers' consultations, with 11 saying they did observations of consultations every day and four saying they did observations once a week. Supervisors were asked about cases where the result of the consultation recorded did not correspond with the result of the RDT. Only one supervisor said this never occurred, while 11 said it happened rarely

and four said these cases happened sometimes (two supervisors) or often (two supervisors). In these cases**,** the result of the consultation recorded would be based on clinical diagnosis (seven supervisors), or microscopy (three supervisors). In the health provider survey, providers were asked what they would do if they had doubts about the RDT results. Most (13 providers) said they would redo the RDT, while 10 said they would do microscopy. Four providers stated they would record the RDT result regardless, and other responses included getting a second opinion (1), recording a diagnosis based on clinical symptoms (1), transferring the patient (1), and giving antimalarials while also considering typhoid fever (1). While most health providers (19 of 32) said that they rarely or never encountered cases where the RDT result differed from their clinical diagnosis, six providers said they sometimes encountered these cases and seven of the providers said they often encountered them. These cases were more common in the dry season (10 providers) than in the rainy season (7 providers).

#2 - Treatment decisions



Based on the results of the diagnostic method used, the provider must then decide how to treat the patient. According to the WHO and national guidelines, providers should treat the patient with antimalarials only if they have received a positive result using an RDT. In practice, providers may not know or adhere to these guidelines, for a variety of different reasons. In addition to the decision about whether to prescribe antimalarials, providers may also decide to treat patient symptoms with antipyretics or pain relievers alone, or prescribe antibiotics, or some combination of the above.

Supervisor and Provider questionnaires – Knowledge of national guidelines

All but one supervisor responded that the health providers at their facility knew the different therapeutic protocols for positive and negative cases, but three said that the providers they supervised rarely respected the guidelines, and three said that their supervisees only sometimes respected the guidelines (Table 7). Of the supervisors who stated that their supervisees did not always follow the therapeutic protocols, seven of the eight said that providers were more likely to respect the therapeutic protocols for positive RDT results than for negative RDT results.

Table 7. Supervisor assessment of how well the health providers at their facility respect the national guidelines and protocols (N=16)

	RARELY	SOMETIMES	OFTEN	ALWAYS	**TOTAL**
Providers respect guidelines on when to use RDT	2	3	7	4	**16**
Providers respect guidelines on recording RDT results	2	1	5	8	**16**
Providers respect therapeutic protocols for positive and negative RDT results	3	3	2	8	**16**

In contrast to the supervisor interviews, the health provider interviews revealed that only 12 out of 32 providers thought there were existing guidelines on when to use the RDTs, while 18 providers said there were guidelines on when to prescribe antimalarials. When these 18 providers were asked what the guidelines indicated, 12 correctly stated that antimalarials should only be given to patients with a positive RDT, while five said antimalarials should be given to all patients with a clinical diagnosis or symptoms of malaria, and one said that all patients presenting with fever should receive antimalarials.

Consulting scenarios for treatment decisions (Providers and Supervisors)

As part of the individual interviews with healthcare providers, respondents were asked how they or a provider they supervised would be most likely to respond to three scenarios of patients who had come into the health facility with a fever:

1. A mother comes in with her 4-year-old child. She says he has had a fever on and off for the past 3 days. She tells the provider she gave the child malaria pills from the pharmacy but has seen no improvement. When the provider administers a rapid test, the test comes up negative.
2. A 30-year-old man comes into the clinic complaining of persistent fever and muscle aches for the past week. He asks the provider for antimalarials, but when the provider runs a rapid test, it comes back negative. The patient insists that he has malaria and that the provider needs to prescribe him antimalarials. There is a long line of patients waiting outside.
3. A pregnant woman arrives at the clinic, telling the provider she has walked for two hours to get there. She has a slight fever and complains of headache and cough. The provider runs a rapid test, but the result is negative.

In each scenario, the patient has a fever but, when a (RDT) is performed, the test comes back negative. Transcripts of provider responses were read and coded according to the following actions:

1=prescribe antimalarials
2=do microscopy
3= run more tests, seek other causes of fever (may include microscopy)
4=just treat symptoms (antipyretics, pain killers, cough suppressants)
5=give antibiotics (with or without antipyretics)
6=give antimalarials and antibiotics (with or without antipyretics)
7=treat symptoms and wait, give antimalarials if symptoms continue
8= wait (X days) and redo RDT
9=other
99=n/a

The findings from the scenarios were coded and aggregated based on the cluster (1-4) into which each facility fell.

Supervisor and provider responses, Clusters 1 (large discordance between HMIS and Deki reader results) and 4 (discordance between current and pre-study HMIS TPR): Supervisor and provider responses indicated limited trust in RDT results. When faced with a negative RDT result, providers offered many reasons to either provide antimalarials regardless, move to microscopy to confirm the presence of malaria, or treat symptoms and have the patient come back a few days later to redo the RDT.

Supervisor and provider responses, Clusters 2 and 3: Both clusters showed concordance in the TPR reported by HMIS and Deki reader data. However, whereas in cluster 2 the TPR was low and showed seasonality, in cluster 3, both HMIS and Deki reader data were high and did not show a difference in TPR between the wet and dry seasons. In the responses to the scenarios, we see that for these two groups both supervisors and providers showed a greater tendency to respond that they would accept the negative RDT result and test and treat for other causes of fever. All six responses from the supervisors in cluster 2 included either testing for other illnesses or treating with antibiotics, and 8 out of 12 provider responses were to run other tests to make an alternative diagnosis in this group. In group 3, 10 out of 12 supervisor responses accepted that a negative RDT indicated that the patient did not have malaria, as did 13 out of 24 provider responses. A full quarter (6/24 scenarios) of the provider responses in cluster 3 stated they would do microscopy to confirm, which differed from both cluster 2 responses for all respondents and supervisor responses for cluster 3, none of which cited microscopy as a response to scenarios presented.

Providers from both clusters 2 and 3 were consistent in that you should not treat malaria without confirmation, but providers in cluster 3 were more likely to distrust the RDT and perform microscopy after, whereas providers in cluster 2 seemed more likely to take the RDT results at face value. It should be noted that there are only two facilities in cluster 2 (6 respondents), so it is difficult to do a comparison. Despite this limitation, an important finding is that supervisors in both clusters 2 and 3 reported that they thought providers would adhere to protocols against providing antimalarials in the absence of a confirmed test. This high adherence was born out in the reported response actions of the providers they supervised, indicating that supervisors may be a good channel to target for improving adherence across facilities.

Given the concordance between the Deki reader and 2022 HMIS data for the facilities in cluster 2, it follows that respondents at these facilities reported high adherence to RDT results (responses were to test and treat for other illnesses). However, it is surprising that the most cited responses for cluster 3

were also to test for other illnesses or treat symptoms, as the trends in the Deki data show high TPR in both the Deki reader and 2022 HMIS data. Preliminary results from the Measure Malaria parent study also showed incidences of providers running the same test through the Deki reader more than once. Higher recourse to microscopy was common in cluster 3 and may be connected to these findings. In cluster 4, the TPR in the HMIS was high in 2018-2021, but was lower in 2022. One explanation is that while reporting practices may have changed with the introduction of the Deki reader, better reporting of RDT results may not actually reflect better treatment practices (with prescription of antimalarials remaining the most common treatment).

There were several reasons why providers stated they would prescribe antimalarials in the presence of a negative RDT result. There was overall little trust in the RDT, with recourse to microscopy being a common response. Providers in all groups expressed that a negative RDT result did not necessarily exclude malaria.

> *This patient should be treated because the RDT, when we do the RDT…often what I've noticed…that gives a negative result, but it doesn't exclude…malaria. (Supervisor, cluster 1)*

> *Even if the RDT is negative…it could be malaria. (Provider, cluster 2)*

There were a wide range of reasons provided for why the RDT might give a negative result when the patient has malaria.

Firstly, providers and supervisors communicated that the RDT may be negative due to "poorly treated malaria" or *palu mal soigné*, in other words, the patient has taken antimalarials and, either because the medication was taken incorrectly or at the wrong dosage, the symptoms continue but the RDT returns a negative result.

> *At that moment, I will give some antimalarials that could help, because when the test is negative, but the fever continues…the man is still sick, these medications, he didn't take them correctly, he didn't respect the dose. (Provider, cluster 1)*

> *So, it's poorly treated. Me, I will always…despite the negative RDT results…I will now give him the appropriate antimalarials…just until he gets better. (Provider, cluster 3)*

Even if the antimalarials taken at home were taken correctly, providers noted the possibility of treatment failure.

> *The RDT is negative because they have already given antimalarials…there we talk about treatment failure…as a nurse, I will start the treatment for simple malaria…I'll give him the ACTs again, day 1…day 2 and day 3. (Provider, cluster 4)*

Providers explained how antimalarials could render the test negative without curing malaria,

> *It has reached the microbes such that the test is negative, but malaria is still present in the body. (Provider, cluster 1)*

Another provider noted that the RDT may be negative due to taking any medication, not just antimalarials.

> *There you think that he has already taken the product, but he took it wrong, it's poorly treated malaria…so you will redo the treatment. You should always think that it's poorly treated malaria…there are people who come to see you and even if they've taken paracetamol, they will come here and test negative…it happens. (Provider, cluster 1)*

In this way, providers were able to explain away a negative RDT test, prescribing antimalarials to the patient despite the negative result (at times a different antimalarial than the patient had originally taken), sending the patient for microscopy to confirm the diagnosis, or giving antipyretics or painkillers and asking the patient to come back for another rapid test in a few days.

Even when the patient has not taken any medication before coming to the health facility, the providers may use clinical signs to diagnose malaria despite a negative RDT.

> *Give quinine, because even though the RDT is negative, the symptoms he is presenting with are symptoms of malaria. (Supervisor, cluster 1)*

Providers went so far as to explain that when a patient had a fever, they automatically understand it to be malaria:

> *He came with a high fever, with muscle aches, we ran an RDT, the RDT was negative, we will still give him antimalarials, because he came in with fever and we'll also give anti-inflammatories for the muscle pain…often when the person has a fever we understand it to be malaria. (Provider, cluster 4)*

Providers may be even more likely to assume certain symptoms are malaria when it comes to pregnant women, because malaria in pregnant women is considered especially serious and poses a threat to the fetus.

> *Because for all pregnant women, when she presents with a case of fever…even if the RDT is negative, we have it in our heads that it's a case of severe malaria. (Supervisor, cluster 1)*

Providers noted that untreated malaria in pregnant women can cause pregnancy loss, which made many providers more inclined to say they would prescribe antimalarials, depending on the gestational age. There was also mention that the provider would put the pregnant woman on preventive malaria treatment if she were not already on it.

Providers are also concerned that RDT may be negative early on in malaria but would be positive a few days later:

> *Because in the training they told us: when you do the RDT…in the blood…the trophozoite there…there's a hormone that we call a protein-rich hormone…in the case of malaria, when this trophozoite hasn't yet released the hormone in the blood…the RDT can come back negative. So, you have to wait two days, give an antipyretic, and two days later you can redo the RDT. (Supervisor, cluster 4)*

As noted above, providers stated that antimalarials could cause the trophozoites to go into hiding, reinforcing the importance of retesting a couple of days later.

> *At that moment I don't give an antimalarial because if I give the antimalarial again, and I redo the RDT again, it will still be negative, better to do…since the child already took [antimalarials], I will give antipyretics and observe for two days, and the third day I redo to see, because as I said, the plasmodium can hide in the red blood cells…that's what we should do. (Provider, cluster 1)*

Even some providers who seemed to accept the negative RDT result and prescribed symptomatic treatment or other tests would still want the patient to come back to redo the RDT days later.

Another concern that providers expressed was that the RDT does not capture all strains of malaria.

> *Sometimes we can do microscopy … to look for the trophozoite…which could also be the cause because here the RDT sometimes doesn't capture all the strains of plasmodium. (Provider, cluster 3)*

Providers also mentioned that different RDTs were better for capturing different strains,

> *The RDT that we had before … with three lines there, that gave us other strains of malaria, but the ones we have currently is only falciform … that's why most RDTs come back negative … it's a problem that we already highlighted when you gave us the Deki reader. (Supervisor, cluster 4)*

Providers complained that different types of RDTs were less effective than others.

> *Your rapid tests here, they are not reliable. I don't know if it's only here but, before we had good tests but now, the ones that they give us, it's rare that we find one that gives positive results, you're trying to say that all those people don't have malaria? And if we treat them for malaria, they respond better even though we changed the tests. (Provider, cluster 1)*

Many providers expressed that the RDTs did not give positive results as often as they thought they should, which made them suspicious of their accuracy.

Finally, even when the rapid test is negative, the person may recover with malaria treatment, leading providers to believe that the patient did have malaria and reinforcing the idea that they should not adhere to the test results.

> *When a person has headaches, aches, often others complain of malaria, they can say I have malaria but the test is negative, but when we go to quinine we see that he still continues to…there are other people if we put them on a quinine regimen they will say "I feel good, I don't have any more pain. (Provider, cluster 4)*

The providers own experiences with prescribing malaria treatment in the absence of a positive RDT reinforced their non-adherence to RDT results.

Given these concerns with the RDTs, providers view microscopy as the gold standard, used either to confirm or contradict the RDT result:

Because you can see at a certain moment you do the RDT but the result is negative but you do microscopy…the result is positive…now when we do the RDT and it's negative, we aren't simply going to say that we have done the RDT…the result is negative…but we will always do another test for malaria so that we can confirm. (Provider, cluster 4)

At some facilities, providers would always perform microscopy, despite the relative ease and rapidity of the RDT.

We always do microscopy, we must always confirm before prescribing an antimalarial. (Supervisor, cluster 1)

There was some concern over the use of microscopy as a money-making scheme, because whereas the RDT is free, microscopy is not.

They reason that often the RDT comes back negative … often, you can do 30 RDTs and you'll have two positives. You have two positive RDTS, so, 28 negatives, but when we do microscopy, microscopy is positive. So, they give those reasons. But in itself, even the Chief Medical Officer, the moderator of the review, what do they say? You are doing that because you're looking for money … you know that microscopy pays … the RDT doesn't pay, that's why you prefer microscopy. (Supervisor, cluster 3)

Microscopy was also seen as better able to capture different forms of malaria parasites than the RDTs were.

He can't prescribe, that could be a different form of malaria, he has to just go to microscopy because it's not falciform, because RDT only gives falciform, it can't be that, but he needs to do more tests. (Supervisor, cluster 4)

There are also cases where the provider prefers to give multiple treatments to cover their bases:

Especially that case of malaria, the RDT there, I'll prescribe for the mother, despite the negative RDT, ACT according to the age, and I will add paracetamol, and I will even add antibiotics. (Supervisor, cluster 4)

Similarly, was a perception that malaria and typhoid could go together:

Because recently malaria has been showing up hand-in-hand with typhoid. (Provider, cluster 4)

The choice to provide multiple treatments may in part point to providers' lack of confidence in their diagnoses, leading them to provide different types of treatments so as not to miss anything.

Given the range of responses that show a lack of confidence in the RDT results, it is not surprising that many providers or supervisors may report malaria cases as positive despite a negative RDT result. These findings support other studies that showed a lack of trust in the RDT results for a similar range of reasons. The findings also show that many providers (outside of group 2 facilities) prefer microscopy to RDT, accepting the RDT results only when they are positive.

Supervisors were also asked if they had concerns about the ability of providers they supervise to diagnose other illnesses if the RDT was negative. Said one supervisor,

> *Yes, there are times…you find that if someone arrives in my absence…if the person has a fever…and the RDT is negative…they give antimalarials…it's after that when I arrive, I cancel that. I say no, you must first give paracetamol and wait three days to verify if the RDT will become positive. (Supervisor, cluster 1)*

However, many other providers were concerned less with the ability of their supervisees to make alternative diagnoses than they were with their ability to correctly administer the RDT:

> *Well each time the nurses do the RDT and that always comes back negative, I can get to the bottom of it, to know how they did the RDT there, maybe they did it badly … so that I can correct it, maybe, because the RDT here, they've trained me … myself I can do that same RDT, maybe I can do the RDT, it will come back positive … now there I would think that the nurse did the RDT wrong. (Supervisor, cluster 4)*

One supervisor even said their role was to ensure their supervisees did not limit themselves to the RDT results and miss a case of malaria.

> *You feel that he is limiting himself to the negative RDT … and giving a treatment … that my role. I look at the file, I say no, despite the RDT, the negativity of the RDT … you must treat with antimalarials. (Supervisor, cluster 4)*

These results demonstrate a pervasive lack of confidence in the RDT results, particularly when the results are negative. Given that the Deki readers report only the results of the RDT test, we see a plausible explanation for why TPR would differ in the HMIS.

Provider questionnaires – Attitudes related to treatment decisions

In the provider questionnaires, there were a series of questions about attitudes towards testing for malaria, interpretation of tests, and malaria treatment.

Table 8. Provider questionnaire: Attitudes toward testing for malaria, interpretation of tests, and malaria treatment (N=32)

Each question consisted of a statement followed by Likert scale response options: Strongly disagree, disagree, neutral, agree, strongly agree.

	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
806. Early in a malaria infection, there are few parasites in the blood, so the RDT may be negative	4	8	4	10	6

	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
807. It is unlikely the RDT will be positive if that child has already taken malaria treatment before coming to the clinic	4	7	1	16	4
814. If we do not prescribe antimalarial drugs, then the patient will obtain them from somewhere else even if the RDT is negative	5	6	1	16	4
818. Malaria is a very dangerous disease, so it is always good to treat if you suspect it, even when the RDT is negative	1	11	0	14	6
822. All of the health care providers around here will treat patients with antimalarials if they suspect malaria, even if the RDT is negative	10	4	5	11	2
823. Providers in my area are more likely to treat for malaria despite a negative test during the rainy season	5	5	4	16	2
824. Providers in my area are more likely to treat for malaria despite a negative test if the patient is a child	9	9	3	6	5
826. If an RDT is negative, some providers will not bother recording the negative test in the register	9	14	3	5	1
832. If the RDT is negative, I am confident in my ability to make alternative diagnoses	2	1	0	23	6

More providers agreed than to disagreed that RDTs were likely to be negative early in infection or if a child had already taken antimalarials before coming to the clinic. They were also more likely to agree than disagree that patients would procure antimalarials elsewhere if they did not receive them at the facility. Twenty out of 32 providers agreed that it was good to treat malaria even if the RDT was negative if you suspected a case, due to the risk malaria poses. One more (14 versus 13) provider disagreed that all providers would treat for malarial even if the RDT was negative, although five responded neutrally. Providers tended to agree that other providers in their area were more likely to

treat for malaria despite a negative test in the rainy season, but most disagreed that they were more likely to do so if the patient was a child. Only six providers agreed or strongly agreed that some providers would report a positive case if the RDT was negative. Most providers were confident in their ability to make an alternate diagnosis when presented with a negative RDT.

Across these questions, a high score would indicate mistrust in RDT results, and a tendency to prescribe malaria treatment to a patient, even if the RDT result was negative. We conducted Reliability Analysis to assess whether these variables could be added together into a scale that measures this tendency to mistrust RDT results and prescribe malaria treatment to people with negative RDT results. The Cronbach's alpha statistic, which indicates the appropriateness of including the set of variables together in a scale, had a value of 0.821, indicating that it was appropriate to create a scale from these variables. This scale had higher means for Clusters 1 and 4 where there was higher discordance between HMIS and Deki reader results, but the differences were not statistically significant.

Table 9. Provider questionnaire: Influence of supervisors, other providers and community on testing for malaria, interpretation of tests, and malaria treatment (N=32)

Each question consisted of a statement followed by Likert scale response options: Strongly disagree, disagree, neutral, agree, strongly agree.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
815. People think I am not a good health care provider, if I do not prescribe an antimalarial drug regardless of the result of the RDT	9	9	1	10	3
817. If I do not prescribe antimalarials, people will be less likely to come to the health center (or will have less trust in the health center)	8	15	0	6	3
821. It is worse to miss malaria in children than in adults	3	6	1	19	3
827. If I miss a case of malaria, other providers will think less of my skills	10	10	2	6	4
828. If I miss a case of malaria, my supervisor will think less of my skills as a provider	11	10	0	8	3
835. Some providers may prescribe antimalarials (even when RDT is negative) because they do not know what to do for other diagnoses	9	8	1	10	4

More than half of providers disagreed that they would be no longer be seen as good providers if they failed to prescribe antimalarials and did not feel that this would prevent patients from coming to the facility. Most providers agreed that it was worse to miss malaria in a child than in an adult but did not agree that other providers or their supervisor would think them less competent for missing a case of malaria. More than half of providers disagreed that some providers would prescribe antimalarials because they were unsure of what to do for other diagnoses.

Across these questions, a high score would indicate a greater influence of the perceived opinions of supervisors, other providers and community members on testing for malaria, interpretation of tests, and malaria treatment. We conducted Reliability Analysis to assess whether these variables could be added together into a scale that measures this tendency to be influenced by others in malaria testing and treatment practices. The Cronbach's alpha statistic, which indicates the appropriateness of including the set of variables together in a scale, had a value of 0.728, indicating that it was appropriate to create a scale from these variables, although it is not as strong a scale as the first one. This scale had a significantly higher mean for Cluster 1 compared to Clusters 2, 3 and 4, and the one-sided T-test for the difference was significant (p=0.036). The means for the latter three clusters were similar. Thus, social influence from supervisors, other providers and community members is a significant determinant of testing and treatment practices, even in a small sample of 32 providers.

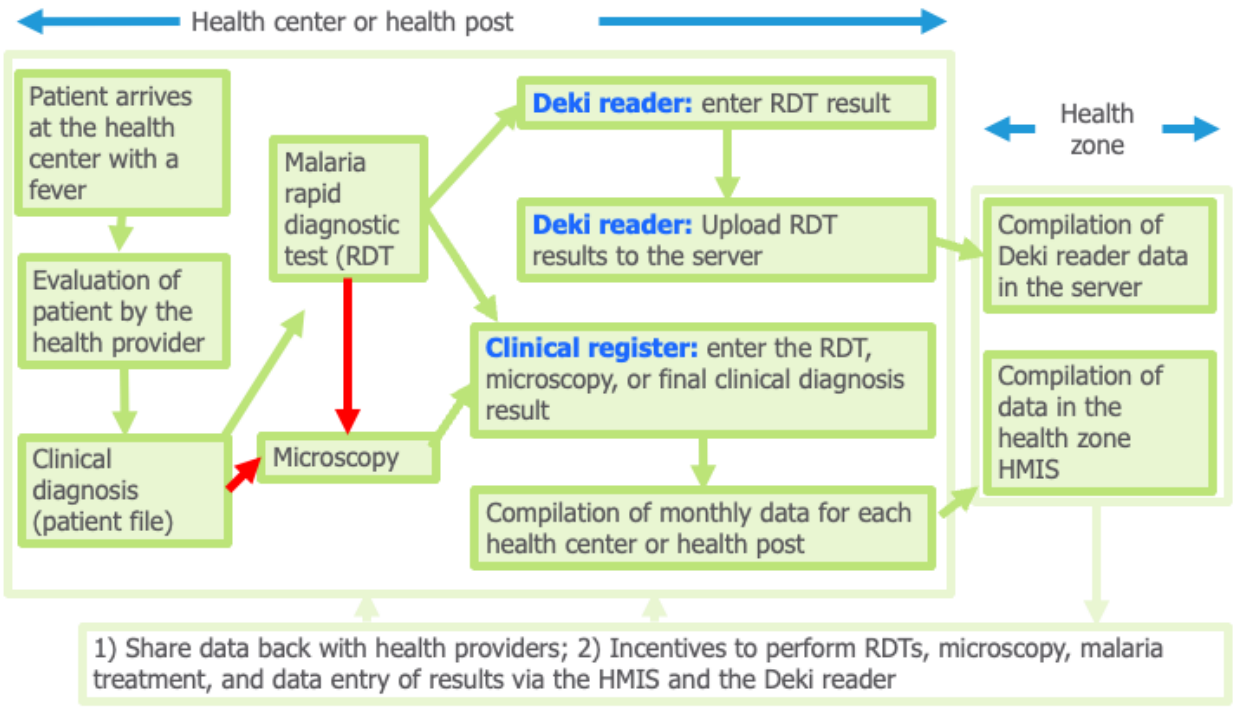
#3 - Reporting of results

Two distinct systems of reporting and compiling data were in place:

1. The existing system for reporting malaria diagnoses and results of rapid diagnostic tests through the national Health Management Information System (HMIS),
2. A parallel system for reading and uploading RDT results to a cloud server through Deki readers.

The flow of data through these two systems from health centers and health posts into the HMIS and Deki readers, and feedback from the zonal and national levels to health centers and health posts, is illustrated in Figure 7.

Figure 7. Flow of data through two information systems for a patient presenting with fever at a health center or health post



When a patient arrives at the health center or health post, they are tested for fever and evaluated by a health provider. Based on a clinical diagnosis of symptoms, including the presence of fever, they are then tested for malaria, either by RDT, thick-smear microscopy, or in some cases both. The results of these tests are entered into the clinical register and compiled monthly. While there is no separate column in the register to enter the microscopy results, positive microscopy may or may not be reported as a malaria case under the RDT heading. In some cases, providers may rely on clinical diagnosis to record a positive result in the register. RDTs are also entered into the Deki reader and uploaded to the server, though barriers to Deki use may diminish the proportion of RDTs entered. Finally, data from the Deki readers and monthly register are received by the health zone central office. Monthly data is compiled in the HMIS for all facilities in the zone. Data from the two sources may be shared back with the facilities and may inform the resources or incentives that the facilities receive.

Provider and Supervisor questionnaires

When RDT results were different from the provider's clinical diagnosis, providers were more likely to record RDT results (20) than their clinical diagnosis (four providers), although six said "it depends". Twenty-four providers said that there were instances where both microscopy and RDT were used, and 22 of these said that these results were rarely (13), sometimes (4), or often (5) in conflict with the RDT results. In these cases, 11 of the 22 providers said they would record the RDT results, compared to seven who said they would record the microscopy results.

Reported results were verified by the supervisor (*infirmier titulaire)* in 13 of 16 facilities, and in the remaining three were verified by the deputy supervisor (*infirmier adjoint)*, the delivery nurse, and the lab tech. The supervisor was also overwhelmingly cited as the member of the staff responsible for entering malaria case data into the HMIS each month (although in one facility these data were entered weekly). In most cases, the staff member who recorded the RDT result in the register was not the same person doing the consultation, or the person prescribing medication, which leaves room for lapses in communication (Table 10).

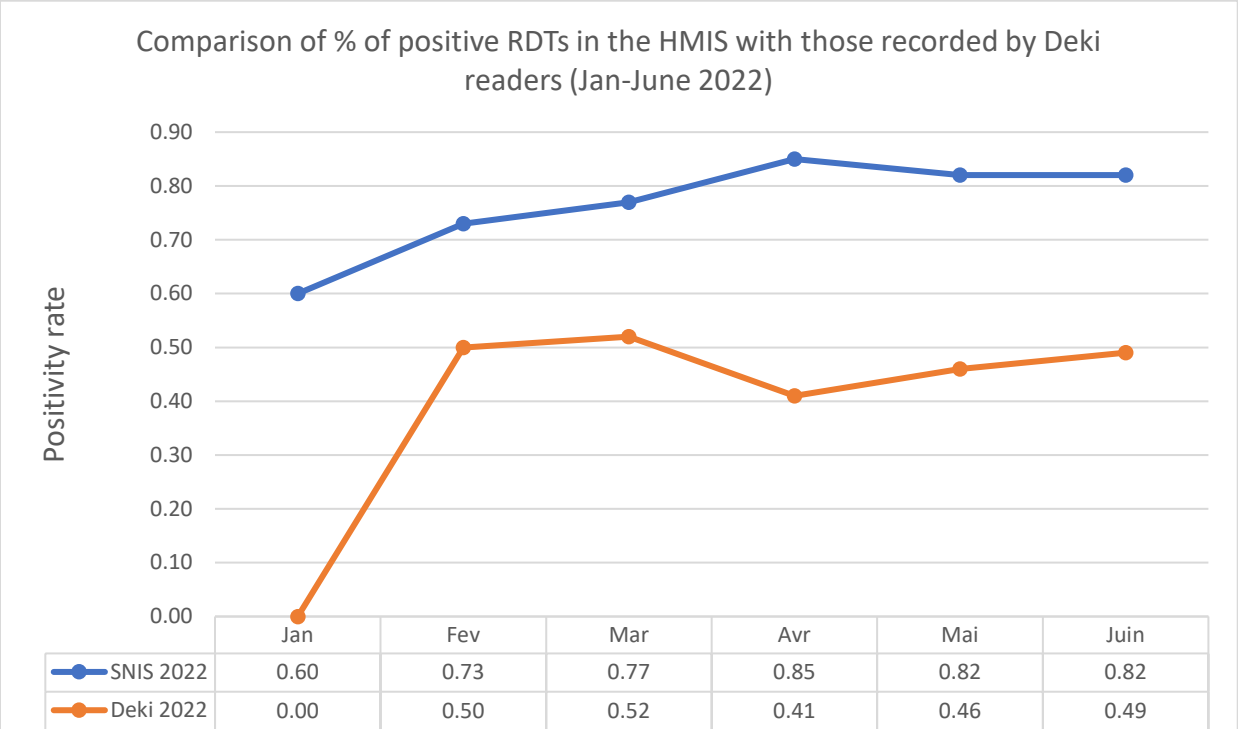
Table 10. Cross-responsibilities of providers involved in consultation, testing, and recording results, according to supervisors (N=16) and health providers (N=32)

	SUPERVISORS (N=16)	PROVIDERS (N=32)
The person responsible for recording the RDT result is the same as the one who does the consultation.	6 (37.5%)	7 (21.9%)
The person responsible for recording the RDT result is the same as the one who reads the RDT results.	9 (56.3%)	17 (53.1%)
The person responsible for recording the RDT result is the same as the one who prescribes medication.	6 (37.5%)	7 (21.9%)

Reporting scenarios (Deki reader and HMIS) from provider and supervisor interviews

In order to better understand how data is reported, both into the HMIS and using the Deki readers, supervisors and health providers were shown graphs comparing the TPR in the HMIS to the TPR reported by the Deki readers in an anonymous health facility that also used automated Deki readers (Figure 8). There was a wide range in the comprehension of and ability to interpret the graphs. In addition, many of the providers involved in consulting were unfamiliar with the use and purpose of the Deki readers. Many were not involved with the reporting of TPR in the HMIS, meaning that they were unable to comment on whether the data shown was typical of what they expected to see in their facility.

Figure 8. Example of a Cluster 1 graph used to visualize similarities and differences between data from routine reporting through the HMIS and Deki readers



Of those who felt able to comment on the data, some said that it was not typical of their facility, or not what they expected to see. Respondents noted the different factors affecting the flow of data in and out of the Deki readers and clinical registers, as shown in Table 11.

Table 11. Factors affecting flow of data in and out of Deki readers and clinical registers

Factors affecting flow into the point of data recording	Point of data recording	Factors affecting flow of data out of the point of data recording to cloud server or district health office
• Lack of power to run the reader • Delay in inserting RDT strips into Deki reader • Concern that RDT strips from previous days can no longer be entered • Failure of RDT strips to be read (tests are labeled “invalid”) • Trained personnel are not available to operate the Deki reader	Deki Reader	• Lack of connection to the internet • Interrupted connection to internet • Lack of power for Deki reader or internet connection
• Delay in transferring data from consultation forms	Clinical register	• Delay in compiling and sending monthly reports

• No column in clinical register to record microscopy results • RDT stockout • Counting or computational errors • Confusion about what to record in the register • Missing registers/forms		

Staff who were responsible for using the Deki readers had concerns related to staffing, electricity, and internet or data connectivity. The most prevalent concern was the lack of electricity at the health facility, which resulted in the Deki reader having to be taken elsewhere to be charged for hours at a time. Due to the need to insert RDTs within a half hour of reading them, the lack of electricity and the Deki readers being out of charge constituted a barrier to timely insertion of the RDTs.

> *When you don't have electricity, the data will be different between the HMIS and RDT data and the Deki data…Because the Deki we capture just after doing the reading. After a day, there's no way to capture it. Now these data, these RDTs there, performed when we didn't have energy in the Deki are recorded in the register and will come out in the HMIS template...that means that, at the end of the month there will be a discordance between the HMIS data and the data reported by the Deki. (Deki operator, cluster 3)*

Other respondents noted that it could take days for the Deki reader to send the images due to poor network connectivity, which could influence the data. However, in most of these cases the central health office was eventually able to help find solutions to the connectivity issues.

> *It could even take a whole day, it doesn't go through, and then it can go even the day after. So… the day we went to the central office, they told us it was a network problem...if that doesn't go through, you will now turn on the Wi-Fi, you use that network there, you make some maneuvers there, they showed us how to do that. (Supervisor, Cluster 4)*

Finally, the third major barrier to consistently and properly using the Deki reader was the lack of trained personnel. Often, only one member of the staff was trained on operating the Deki reader, in most cases the laboratory technician. To this point, during the pretest of study instruments, data collectors noted that the consulting providers interviewed were unable to provide much insight on how the Deki readers functioned or what their utility was to their practice. This lack of trained personnel resulted in RDTs not being entered into the Deki reader when the person responsible was away from the facility, whether that was overnight, on the weekend, or while they were traveling,

> *We didn't capture it because the person who should capture it wasn't there. As was the case in a facility that we had in the group, there were 10, 15 days that he was traveling…we did the RDT but we didn't capture it because he wasn't there. (Supervisor, Cluster 3)*

Given that the RDTs must be entered into the Deki reader soon after they are used, the lack of electricity, connectivity, and personnel all contributed to RDTs not being captured in the Deki reader data, but at the same time being entered into the patient registers.

On the other hand, if it isn't clear, the test will come out invalid. Now in the facility that's still there, we believe that it's a, we have a positive case recorded in our register and reported in our HMIS report, but on the other hand in the server it comes out invalid. (Deki operator, Cluster 3)

Tests that have not been entered in a timely manner may show us as invalid in the Deki reader but be entered as either positive or negative in the patient register. This difference in reporting is one factor that results in discordance between the TPR in the Deki reader data and the TPR reporting in the country HMIS.

Respondents mentioned several other concerns that could explain discrepancies between the HMIS data and the Deki reader data. These included forgetting to record a test in the Deki reader,

The case there, so they didn't use the Deki, they just recorded it in their register, they forgot to use the Deki because often when we use the Deki reader, it must be the same, the amount in the Deki with the amount in the register must be the same. (Provider, Cluster 4)

and forgetting that a test had already been recorded.

For example, I had ten cases of positive RDTS … I sent that then I forgot, I forgot to note somewhere that the RDTs here that I had used there, but I see them after! Have I not yet sent those? I send them again. (Supervisor, Cluster 1)

There would also be discrepancies in the TPR when patients go to the laboratory directly to get a malaria test, without passing by a consulting provider first. These patients' results may end up in the Deki reader data but not in the patient register.

The person comes directly to the lab, he doesn't pass by the consultation, he goes to the lab and when he passes by the lab, they can do his exams there. They give the ticket to the patient, and he goes now to be treated there where we asked him for the tests. And if it's positive, the reader will say that and will consider it; and the data there won't be accounted for in consultation, at the curative care level, but the data will be accounted for in the Deki. (Supervisor, HK, Cluster 2)

On the other hand, if a patient received a positive test using microscopy, that result would be entered into the patient register but not the Deki reader.

We can't, when we have only taken the thick smear [microscopy], we can't put the thick smear in the Deki reader. (Provider, Cluster 4)

There were also cases of poor reporting, whereby the number of cases in the patient register could be miscounted,

For ten women, you have now thirteen women … , the others, where did you find them? I think that it's a problem we have…who from time to time that happens, it's necessary to be attentive to say come with it, we will count together. (Supervisor, Cluster 4)

In all, respondents provided many explanations why the Deki reader data may not be accurate, why the patient registers may have errors, and why the two data sources may be different.

Despite the issues with using the Deki readers, many respondents identified ways in which the Deki readers positively informed their practice. Several respondents said that the Deki reader taught staff not to record false results,

> *The Deki teaches us not to falsify the RDT results, that's what the Deki want to show us. (Supervisor, Cluster 2)*

In this same vein, respondents noted that the Deki reader avoided human error that could occur when interpreting the RDT with the naked eye.

> *Well, the Deki reader is a machine that is meant to detect real cases, the true RDT positives since … but if we read the RDT with the naked eye like that, it shows us, maybe you see that it's positive, but the Deki reader will find it negative. (Supervisor, Cluster 2)*

One supervisor appreciated that the feedback on invalid tests was an important learning tool, and that prior to having the Deki reader at the facility many of the tests that were poorly done would have been reported as positive:

> *The Deki reader data are magnificent compared to the HMIS data. Because before, we didn't have the Deki, even if we put a lot of blood there, even if we found people positive, we will always put positive, but here if you put a lot of blood there, that will come back invalid. That's why I find the Deki very beneficial. (Supervisor, Cluster 4)*

The end goal of the Deki reader was not seen simply as increasing the capacity of staff to correctly interpret RDTs, but also to make sure that the data shared with the central health office was accurate.

> *It's not that the Deki came only to help us improve. To not keep transmitting data that are not valid. That's what the Deki is here to do. (Deki Operator, Cluster 4)*

The Deki reader also changed the way some health centers managed suspected malaria cases, outside of reporting the test results:

> *Yes, at the very beginning, what I was going to say, at the very beginning, before we had the Deki, there were other facilities using even the thick smear and others. Now, since we have the Deki reader, almost all the suspected malaria cases…are tested by rapid test. (Deki operator, Cluster 3)*

Overall, the Deki reader was found to be useful, especially for encouraging frequent and correct use of RDTs and improving reporting and data quality.

Moving from microscopy to RDT was one of several changes cited as a result of the training and directives that came with the Deki readers. Others cited that new training had taught the staff how to properly use and interpret the Deki readers in a timely manner:

> *In 2022 … the RDT here, we can interpret it, we can do it at night and interpret it in the morning … Now with the evolution of the training that they gave us on how to use the RDT, how*

to interpret it, respect the minutes and how to interpret, we started to follow the normal RDT procedures. (Supervisor, Cluster 4)

In Haut Katanga, one respondent remarked that before the Deki readers, suspected cases would be classified as positive, but with the arrival of the Deki readers, the reporting was based on RDT results:

It could be said that, as we have the RDTs available at the moment, with the Deki that is also here for us to send them or to show us where we've messed up…that said you can never get it wrong…because there won't be suspect cases…what we used to do, the suspect cases, you would send them directly as positive cases…Now for the moment, the Deki reader, we have the RDTs available. What you do, is you send that directly. (Deki operator, Cluster 4)

These findings from cluster 4 respondents help to explain why the HMIS data decreased from one year to the next in these facilities.

The presence of the Deki readers may also have driven some providers to think more critically about the RDT results,

Often, I ask the lab tech, he tells me "when I enter it, it just comes out negative" when he enters it in during the rainy season, it was positive but now when he started, I also asked what's happening so that it's always negative, negative? It told me "I don't understand either." And me, I don't know if it's the Deki and the rapid tests that are giving us the negatives our if it's that the people who come to the hospital don't have malaria. (Provider, Cluster 1)

While there is widespread distrust in negative RDTs, the addition of the Deki reader prompted the provider to wonder if the perhaps the patients coming to the hospital truly did not have malaria. This confusion was further aggravated by the disconnect in RDT results compared to microscopy results:

When we enter it, it's often negative, negative, but often when we move to microscopy like that it's positive. (Provider, Cluster 1)

There were also questions that arose when the TPR at a facility did not align with the TPR reported in the rest of the province, likely by facilities without a Deki reader.

Compared to our province, there is a lot of positivity but the RDTs that we use there's a lot of negativity. That the problem, we don't understand often if we have ten cases, one case even out of 20 cases, you can see, you find one positive RDT, only one out of 20. (Deki operator, Cluster 1)

While the data in the Deki readers was not systematically shared back with the facilities submitting it, the presence of the Deki readers provided an opportunity for discussion around the expected TPR and the actual TPR.

A final theme that came out of the reporting scenarios was that of financial or resource incentives.

That could pose a problem how? Because those who send their, their products, they will reduce what they send because they know that there, the problem…the malaria we see that there was

even a relapse…While they were sending the [antimalarials] it was to stabilize the malaria…for treatment. While you are sending such results, for example what, the RDT that there is a decrease. Then there is a rate of malaria that, there is a relapse. (Deki operator, Cluster 1)

When prompted about whether there was also a monetary advantage having more malaria cases the respondent said,

Ah … money no. Money, maybe, for the money I can say that maybe … they give something while we work for the RDTs. It's after some, maybe two months, after one month, that depends. (Deki operator, Cluster 1)

Another respondent in a different facility described a similar scenario, whereby there were financial or resource-related benefits to having more malaria cases.

Those working on the ground have realities to maximize the data. Because, while they are doing the maximizing, in certain other health facilities the data are elevated… It's based on that also, that the financing or the supply of products are done. It's that, when we have a lot of data, that permits them to give us a lot of medicine. (Deki operator, Cluster 3)

The respondent continued, describing that there was a TPR threshold that facilities would reach, although it was not clear what the consequences of attaining (or not attaining) the threshold were.

There is also the notion of attending the threshold. Now once the threshold is reached, there is a number already maintained … Now that number there … that should also be a notion, a subject for the supervisors … during their visits to the field perhaps someone should be considered … beyond 50% et 55% ... when we find ourselves with someone who has 49%, he is not considered … Now in the criteria, we can say that we have to add something for those who have 50-55%. (Deki operator, Cluster 3)

One supervisor discussed these implicit incentives as possible reasons for misrepresenting data, saying,

It's to see that they have the attendance sometimes where there are antimalarials, they can say no, no like that we can receive a large quantity…in that sense, the others can say no, no it's so they know at the central office that my structure has a higher attendance than the others…the others don't know how to fill out the tools and sometimes they fill out the template.. the tools that have a manual to fill them out. (Supervisor, Cluster 2)

However, another respondent noted the potential consequences of misreporting the TPR in their facility on other facilities with greater need:

That poses a problem because for example if we send what we have it it's an 80% rate of malaria here … in our community or in our facility … I think that they're going to really finance us for those cases there. But if the data are not … if we falsify the results and say that's gone up…the central office or the organizations that finance for malaria could give a lot of medication even if we don't have those rates there, and now we are penalizing other facilities or other places that are really in crisis, instead of being served, it's us who benefit from these products or donations

while we don't have the correct rate or we haven't given the correct rate concerning our ask. So, we have done a bad job with the HMIS data. (Deki operator, Cluster 4)

These implicit incentives may affect reporting into the HMIS, as well as acceptance or concern about the presence of the Deki reader.

Key Informant Interviews

Key informants, who included technical staff at the zonal, provincial, and national levels, were aware of issues with management of suspected malaria cases. There were concerns about adherence to directives around use of RDTs, treatment decisions, and reporting. They recognized that some providers would treat patients for malaria when the test was negative, often because they trusted their own clinical evaluation of symptoms more than the test.

Someone is negative but the health provider decides to put him under treatment. This lack of respect for the guidelines … Why? Because the health provider thinks that he alone can decide if the person is sick or not. After the test tells him that you are not sick, the person is not sick with malaria. But he lists it, or he forces it in putting it as positive in the register, even though the test is negative, or he says that in any case the person must be sick. The symptoms he is presenting with are textbook malaria. Most of the time they do that. – Key informant, Kinshasa

There were also concerns about data quality, where the data was found not to represent the reality observed at facilities during supervisions.

We found a facility where wrongly…the nurse who had arrived was not trained…they reported all the cases of RDTs performed as positive RDTs and while we went there on supervision to verify if the situation was real, we found that it wasn't that, that there was no mastery of the indicator. – Key informant, Haut Katanga

As was clear in this instance, respondents noted that lack of training could exacerbate errors in data reporting.

Given this observation, one of the major themes from the key informant interviews was the importance of training and supervision in supporting staff to adhere to prescribed practices. Said one respondent,

There are those who apply these guidelines correctly … because they attended a training. And then, there are those who apply these guidelines poorly … if they did not attend the training. – Key informant, Kasai Central

As national guidelines are not available or posted in all facilities, training and supervision are ways to ensure that providers are aware of the guidelines, and how they may have been updated since the providers were first trained.

If the providers are not yet briefed, they will go to the outdated treatments, that's to say, they won't respect the national protocol. – Key informant, Haut Katanga

Key informants avowed the need to ensure that all staff, from supervisors to clinicians, be trained on the national guidelines.

> *Let's not only focus on the IT (infirmiers titulaires) of the catchment areas, let's also think about training first the clinician in a general sense because they are the ones who are doing the diagnosis, but also the biologists … or as we call them in our terms, the lab techs … try a bit to do this exercise, you will see that, we train more the ITs than the biologists and the doctors … and the other nurses. When the ITs are trained they will bring the theory, but it's not just them who will execute [the theory]. – Key informant, Haut Katanga*

While some financial and technical partners would choose to train the ITs and their adjoints, informants stressed the value in providing all health personnel with training. In addition to the training, frequent supervision was seen as the best way to make sure that providers were following the guidelines:

> *People can say that no, no, we will keep doing what we have always done. However, if there is supervision and frequent support, I think that things will move forward. – Key informant, Haut Katanga*

Providers with access to training and frequent, supportive supervision were better placed to apply the national guidelines correctly.

However, key informants also noted that providers may work in suboptimal conditions, which effects their motivation to perform their duties adequately. Poor working conditions and noncompetitive pay may cause providers to go elsewhere, resulting in high turnover of providers with training and experience. One respondent said,

> *Most of those who work in these facilities…don't have a bonus, nor a salary. But they still do their work. – Key informant, Kasai Central*

Another respondent noted,

> *Even in the rural areas, even if the Congolese state has some health facilities in rural areas, remember that people can leave due to difficult conditions. You train them and then, they find something better. It's as if the people who work with us are there waiting for something better to come along. – Key informant, Kinshasa*

Given low pay and poor conditions, technical personnel noted that financial incentives were an important factor in provider adherence or nonadherence. There were mentions of companies that market specific medications to health facilities, offering gifts or financial incentives to promote their product:

> *But we have difficulties in the health area with the proliferation of firms and Indians who market in our facilities ... Sometimes they offer gifts to other facilities instead of prescribing the drugs that are uh decreed by the national office. – Key informant, Haut Katanga*

There were also instances where providers would provide higher level care or treat for severe malaria when severe malaria was not indicated, as they could charge more for IV treatment than for prescribing pills.

> *There are some facilities … who say that we live because of malaria. If we always stay with the ACT and all that, we will have nothing. – Key informant, Haut Katanga*

As malaria is prevalent, charging for malaria treatment rather than providing free treatments as required by the national guidelines can make a noticeable difference on the amount of money providers bring into the health facility.

> *As the Quinine infusion is a bit expensive compared to the Artesunate, you will find that in front of a case that is not, that is not really simple eh that is not really serious but that is simple, you find that the doctor is there, he, he takes it in charge but while submitting. Instead of going to the first intention, directly, he is at the second intention doing the ... the infusion. And when you get there and you find that there's really the Artesunate in sufficient quantity. The patients, almost all the patients are subjected to infusions in due to er ... to a monetary bias. – Key informant, Kasai Central*

A respondent noted that some providers did not follow directives for when to use RDTs, instead charging for the tests which the facility had been provided for free:

> *There are some structures that in order to uh, have money, they take money from pregnant women, they say that when a pregnant woman comes directly, they must be submitted to the RDT ... they charge for the tests at the facility, but we give them for free, it enters in the costs, and you will see that the tests will always be negative. – Key informant, Haut Katanga*

Pregnant women are at greater risk of malaria, but according to the directives should only be tested for malaria if they present with fever – the same guidelines that apply to the population in general. Finally, financial incentives could also explain lack of adherence to guidelines around using RDTs only at lower-level clinics, rather than microscopy. Said one informant,

> *You know that the cost in the city of microscopy can be evaluated between five thousand francs to twenty thousand francs ... so ten, ten dollars ... imagine that you do, that you do thirty a month, it is already three hundred dollars, which can guarantee you the payment of some people. – Key informant, Kinshasa*

Because RDT is supposed to be a free service, there is more monetary gain in sending patients for microscopy.

To improve data quality, key informants recommended that tools for data collection and reporting as well as the directives be consistently available and that monthly data reviews be held at the health zone level. They also recommended that payment be provided for transport for supervision visits to increase their frequency and consistency.

It would also be better if there were funding that could motivate supervisors even more, that could motivate supervisors even more to do more supervisions that would also be a good thing. – Key informant, Haut Katanga

Others stated that providers and health facilities were underfunded and would be able to do better work if they had proper pay and resources. One key informant noted that it would be good to review the data entry form to make sure there is a column for the number of suspected cases, the number of positive RDTs, and the number of positive microscopy cases so there was less confusion over what to report. Another recommended instating an electronic feedback mechanism for supervision. Overall, there was a sense that going back to basics and increasing the number of trainings and supervisions was essential for improving provider adherence.

Community perspectives on assessment and treatment

Focus group discussions (FGDs) with community members in the health catchment areas surrounding the selected health facilities provide a perspective on the external pressures that may influence provider assessments and decision-making for treatment. In both Haut Katanga and Kasai Central, community members noted inconsistencies around how suspected malaria cases were diagnosed and treated. Although health posts and health centers are not usually equipped to do thick smear microscopy, and national guidelines require an RDT to confirm malaria at lower-level facilities prior to prescribing antimalarials, community members described experiences where RDTs were not available, and the provider resorted to microscopy or symptomatic diagnoses instead. In Haut Katanga, participants of both men's and women's FGDs stated that RDTs were not common:

The rapid test that they talk about, the ParaCheck, I've started to find those are rare in the hospitals. (Man, Haut Katanga)

The lack of RDTs could push providers to rely on observation and presentation of symptoms to diagnose malaria, as one man in Haut Katanga noted:

In those centers they don't really have the materials to do the tests. In those centers it suffices for them to just observe to confirm that it's malaria and put a catheter in you. (Man, Haut Katanga)

Participants in Kasai Central also discussed instances where the provider would resort to clinical diagnosis rather than using RDTs:

Sometimes the provider, you can go to the hospital to find that the RDTS are not ready. Sometimes the lab techs are not there yet, at the hospital the provider can't do the test because there are no RDTs at the center, even at the laboratory he can just give the person a medication to lower the fever and you return another day to do the test, we don't do them every time. (Man, Kasai Central)

There were also providers who were more likely to rely on microscopy, either due to the unavailability of RDTs or because providers have more confidence in microscopy. One woman in Kasai Central stated

"Only when the provider does the thick smear, it's then that he knows". While community members were overwhelmingly familiar with RDTs, there was a range of experiences at the health center, from those who said RDTs were performed to those who were diagnosed via microscopy or clinical diagnosis based on symptoms. There were also participants who, while familiar with the RDT, did not know what it measured. Some community members thought that the RDT was used to identify the level of malaria in the blood, rather than whether the person had malaria, saying "It verifies the level of malaria in the person's blood" (Woman, Kasai Central). In these cases, the patient may not recognize the binary between positive and negative RDTs, instead thinking the test measures the severity of malaria.

When RDTs were used, patients, like the providers themselves, were more likely to trust a positive result than a negative result. Patients were easily able to identify common symptoms of malaria, and many felt confident that they could assess when they had malaria based on symptoms alone. One woman said that she would trust the provider if she had a negative test, but would still have questions.

> *I will pose the question, "but I personally know that I am suffering from malaria. But you are telling me it's not malaria, so what could it be?"*

However, there were also many community members who expressed that malaria could only be confirmed at the health center and identified typhoid fever as having similar symptoms. Patients expressed widespread trust in provider expertise, which in some cases cancelled out distrust of negative RDTs, and other times did not. Some patients noted that it was always necessary to test before treating, with one woman stating,

> *If he could give medication without having done the tests, how will he know which medication to give? (Woman, Kasai Central)*

A man in another FGD in Kasai Central explained,

> *Because even the providers who are accustomed to that can look with their eyes, but to be really sure, they have to do the tests because there are diseases that have similar symptoms, we can think that it's malaria but it's not malaria, it's another disease, so it's better to do the tests to be sure. (Man, Kasai Central)*

Most respondents agreed that RDTs could give false negatives, with some attributing these false negatives to human error:

> *So, the person using it does not have the experience or the mastery, he will only get bad results. (Woman, Kasai Central)*

and some finding fault with the tests themselves:

> *If the machine that he uses is not in good shape, that can lead him to have bad results, condemning him to be wrong because the machine is in bad shape. (Woman, Kasai Central)*

Providers would sometimes communicate their distrust of negative RDTs to the patients. Said one man in Kasai Central,

But if this is not the case for malaria, we have that in the blood, even if we do, when he brings out the results, he tells you that maybe your malaria is not too serious, maybe the percentage is minimal or sometimes, they can tell you, for example, take some products to fight it or you might just be at the beginning of the malaria, we often have that.

Due to the providers' perceived expertise, their attitudes toward the RDTs were easily communicated and influenced the patients' perceptions.

If patients were skeptical of a test result, they would either ask to redo the test (the same day or a few days later) or go to a different health center for another test. Said one parent,

If where I go, the test is always negative, I will look for there where it will be positive. (Parent, Kasai Central)

Some would simply buy antimalarials themselves at the pharmacy or resort to traditional medicine.

Hm, a lot are like that, they return home, saying to themselves "the symptoms that I have, it's malaria that's bothering me, but the provider did not help me to take the antimalarials" and directly this person makes themselves a provider, they start to buy [antimalarials] in the pharmacies. (Woman, Kasai Central)

Patients often expected to receive antimalarial treatment and would obtain it elsewhere if they did not. One woman stated that lack of treatment for malaria could color a patient's perception of the health center:

And she will not have confidence in you next time even if she is seriously sick, she will say to herself there's not a hospital here. She won't come, even if she sees her child is sick, she will not come. You will hear "I went there, I walked for many hours and even tired, I arrived, and they didn't even greet me, they didn't even give me medication, I didn't even stay they told me to go home". (Woman, Kasai Central)

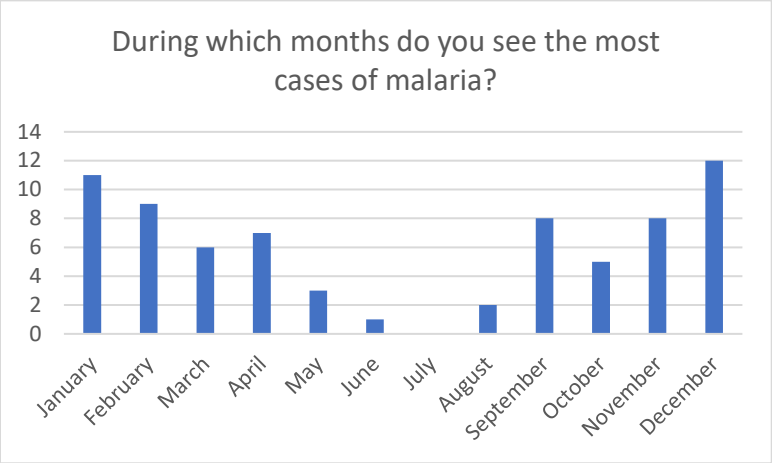
Overall, community members trusted in the training and expertise of providers, while acknowledging that not all providers were equally competent and that RDTs could at times be wrong. Past experience with malaria made community members more confident in their ability to self-diagnose, creating doubts when RDTs came back negative. Often one negative RDT was not enough to convince someone they did not have malaria, but two negative tests were. Provider skepticism around the RDT results can reinforce this distrust.

Perceptions of seasonality

Facility-based respondents recognized that the prevalence of malaria and of mosquitos fluctuated throughout the year. Supervisors noted that most cases of malaria occur in December and January, mapping onto the rainy season which spans from October to April. The fewest cases were reported in May, June, and July, mapping onto the dry season. The estimated number of RDTs used per day during the high-malaria season ranged from 5-15, compared to 2-8 RDTs per day in the low malaria

season. One facility was an outlier, with a high-season estimate of 100 tests a day and a low-season estimate of 40 tests a day.

Figure 9. Facility supervisor reports of the months where they see the greatest number of malaria cases



> *It's different, you see in the rainy season, the rate is higher, there are a lot of cases, and in the dry season, the cases go down; maybe it's related to the mosquitos because during the rainy season, there are a lot of mosquitos now that give malaria, but in the dry season, the mosquitos disappear a bit. (Provider, cluster 2)*

Providers also noted that, in addition to using fewer RDTs in the dry season, the tests were also more likely to return negative results.

> *Well, the concerns, it's just to know, why a lot of cases their results are always negative. And we have responded to this questions that it's related to the climate that we're having now during the dry season. There, we always run to these negative results. (Provider, Cluster 1)*

Given this widespread recognition of seasonality by respondents, some participants noted that the graphs, especially the HMIS data, did not reflect what they felt was typical in their facility due to a lack of seasonality in the data. One staff member who was responsible for operating the Deki reader, when shown the HMIS data which did not reflect seasonal variation, said:

> *That doesn't match up because starting in March until June, each year, the graph varies between 60 to 90 while the other or the current months with this season, we have not had a lot of patients who can have RDTs, who could provide positive results. So at least, there is this tendence of incompatibility compared to our current season. (Deki operator, Haut Katanga)*

However, there were two facilities in Kasai Central that posited that the TPR remained high in the dry season because community members slept outdoors by the river:

> *Although there is not a little rain, a lot of people in our areas, they have a tendency to go cultivate nearby and close to the rivers, but since there's no rain, the mosquitos also take advantage of where there is a little water to go, but as these people are going there to cultivate,*

to sometimes even spend the night there in bad conditions, he is obligated where there is a little more. (Provider, Cluster 1)

In addition, many people work in the forest and may sleep there without protection from mosquitos.

Now the dry season … here currently, there are a lot of people who work in the forest and the mosquitos during this period will leave the rural area to go concentrate somewhere in the forest where there's water. And the people who work during this season, the others sleep in the forest without protection … they might think that they're lighting a fire, that that will protect them against the cold. But the mosquitos, the other will now sleep next to the water … especially the fishermen … they will sleep there, now the mosquitos … are going to now be there somewhere during this time. So, they will bite them, there will be the possibility of transmitting malaria. (Supervisor, Cluster 3)

Discussion and Conclusions

The results of this qualitative study provide explanations for the discrepancies seen in the Measure Malaria study between the TPR reported in the Deki and the TPR reported in the HMIS across the case management process from patient intake to reporting. Health centers and health posts were sampled based on preliminary results from the Measure Malaria study, with the criteria that they must have an operational Deki reader and have submitted at least 10 interpretable RDT results each month from April to June 2022. One limitation of the current study is that certain results may not be generalizable to facilities that do not meet these criteria, as facilities with fewer than 10 submissions per months may face greater barriers to Deki reader use.

It is, however, clear that deviation from prescribed policies is widespread at health centers and health posts at each of the three steps, from (1) patient assessment, which is not uniformly done with RDTs and may be based on symptoms alone or on microscopy (whether alone or in concert with an RDT), to (2) treatment decisions, which often do not conform to RDT results, particularly when they are negative, and to 3) reporting, where a variety of factors influence if cases are reported consistently and correctly. Many of the findings existing in the literature were also evident in the data collected during this study. Table 12 presents explanations for TPR discrepancy as described by past studies.

Table 12. Possible Explanations for differences in TPR in the literature

Patient Assessment	• Providers consider fever patterns, home environment, and whether the client uses a mosquito net to inform their diagnosis (Johansson et al., 2016) • Many campaigns have been conducted around the threat of malaria, and thus providers conclude that most fevers are malaria (Beisel et al., 2016) • Providers express doubts about the sensitivity of RDTs for detection of low parasite loads, particularly at illness onset or if the patient reports recent treatment with an antimalarial (Altaras et al., 2016; Johansson et al., 2016) • Providers may view RDTs as challenging their expertise or as disruptive to consultation flow (Johansson et al., 2016; Burchett et al., 2017)

Treatment Decisions	• Health workers feel obligated to provide treatment and may perceive social pressure to do so, do not want to be perceived as refusing care, believe the client expects medication, and feel medication provision fosters a better client-provider relationship (Beisel et al., 2016; Johansson et al., 2016) • Providers recognize that if they do not prescribe treatment the patients may purchase the medication themselves at the pharmacy (Diggle et al., 2014) • Malaria treatment medication was more likely to be prescribed for RDT negative cases when the patient was under 5 years (Mokuolu et al., 2018) • Patients or caregivers with higher educational attainment were more likely to demand medication for malaria treatment (Mokuolu et al., 2018) • Providers may be concerned that the risk of not treating for malaria is too great and may consider potential disease severity and client challenges to care-seeking as reasons to err on the side of treatment with antimalarials in order to avoid a client becoming sicker and potentially needing to return to the facility (Altaras et al., 2016; Beisel et al., 2016; Burchett et al., 2017; Johansson et al., 2016). • A lower-than-expected number of RDTs returning positive results can create skepticism around the reliability of the RDTs, with providers showing less trust in negative RDT results than positive results (Diggle et al., 2014) • Health workers lack proficiency in differential diagnosis and identifying alternate treatments in the case of negative test results (Burchett et al., 2017)
Recording and Reporting	• Health workers sometimes do not record RDT negative cases in their client register, and primarily record positive RDT cases (Mokuolu et al., 2018) • Recording of relevant data in the register is sometimes done by the healthcare provider, whereas other times there is a nurse or midwife dedicated to this task. The healthcare provider or the nurse or midwife may summarize data across register records on a daily or monthly basis, or this task is handed over entirely to the Nurse Administrator (*Infirmiere Titulaire, IT*) or their assistant (*Infirmiere Titulaire Adjointe, ITA*). Some data may be lost or changed at each step – from what the provider does and sees, to what is recorded into the register, to what is summarized into monthly totals reported into the HMIS (Breakthrough ACTION-DRC, 2021).

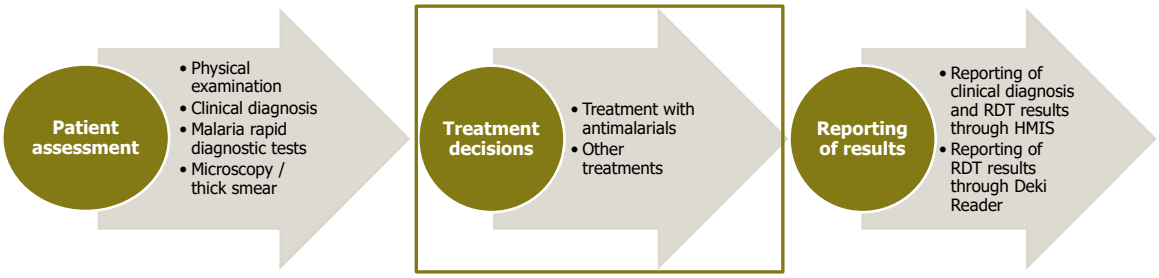
#1 - Patient assessment

As in other studies, providers may assess malaria based not on RDT results, but on symptoms. Contextual factors such as whether the patient had already taken antimalarials (or antipyretics) and if the patient had only recently developed symptoms could inform the assessment. Other contextual factors include the long-standing belief that all fevers were indicative of malaria, and that malaria was prevalent, resulting in distrust a greater-than-expected proportion of negative RDT results, and if the patient was a pregnant woman, which could lead the provider to be more cautious due to the risk to the fetus. Distinct from some prior studies included in the literature review, providers did not find the RDTs burdensome to their workflow, but rather found them an asset when it came to confirming malaria with a positive diagnosis. It was only when the RDT came back negative that the provider was forced to decide between accepting the result, excusing the result, or seeking an alternate diagnosis. A new finding from the current study highlighted the greater trust in microscopy, which was felt to be more sensitive, more accurate, and better able to detect different types of parasites. In cases where microscopy was available, some providers would use it as a back-up diagnostic tool when a patient with malaria-related symptoms received a negative RDT result. Interestingly, the lower-level health centers and health posts are not capacitated to perform microscopy, and more research should be done to determine how the slides are analyzed and by whom. Recommendations for improving adherence to guidelines on assessing patients for malaria include:

1. Training providers (not just supervisors) on proper use of RDTs, including a module on addressing misconceptions around RDT negativity (after self-medication, early in infection, and for different types of parasites). It is clear that the idea of "trickle-down training" is prevalent, but supervisors may not be skilled trainers and may not have the materials available to pass along the full training they receive to their supervisees. However, it is also the case that supervisors' adherence to national guidelines influences the practice of the staff they supervise, so both trainings are necessary.
    - When training is only provided to supervisors, they should be provided simple, succinct materials to bring back to their facility to aid in passing the content along to other staff.
    - Training materials should where possible indicate that the recommendations are based on the situation as it has been documented in DR Congo. This might include:
        - Information on the occurrence of Plasmodium parasites other than P. falciparum in DR Congo, and the effect that these parasites might have on RDT results;
        - Prevalence of other conditions such as typhoid fever among patients presenting with fever in DR Congo; and

    - The effect of prior antimalarial treatment on RDT results, e.g., if the patient took a dose of antimalarial treatment the day before the clinic visit.
  - Training materials might be complemented by video clips of interviews with respected Congolese researchers and health authorities, indicating their familiarity with the local situation in health facilities, explaining their perspective on the importance of testing with RDTs, and addressing common misconceptions about malaria testing and treatment.
  - It is also important that health actors at the zonal and provincial levels receive training and be given the opportunity to ask questions they might have about situations in which RDT results may not be reliable, as distrust in RDTs by higher level health professionals filters down to health area supervisors and facility-based providers
2. Assuring consistent use of RDTs and address use of microscopy. It is not clear from these findings what the state of microscopy is in health posts and health centers in the DRC. While some facilities may send blood samples to other labs, some may perform microscopy in their own labs, without proper equipment or adequately trained personnel. Further research is needed to ascertain the accuracy of microscopy results at this level, and to address the misconception that microscopy is necessarily the gold standard for malaria diagnosis. It is also important to address RDT stockouts so that providers are able to use RDTs for all suspected malaria cases.
3. Working with pharmacists and traditional healers to refer clients to health facilities for testing to reduce self-medication. Working to increase referrals from other sectors of the healthcare system would decrease the number of people who are self-medicating, while also removing the concern that providers have that the RDT is only giving a negative result because the patient has already taken antimalarials.
  - Conversely, equipping pharmacists and community health workers to perform RDTs (and report results), if done well and with adequate training, could increase the number of suspected malaria cases who are tested with RDTs prior to receiving medication.
4. Develop mass media and interpersonal communication content on testing before treatment. Providers do not exist in a vacuum, and community expectations around needing an RDT to confirm malaria could create external pressure for providers to use them more consistently.
  - Stress the importance of provider expertise on taking medication. It is important to take the correct medication at correct dose, especially for children.
  - Communication should also highlight that, while every fever could be dangerous and parents (and individuals) should seek care within 24 hours, not every fever is malaria. Correctly identifying the cause of fever is the first step to effective treatment.

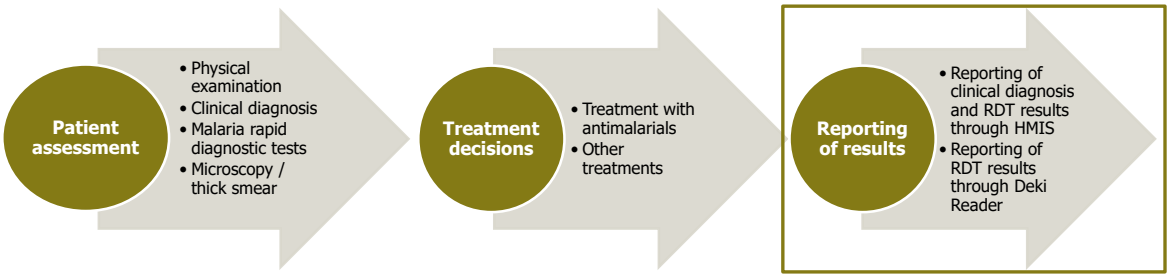
#2 - Treatment decisions



Findings from this study also confirm what has been discovered by prior studies around treatment decisions. Providers were skeptical of negative RDTs, and many were unlikely to adhere to the guidelines for management of febrile patients with negative results. Perceived pressure from patients was also a factor, and patient expectations as well as the possibility of them obtaining antimalarials elsewhere contribute to nonadherence. Social influence from supervisors, other providers, and community members was found to be a significant determinant of testing and treatment practices Another widespread problem was that of self-medication. Providers were quick to assume that negative RDTs were the result of improperly treated malaria, either due to the wrong medication or the wrong dose. They would either prescribe another course of antimalarial or prescribe a new antimalarial to treat the malaria that they thought was "in hiding" from the RDT while still causing symptoms. Recommendations for future interventions are:

1. Better communication around seasonality and how that affects the RDT results throughout the year. Rather than being suspicious of disproportionately negative RDT results, providers should be educated on the lower prevalence in the dry season. While most providers recognize malaria seasonality, there is a disconnect when it comes to understanding trends in the data.
2. Communication around alternate illnesses aimed at both communities and providers, stressing the importance of not missing typhoid fever and other diseases. Communication campaigns, particularly in health centers, or job aids to help providers explain alternate diagnoses to patients, should address the risk of other illnesses that may be missed if the provider assumes malaria.
3. Peer advising from less discordant TPR facilities, or testimonials from well-known Congolese researchers and other experts, or respected providers who adhere to RDT results, could help change social norms stemming from perceptions of other providers not adhering to negative RDT results.

#3 - Reporting of results



Confusion around reporting was common in cases where the RDT was negative, an RDT was not performed, or where the RDT result conflicted with that of another diagnostic measure. Respondents also communicated the potential for errors or even falsifying data in order to ensure the facility had enough resources. While many facilities experienced setbacks to using the Deki readers due to lack of electricity, connectivity, and trained personnel, facility personnel also recognized the benefits of better data quality and improved practices around malaria case management, especially around consistent use of RDTs. The Deki reader provided a quality assurance tool by identifying invalid tests that providers may otherwise have reported as positive. These findings support the need for:

1. Increased discussion and sharing of data, including the development of a tool and discussion guide around reviewing monthly TPR and associated graphs. Provide training on reading and understanding the TPR data and graphs to all staff, so that they are better able to identify data quality issues or discrepancies in reporting.
2. Training for providers (not just supervisors) on how to record cases in the curative register. Depending on provider feedback, adapt registers to include information on whether RDTs were used or if they were out of stock or otherwise unavailable.
3. Advocacy to providers and supervisors around the importance of data accuracy, including assurances that seasonality will be taken into consideration when budgeting resources in order to allay fears that lower TPR in the dry season will result in fewer resources when they are needed.

Overprovision of antimalarials is a waste of resources and could cause eventual pharmacological resistance. It may also result in providers missing other, potentially serious diseases that require treatment. Misreporting of malaria positivity affects data quality at the national level and may also obscure the prevalence of other diseases. Interventions must target mitigating factors determining how suspect malaria cases are assessed, treated, and reported in order to improve treatment outcomes and data quality around malaria prevalence in the DRC.

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