RESEARCH ARTICLE

Two parallel reporting systems for malaria surveillance in Pakistan, 2013–17: is exact burden reflected? [version 1; peer review: 2 approved with reservations]

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V1 First published: 28 Dec 2018, 7:1986
<https://doi.org/10.12688/f1000research.17202.1>

Latest published: 28 Dec 2018, 7:1986
<https://doi.org/10.12688/f1000research.17202.1>

Abstract

Background: Pakistan is facing challenges regarding the availability of reliable data for malaria surveillance. These include lack of coordination between different reporting systems and fragmented information system. This study aimed to compare the reporting of malaria surveillance systems in Pakistan.

Methods: There are two parallel reporting systems for malaria surveillance in Pakistan, the District Health Information System (DHIS) and Malaria Information System (MIS). DHIS reports on all morbidity at health facility level, while MIS is only used for malaria surveillance in the donor supported districts. A cross sectional study was conducted between July-September 2018 by using the retrospective records of DHIS and MIS data reported to the Directorate of Malaria Control (DOMC) Islamabad during 2013-17. Descriptive and inferential analysis was performed to compare the coverage, outcome and impact indicators.

Results: During 2013-17, all districts (n=145, 100%) across Pakistan reported on the DHIS. The MIS reporting coverage has gradually increased from 21 (14.5%) to 72 (49.7%) districts. Reported number of suspected screened and confirmed malaria cases were compared. MIS reported twice the number of suspects screened for malaria (100.5%) and confirmed malaria cases (124.4%) as compared to the DHIS. The difference in the reported average annual blood examination rate (ABER) was 3.8, test positivity rate (TPR) was -0.9 and the annual parasite incidence (API) was 4.9/1000 population over five years between two systems. DHIS reported only half the ABER and API as compared to MIS.

Conclusion: There is huge under-reporting of suspected and confirmed malaria cases in the DHIS as compared to MIS. Urgent

Open Peer Review

Approval Status ? ?

	1	2
version 1
28 Dec 2018	view	view

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Any reports and responses or comments on the article can be found at the end of the article.

attention is needed to address this, as it is vital to have uniform reporting of true disease burden across the country. An integrated disease surveillance system, improved data validation systems, and use of the online DHIS-2 are potential options for better integrity and coherence of reported data.

Keywords

Malaria surveillance, comparison, operational research, DHIS, Pakistan, reporting system

This article is included in the TDR gateway.

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Author roles: **Habib H:** Conceptualization, Data Curation, Formal Analysis, Funding Acquisition, Investigation, Methodology, Project Administration, Resources, Validation, Writing – Original Draft Preparation, Writing – Review & Editing; **Fatima R:** Funding Acquisition, Methodology, Project Administration, Software, Supervision, Writing – Review & Editing; **Achakzai AB:** Conceptualization, Project Administration, Resources, Supervision; **Wali A:** Formal Analysis, Methodology, Resources, Software, Validation, Writing – Review & Editing; **Yaqoob A:** Data Curation, Formal Analysis, Investigation, Methodology, Software, Validation, Writing – Original Draft Preparation, Writing – Review & Editing; **Najmi H:** Methodology, Validation, Writing – Original Draft Preparation, Writing – Review & Editing; **Haq MU:** Methodology, Resources, Software, Writing – Review & Editing; **Majeed A:** Conceptualization, Methodology, Resources, Supervision, Writing – Original Draft Preparation

Competing interests: No competing interests were disclosed.

Grant information: This research was conducted through the Structured Operational Research and Training Initiative (SORT IT), a global partnership led by the Special Programme for Research and Training in Tropical Diseases at the World Health Organization (WHO/TDR). The training model is based on a course developed jointly by the International Union Against Tuberculosis and Lung Disease (The Union, Paris, France) and Médecins Sans Frontières (MSF, Geneva, Switzerland). The specific SORT IT programme that resulted in this publication was implemented by the National Tuberculosis Control Programme of Pakistan, through the support of the Global Fund to Fight AIDS, Tuberculosis and Malaria (The Global Fund, Geneva, Switzerland). The publication fee was covered by the Special Programme for Research and Training in Tropical Diseases at the World Health Organization (WHO/TDR).

The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

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How to cite this article: Habib H, Fatima R, Achakzai AB *et al.* **Two parallel reporting systems for malaria surveillance in Pakistan, 2013–17: is exact burden reflected? [version 1; peer review: 2 approved with reservations]** F1000Research 2018, 7:1986 <https://doi.org/10.12688/f1000research.17202.1>

First published: 28 Dec 2018, 7:1986 <https://doi.org/10.12688/f1000research.17202.1>

Introduction

Malaria ranks sixth amongst the top ten causes of deaths in low income countries of the world¹. In 2016, 91 countries reported an increase in malaria cases (216 million) as compared to 2015 (211 million). Around 0.4 million deaths have also been reported during the same year. Most cases were reported by the World Health Organization (WHO) African Region (90%), followed by the South-East Asia Region (7%), and the Eastern Mediterranean Region (2%)². The incidence of malaria cases varies from low to high in different countries. Countries with low malaria incidence are progressing towards malaria elimination, while others having a high disease burden, including Pakistan, have implemented malaria control programs³.

The World Health Organization (WHO) has emphasized the critical need for transforming malaria surveillance as a core intervention in the Global Technical Strategy for Malaria. WHO has further stressed on the importance of prioritizing investments in malaria surveillance system to ensure that reliable data is available for decision making⁴. Effective surveillance of malaria is essential for identifying and prioritizing the most affected areas or population groups⁵. Moreover, uniformity of the surveillance tools and timeliness of reporting is important in countries with low disease burden at the malaria control phase⁶. It has been observed that despite all the efforts and investments, malaria surveillance system has many challenges related to the timeliness, representativeness, data quality and reliability in high and low burden countries from the WHO African and Eastern Mediterranean regions^{7,8}.

Pakistan is among seven countries of the WHO Eastern Mediterranean Region sharing 95% of the regional malaria burden⁹. An estimated 98% of Pakistan population (205 million) is at varying risk, while around 60% population (123 million) at high risk for malaria². In Pakistan, Malaria due to *Plasmodium vivax* is most common (88%), followed by *Plasmodium falciparum* (12%)¹⁰. Epidemiologically, Pakistan is classified as a moderate malaria endemic country with the national annual parasite incidence (API) averaging at 1.16, with a high variation within different provinces of Pakistan¹¹. The districts and agencies in the Five provinces and Federally Administered Tribal Areas (FATA) region of Pakistan were stratified into three strata (I, II and III) based on the malaria annual parasite incidence (API), and slide positivity rate (SPR) of 2011–13 under the country's National Strategic Plan. Based on this stratification, 72 districts are placed in stratum-I (having API >5), ten in stratum-II (API 1–5) and 63 in stratum-III (API <1) for prioritizing the highest endemic districts for resource allocation¹².

The malaria surveillance in the country has many issues. Major challenges include lack of coordination between different reporting systems, fragmented information systems and relying on parallel reporting for malaria cases in the highest burden sharing districts through a paper based malaria information system (MIS) and district health information system (DHIS)¹³. The diverse epidemiology of malaria disease in Pakistan stratifying the country into high and low burden sharing areas has further contributed to the difficulties in proper disease surveillance¹².

It is estimated that due to such challenges, only around 23% of malaria cases have been captured in Pakistan through various surveillance systems during 2016².

Limited evidence has been found regarding the comparison of various malaria surveillance systems in Pakistan. This study aims to compare the malaria coverage, screening, cases, outcome and impact as reported through the MIS and DHIS in high burden sharing districts of Pakistan.

Methods

Study design and setting

This was a cross sectional retrospective record review of malaria routine surveillance data for the period 2013–17 reported through the DHIS and MIS from donor supported districts of Pakistan. The study was conducted from July to September 2018 at the Directorate of Malaria Control (DOMC), Islamabad which is an attached department of the Ministry of National Health Services, Regulations and Coordination. DOMC is primarily responsible for malaria surveillance in Pakistan in collaboration with the provincial malaria control programs. The Global Fund (donor) is supporting the malaria control interventions in the highest burden sharing stratum-I districts located mainly in the provinces of Balochistan, Sindh, Khyber Pakhtunkhwa (KP) and FATA¹².

Malaria surveillance data from the public health facilities is reported through two parallel systems, namely the DHIS (introduced in 2008 for all districts) and MIS (only for the Global Fund supported districts). DHIS reports on all morbidity at health facility level while MIS is used in only the donor supported districts for malaria surveillance¹³. Fever cases with signs and symptoms of malaria are screened as suspected cases, confirmed through the microscopy or rapid diagnostic test (RDT) kits, and then reported in the DHIS and MIS according to the identified species, i.e. *P. falciparum*, *P. vivax* or *mix cases* on monthly basis (Figure 1). Data of five years as reported by the districts having both DHIS and MIS simultaneously from 2013 to 2017 was used for comparing the annual blood examination rate (ABER), test positivity rate (TPR) and annual parasite incidence (API).

Study population

All malaria cases reported to the Directorate of Malaria Control (DOMC) through DHIS and MIS between 1st January 2013 and 31st December 2017 from the districts where parallel reporting on both DHIS and MIS has been used.

Data collection, analysis and statistics

Epidemiological records of five years are available in electronic forms at the Directorate of Malaria Control in Islamabad. The data of this particular study was extracted from the DHIS and MIS. Study variables including the suspected cases screened for malaria, and confirmed malaria cases disaggregated by species (*P. falciparum*, *P. vivax* and *mix*) were doubled entered, and cleaned in the EpiData Entry version 4.4.3.1.

Descriptive analysis of selected variables such as reporting coverage of the two systems, annual blood examination rate,

Figure 1. Malaria Surveillance Systems in Pakistan (information flow).

test positivity rates and reported annual malaria cases was performed in SPSS version 23. The DHIS and MIS data is regularly validated on monthly basis for the DHIS, and quarterly basis for the MIS at the district, provincial, and federal levels. Randomly, the hard copies of the reported data were matched with the entered data for validation.

Ethical approval

As this study was conducted on two malaria surveillance systems comprising of aggregated districts level data, there was no human subject directly involved in this study. Ethical and administrative approval (Reference F.No.2-30/2018/CMU-NFR; M&E/Surveillance/SORT-IT) was taken from the Director, DOMC for using the malaria program data for this study.

Results

During 2013–17, all districts (n=145, 100%) across Pakistan reported on DHIS. Reporting on the MIS increased gradually from 21 (14.5%) districts in 2013 to 72 (49.7%) districts in 2017. (Figure 2) For this study, data of only those districts was analyzed which had reported simultaneously on the DHIS and MIS during these five years. (Table 1)

For screening the suspected malaria cases, DHIS reported a total of 4,260,610 suspected cases screened for malaria. During the

same period, MIS reported a total of 8,540,702 suspected cases screened for malaria, which was 4,280,092 (100.5%) more than the DHIS from the same districts. The reported number of total confirmed malaria cases in the DHIS was 436,273. Out of these, *P. vivax* was the highest reported cause of malaria with 350,892 (80.4%), followed by *P. falciparum* (80,230, 18.4%) and mixed infection with 4,697 (1.1%). MIS reported 979,192 confirmed malaria cases during the same period for the same districts. *P. vivax* was the most reported cause of malaria (769,016, 78.5%), followed by *P. falciparum* (150,398, 15.4%) and mixed infection with 59,778 (6.1%). MIS reported 542,919 (124.4%) confirmed malaria cases more than the DHIS. (Table 2)

DHIS reported an average annual blood examination rate (ABER) of 3.3, test positivity rate (TPR) of 13.6, and annual parasite incidence (API) of 4.4 for the five years. MIS reported an average ABER of 7.1, TPR of 12.7 and API of 9.3. The difference in the reported ABER was 3.8 (115.2%), TPR was -0.9 (6.6%) and API was 4.9 (111.4%). (Table 2)

Discussion

Pakistan like other low and middle-income countries (LMICs) has substantial reliance on external funding¹⁴. The Global Fund providing 50 percent of all international financing for malaria, has

Figure 2. Trends in number of districts reporting on DHIS and MIS for malaria in Pakistan, 2013–2017. DHIS=District Health Information System, MIS=Malaria Information System, API=Annual Parasite incidence, TGF= The Global Fund, *MIS-reported API= The cases include cumulative figures for only the Global Fund supported districts for 2013–2017, *DHIS-reported API= The cases include cumulative figures for only the Global Fund supported districts for 2013–2017.

Table 1. Malaria reporting coverage through DHIS and MIS in different provinces of Pakistan, 2017.

	Total Districts n=145	DHIS (2013–2017) n=145	MIS				
			2013 n=21	2014 n=21	2015 n=47	2016 n=47	2017 n=72
Provinces/Regions							
AJK	10	10	00	00	00	00	00
Balochistan	32	32	11	11	21	21	31
KP	25	25	03	03	07	07	14
KP – Tribal districts	13	13	03	03	13	13	13
Punjab	36	36	00	00	00	00	01
Sindh	29	29	04	04	06	06	13

AJK= Azad Jammu Kashmir, FATA= Federally Administered Tribal Areas, KP= Khyber Pakhtunkhwa, DHIS= District Health Information System, MIS= Malaria Information System

been supporting the Government of Pakistan for the control of TB, AIDS and malaria since 2003³. This support has been mainly targeted for decreasing the burden of disease in the highest endemic districts of the country through the provision of prompt diagnostic, treatment, and preventive services for malaria¹³. Keeping in view the importance of surveillance, the Ministry of Health in Pakistan has taken strengthening the Health Information Systems as a major thematic pillar under the 10 years National Health Vision¹⁵. However, studies in Pakistan have highlighted issues related to the data reliability, and concrete data analysis in various health programs¹⁶.

Disease reporting in Pakistan across all provinces and at the federal level is carried out through the DHIS and several other parallel surveillance systems for the diseases according to the

specific needs of the programs. Some of these parallel systems include Malaria, Dengue, TB, EPI, and HIV/AIDS. DHIS is the nation-wide health information system which is being used for reporting of the district level aggregated data from all the public health facilities¹⁷.

Our study shows that reporting coverage through the MIS, which is mainly used for reporting malaria in high burden districts of the country, has been increasing gradually from 21 to 72 districts from 2013–17. Balochistan and FATA provinces have the highest average number of districts reporting on both DHIS and MIS, which may be due to the highest annual parasite incidence in these provinces; hence they are supported by donor funds by the national program, and prioritized for malaria control interventions¹⁸.

Table 2. Malaria interventions coverage, outcome and impact in donor (*TGF) supported districts of Pakistan, 2013–17.

	DHIS	MIS	Difference	
			n	(%)
Coverage	(n in thousands)	(n in thousands)	(n in thousands)	
Suspects screened	4,260	8,540	4,280	(100.5)
Confirmed malaria cases	436	979	542	(124.4)
<i>P. falciparum</i> cases	80	150	70	(87.5)
<i>P. vivax</i> cases	350	769	418	(119.2)
Mix case	4	59	55	(1172.7)
Outcome				
ABER	3.3	7.1	3.8	(115.2)
TPR	13.6	12.7	-0.9	(6.6)
Impact				
API	4.4	9.3	4.9	(111.4)

TGF= The Global Fund, ABER= Annual Blood Examination Rate, API= Annual Parasite Incidence, Confirmed cases = Number of tested suspects confirmed as malaria cases, DHIS= District Health Information System, MIS= Malaria Information System, Suspects screened= Number of fever cases tested for malaria, TPR= Test Positivity Rate

This study reveals major differences in the numbers of suspected screening for malaria and confirmed malaria cases reported between the two surveillance systems. A consistent under-reporting of suspected and confirmed malaria cases was seen in the DHIS as compared to MIS. This is contradictory to the findings of another recent study conducted in Swaziland comparing three reporting systems in malaria elimination settings where the national reporting system was found to be over-reporting malaria cases¹⁹. Although both the DHIS and MIS are paper based surveillance systems, the difference in reported number of suspected cases screened and malaria confirmed cases observed from this study is very high. The reported confirmed malaria cases in MIS are 121.9% more as compared to the DHIS. Another study conducted in Malawi on data quality has shown discrepancy of 12–24% between paper-based and electronic data systems²⁰. Ideally, there should be no variance between the two surveillance systems as the reported data is from same health facilities within the same districts.

The huge difference and under-reporting of malaria figures from DHIS may be due to several reasons. First, the start of donor support for malaria control interventions in the country has brought with it an additional reporting system to the DHIS, i.e., the MIS which is more comprehensive, and has many additional indicators as per the donor requirement. The MIS has its own data recording and reporting tools at the health facility level in parallel to already existing tools for DHIS. When there are parallel reporting systems with different recording and

reporting tools in the same health facilities, the data quality is usually compromised as entering the data into separate platforms results in more errors¹⁹.

The second important factor to be explored will be that of who is responsible for data entry and reporting into DHIS and MIS at the very basic level, i.e. the health facility and district levels. Thirdly, there was considerable under-reporting of confirmed malaria cases in the DHIS. A possible reason may be that the tools in the DHIS are more specific for screening of malaria suspects with microscopy, which is the gold standard for confirmed diagnosis of malaria cases. However, DOMC with the support of the Global Fund grant, introduced RDT kits in health facilities without microscopy diagnosis facilities in the high burden districts, mostly in Basic Health Units (BHUs). This may have resulted in screening of more suspects using RDT at these health facilities and reporting of more confirmed cases. The cases screened and confirmed through RDTs may not have been reported into the DHIS by many of these centers as RDT is a relatively new diagnostic method²¹.

The study strengths are that the national surveillance data reported to routine program settings was used for analysis which is likely to reflect the reality on the ground. All districts reporting simultaneously on DHIS and MIS over the span of five years were included in the study across all provinces of Pakistan. The data reported in the MIS has been used as the benchmark as this database is carefully supervised and validated at the

district level on a quarterly basis. The Global Fund grant has comprehensive data validation and quality assurance mechanisms in place hence we believe that the MIS data is more reliable²².

The current study is limited by the fact we did not have facility level data for analysis and we did not explore the exact reasons for observed discrepancies between the two surveillance systems. In-depth interviews of the district level supervisors and data entry operators for the DHIS and MIS along with the health facility staff actively involved in reporting on the two systems may help in better understanding of the dynamics and reasons for these discrepancies.

Despite of these limitations, the findings have a number of policy and practice implications. In the context of devolution in Pakistan, DHIS has utmost importance for timely surveillance of communicable diseases at the provincial level. MIS, being donor driven, is present in only around half of the country. The major concern in regards of the under-reporting seen in the DHIS is that the true malaria burden may be under-estimated. This under-reporting of the confirmed malaria cases can delay the early detection of malaria outbreaks predisposing the population to malaria epidemic. Moreover, the data from DHIS is used for decision making, disease prioritization and resource allocation according to the reported disease burden in the provinces. Under-reporting from DHIS will result in reporting of false burden of malaria cases, i.e. fewer cases than actual. This may result in lesser disease prioritization due to false reporting of low disease burden and hence less resource allocation.

Further research is required at the health facility, district and provincial levels to assess whether there is any mechanism for data validation, combined reporting, comparison and coherence for the DHIS and MIS data before being finalized for reporting into the two parallel systems. This is important as continuous

validation of the health facility data is important before reporting into various systems²³. The DHIS-2 being a free and open source, web based software may be the potential option for improving the completeness and quality of surveillance data being reported for malaria surveillance^{24,25}.

Data availability

Underlying data

Open Science Framework: Pakistan malaria surveillance data 2013–17 (DHIS-&-MIS), <https://doi.org/10.17605/OSF.IO/NC54V>²⁶.

Data are available under the terms of the [Creative Commons Zero “No rights reserved” data waiver](#) (CC0 1.0 Public domain dedication).

Grant information

This research was conducted through the Structured Operational Research and Training Initiative (SORT IT), a global partnership led by the Special Programme for Research and Training in Tropical Diseases at the World Health Organization (WHO/TDR). The training model is based on a course developed jointly by the International Union Against Tuberculosis and Lung Disease (The Union, Paris, France) and Médecins Sans Frontières (MSF, Geneva, Switzerland). The specific SORT IT programme that resulted in this publication was implemented by the National Tuberculosis Control Programme of Pakistan, through the support of the Global Fund to Fight AIDS, Tuberculosis and Malaria (The Global Fund, Geneva, Switzerland). The publication fee was covered by the Special Programme for Research and Training in Tropical Diseases at the World Health Organization (WHO/TDR).

The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

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Open Peer Review

Current Peer Review Status: ? ?

Version 1

Reviewer Report 13 August 2019

<https://doi.org/10.5256/f1000research.18810.r51672>

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Mrigendra P Singh

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Record of malaria cases was reviewed for the period of 2013-2017 retrospectively. Therefore the statement "a cross sectional study conducted between July - September" is confusing and need to be deleted.

Descriptive analysis to compare the coverage and reported suspected and confirmed malaria cases either by microscopy or by RDT was performed. No any inferential statistics was performed to analyze the relation between outcome and impact indicators. Therefore, this line should be corrected.

Authors did not mentioned the methods of surveillance for malaria screening in DHIS and MIS reporting system. As per our understanding DHIS is a passive and MIS is an active surveillance system. Patients with any ailments visited to the health facilities were reported in DHIS if they have febrile illness (Passive) and under MIS, specific field staff particularly engaged for malaria survey visited to the villages/households (door to door visit) for screening of suspected malaria cases (Active) and if it is true then analysis, discussion and conclusion should be revised accordingly. The previously published literature (Singh et al. 2016)¹ mentioned that less cases reported in passive surveillance as compared to active surveillance system.

Population coverage during the reported period is not mentioned whereas API and ABER indices are dependent with population coverage.

Table 1: Zero showed that there was no cases reported instead of no survey was conducted. It should be replaced with DASH or NA (information not available).

Table 2: A separate column for population covered in DHIS and MIS districts should be mentioned for more detail understanding.

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Is the work clearly and accurately presented and does it cite the current literature?

Partly

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?

Partly

If applicable, is the statistical analysis and its interpretation appropriate?

Partly

Are all the source data underlying the results available to ensure full reproducibility?

Partly

Are the conclusions drawn adequately supported by the results?

No

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Epidemiology, Malaria and other vector borne diseases

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Reviewer Report 12 June 2019

<https://doi.org/10.5256/f1000research.18810.r48960>

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We appreciated reading this paper by Habib and colleagues on a topic that is timely as many countries are assessing the utility of different platforms for routine malaria surveillance data and, importantly, how best to harmonise them.

Overall, the authors demonstrate that the MIS data is more reliable than the DHIS system, which

they attribute to the comprehensive data validation and quality assurance mechanisms embedded into Global Fund grants. They conclude that further research is required, but it seems clear that the MIS platform is advantageous. Rather than conducting further research, what is likely to be more useful now are developing more detailed recommendations on lessons learned from the MIS system and how this could be adopted or incorporated into national platforms once donor funding ends.

Specific areas that would benefit from additional clarification or modifications in data presentation include:

Introduction:

- “Stratifying the country into high and low burden sharing areas has further contributed to the difficulties in proper disease surveillance.” – Some explanation as to why and in what ways this has caused issues would be helpful.
- “Limited evidence has been found regarding the comparison of various malaria surveillance systems in Pakistan.” – Is this because there have not been parallel reporting systems in the country until recently and have there been similar assessments conducted in other countries?

Methods:

- This study was conducted between July and September – was there any influence of the season on the survey?
- “Fever cases with sign and symptoms of malaria area screen as suspected cases, confirmed through microscopy and rapid diagnostic test (RDT) kits.” – Is there any prior evidence of discordance or different reporting rates between the two methods in the country and how might this be accounted for in the analysis?

Results:

- Is the reason that MIS reporting coverage has gradually increased due to the fact that the MIS is targeted and this indicates that burden has increased in these districts? Some details on how Global Fund MIS-supported districts are selected should be included. For instance, what are the risk-strata used to select?
- Figure 1 - It would be helpful to include more detail to address whether there are potential structural explanations for the discordance between reporting systems. For example, are there separate forms in the districts with both systems?
- Figure 2 – The data presented here may be more clear as a bar chart indicating the proportion or percent of MIS-reporting districts out of the total
- Table 1:
 - The data in this table would benefit from being reported by risk strata or endemicity.
 - Is there are reason for the lack of MIS data in AJK and Punjab regions?
 - Zero reporting data can be represented with a dashed line instead.
- Table 2:
 - Do the reporting discrepancies differ by province/region or over time, given that the number of MIS-reporting districts gradually increases over the period of the study?
 - The methods used to calculated ABER and TPR should be detailed in the footnotes, as well.
 - There should be further details in the methods regarding how cases are confirmed.
 - Percent difference is a somewhat unclear way to present the differences, as their comparison between different metrics is not easily interpreted.

- In the Table title, “impact in donor supported districts”. It should be clarified that this study is in places with both systems. Similarly, for the text “During 2013-2017, all districts across Pakistan reported on DHIS”, it should be clarified that this is only in districts which also had the MIS system.

Discussion:

- “...there is a huge-under reporting” – “Huge” should be expressed as “significant”, with the appropriate statistical tests to justify this statement conducted.
- “This study reveals major differences in the numbers of suspected screening for malaria and confirmed malaria cases” – It would be good to clarify whether this underreporting is due to data not being entered and reported.
- “When there are parallel reporting systems with different recording and reporting tools in the same health facilities, the data quality is usually compromised as entering the data into separate platforms results in more errors.” – Some discussion by the authors about the specifics of the data forms/platforms that might result in biased reporting would be useful here.
- “The second important factor to be explored will be that of who is responsible for data entry and reporting into DHIS and MIS at the very basic level” – Similar to the comment above, details or examples of staffing differences that might lead to systemic differences in reporting would be useful for the reader here.
- “DOMC introduced RDT kits in health facilities without microscopy diagnosis facilities in the high burden districts...This may have resulted in screening of more suspects using RDT” – Can the authors clarify which year was it introduced and whether this coincides with any temporal variation between DHIS/MIS discordance?

Is the work clearly and accurately presented and does it cite the current literature?

Partly

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?

Yes

Are all the source data underlying the results available to ensure full reproducibility?

No source data required

Are the conclusions drawn adequately supported by the results?

Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Malaria epidemiology and surveillance

We confirm that we have read this submission and believe that we have an appropriate level

of expertise to confirm that it is of an acceptable scientific standard, however we have significant reservations, as outlined above.

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