

Community patient follow-up as a part of *P. vivax* case management in Cambodia: a mixed methods study

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Abstract

Background

Community health workers have been key to improvements in global health. In Cambodia, a malaria-endemic country, village malaria workers (VMWs) have helped reduce the malaria burden over the last two decades. In 2021, VMWs were tasked to support health facility workers (HFWs) in conducting follow-up of patients with *Plasmodium vivax* malaria to ensure adherence to treatment and patient safety. Implementing routine safety monitoring at the community level for malaria treatment has yet to be studied.

Methods

Mixed methods were employed with a period of analysis between January 2021 and March 2023. Qualitative data were collected from policymakers, sub-national program officials, HFWs, VMWs, and patients. Patient-specific quantitative surveillance data were gathered from nine study sites and complemented with national aggregate data. A thematic analysis of the qualitative data was conducted, and key proportions were derived from quantitative data. All data were interpreted together with an interpretivist theoretical framework of implementation, combining existing frameworks' components, such as expectation, coherence, adoption, and fidelity.

Results

Overall, 2,169 patients with *P. vivax* malaria received primaquine in 2021 and 2022, of whom 60% received follow-up visits in 2021 and 90% in 2022; more than half of these visits happened at the community level. Qualitative data indicated that the way and extent to which follow-up was implemented varied depending on the strategies VMWs adopted to ensure that the intervention was 'doable'. These strategies included calling patients to make an appointment, flexibility on which days patients were visited, and reaching patients through their families. VMWs aimed to achieve the intervention's purpose as per the guidelines, which is to enhance adherence and treatment safety. They also sought to achieve additional value attributed to the intervention, including comforting patients or conducting health education.

Conclusions

Follow-up visits were well embedded into VMW's role and responsibilities. This was supported by VMWs' understanding of the intended purpose and added value they attributed to the intervention, as well as their adaptive implementation strategies to make the intervention 'doable'. These strategies should be

integrated into policy and existing infrastructure while encouraging and resourcing problem-solving to achieve the intervention's intended purpose and added value.

Background

Community health workers are an integral component of primary healthcare, especially in resource-limited settings; they serve as a link between people and health facilities, bringing health services to the community (1). Community health workers are community members with different levels of training to provide health education or services; their origin can be traced back to China in the 1920s and the barefoot doctors of the 1950s (2). Their introduction was formally supported by the World Health Organization in the late 1970s (3), and this global commitment was re-established in 2016 (4,5). Community health programs have been critical to improving maternal and child health, as well as supporting the control and treatment of infectious diseases, such as HIV, tuberculosis, and malaria (1,2,6).

Few disease programs have incorporated follow-up visits through community health workers to improve adherence and ensure treatment safety. However, community health workers can support treatment adherence, leading to better health outcomes (6,7), and have been deployed to support treatment adherence for patients with HIV and Tuberculosis (8–12). Examples of safety assessments conducted through community workers are limited (13,14); however, they have been involved in screening programs for maternal and child health and non-communicable diseases, including COPD, cardiovascular disease, and cancer (15–18), requiring similar skills.

In the Greater Mekong Subregion, where malaria is endemic, National Malaria Control Programs have leveraged Village Malaria Workers (VMWs) and Mobile Malaria Workers (MMWs) to enhance access to malaria diagnosis, treatment, and prevention (19–21). In Cambodia, VMWs and MMWs have played a key role in reducing malaria burden (22), though this success has been more pronounced for *P. falciparum* malaria than *P. vivax* malaria (19,23).

P. vivax malaria is the second most common malaria species globally, with 80% of recurrences attributable to relapse (24,25). Relapses are unique to *P. vivax* and *P. ovale* and occur when the parasite's dormant liver stages (hypnozoites) are reactivated to cause recurrent episodes of bloodstream infection weeks or months after an initial infection. Effective treatment for *P. vivax* requires a combination of drugs to eliminate the parasite's blood stages, causing acute disease, and liver stages (radical cure). To kill hypnozoites, the 8-aminoquinoline drugs, primaquine and tafenoquine, are the only licensed drugs. Individuals with low activity of the glucose-6-phosphate-dehydrogenase enzyme (G6PD deficiency) are at increased risk of drug-induced hemolysis (26).

In Cambodia, there is a high prevalence of G6PD deficiency (~ 10–12% overall and up to 19% in males) (27–30) and a history of drug-induced haemolytic events (31). Until recently, point-of-care G6PD was not available, preventing the consistent use of primaquine, despite its inclusion in national guidelines in 2014 (31,32). In 2021, point-of-care G6PD testing at high-burden health centers was introduced, enabling the

rollout of primaquine treatment (3.5mg/kg total dose over 14 days). To ensure adherence and monitor safety by identifying signs indicative of adverse events that primarily occur in the first five days of primaquine treatment (33), VMWs were tasked to conduct patient follow-up visits 3, 7, and 14 days after treatment initiation. In 2022, Cambodia's National Treatment Guidelines for malaria were updated to include G6PD testing and follow-up (34). The 2022 revised guidelines also included a change to a shorter primaquine treatment regimen (3.5mg/kg total dose over 7 days) and a corresponding reduction of VMW follow-up visit days (days 3 and 7) (34). Implementation started in mid-2023.

To our knowledge, community health workers implementing routine safety monitoring and pharmacovigilance in the context of malaria has yet to be explored. This study assessed the implementation of VMW follow-up visits in Cambodia and explored the perceptions and experiences of policymakers, health providers, and patients on its implementation.

Methods

Study Overview

In this study, mixed methods were utilized, taking a convergence triangulation approach (35). Qualitative and quantitative data were collected at different times but covering the same period of analysis (January 2021 to March 2023). In addition to individual-level patient-specific quantitative data collected from select study sites, an analysis of national aggregate data provided by the National Center for Parasitology, Entomology and Malaria Control (CNM) was conducted. Data analysis was conducted separately for qualitative and quantitative data, and findings were interpreted together. A conceptual framework of implementation was developed to guide the data collection and analysis. Data are reported according to the GRAMMS Checklist for mixed methods studies (Appendix 1) (36).

Conceptual Framework and Definitions

The applied conceptual framework drew from several existing implementation frameworks grounded in different paradigms, including the post-positive and interpretivist paradigms (35). While post-positivism assumes the existence of an objective reality, the interpretivist paradigm postulates that there are multiple truths dependent on actors. Combining frameworks from both paradigms allowed for a more complete picture of the implementation and the factors that affect it. The framework relied mostly on elements from Proctor *et al.*'s 'implementation outcomes:' appropriateness, adoption, fidelity, feasibility, implementation cost, acceptability, and sustainability (37). These were complemented by components of Greenhalgh and Russel's framework (expectation) (38), and normalization process theory (coherence) (39) (Table 1). The data was analyzed with an interpretivist lens. Qualitative data exploring these components of implementation were triangulated with quantitative data informing the adoption and fidelity components.

Table 1
Applied Analytical Framework of Implementation

Framework Component	Original Framework	Applied Definition in this Study	Revised Definition after Analysis in this Study
Expectation	Greenhalgh and Russel	What different actors expect to achieve from the intervention	Same as applied.
Coherence	Normalization Process Theory	How policymakers, health service providers, and service recipients understand and make sense of the intervention and its use	How policymakers, health service providers, and service recipients understand and make sense of the intervention, its use, and its procedures.
Appropriateness	Proctor <i>et al.</i>	Whether the intervention is seen as suitable for the context in which it is implemented	Same as applied.
Adoption	Proctor <i>et al.</i>	Whether the intervention is part of health service provider's routine practice	Whether the intervention is part of health service provider's routine practice and how it becomes so.
Fidelity	Proctor <i>et al.</i>	How the practices of health service providers and, in certain instances, service recipients compare to guidelines they are supposed to implement or expectations of them when it comes to patients	Describes how the intervention is made to work, referring not only to the intended purpose but also to additional values that actors identify
Feasibility	Proctor <i>et al.</i>	If an intervention can be implemented in a particular setting based on factors at the policy-making level as well as relating to health service providers and service recipients	If an intervention can be implemented in a particular setting based on factors at the policy-making level as well as relating to health service providers and service recipients. Feasibility includes an interventions' 'doability.'
Doability	Fujimura <i>et al.</i>	Alignment of values, interests, constraints, and practices of individuals and organizations in different spaces and whether the intervention employs the right tool for the job.	Alignment of values, interests, constraints, and practices of individuals and organizations in different spaces and whether the intervention employs the right tool for the job. It is informed by the varied jobs that it achieves and the adaptive strategies and tools that actors employ.
Implementation Cost	Proctor <i>et al.</i>	Costs associated with implementing the intervention or for service	Same as applied.

Framework Component	Original Framework	Applied Definition in this Study	Revised Definition after Analysis in this Study
		recipients, the cost of receiving the services	
Acceptability	Proctor <i>et al.</i>	Whether the intervention is welcomed and desired by study participants	Same as applied.
Sustainability	Proctor <i>et al.</i>	Whether the intervention can be consistently implemented over a long period of time	Same as applied.

Policy Context

At the time of the study, low dose (3.5mg/kg total dose) primaquine was administered over 14 days with follow-up by VMWs on days 3, 7, and 14 after treatment initiation. According to job aids (Appendix 2), in-person patient visits entail VMWs traveling to patients' houses in person and reporting back using the malaria information system (MIS) application on their program-provided mobile phone. The visit includes checking treatment adherence using the patient's follow-up card and pill count, the recording of symptoms or side effects, and a real-time urine check. Patients are expected to fill out their follow-up cards and monitor their symptoms (Appendix 3).

Study Setting and Sites

The study was conducted in three high-burden provinces, two in the western part of Cambodia and one in the East. The study sites were spread across eight districts. During the study period, the three provinces had the highest malaria burden, with transmission happening year-round but peaking during the height of the rainy season between June and September. Study sites comprised rural, forest, or forest-fringe areas, semi-urban, and urban localities (Fig. 1), with most malaria cases occurring in forest or forest-fringe areas.

There were 12 study sites; quantitative data was collected from nine sites, and qualitative data was collected from eight sites (Table 2). Qualitative and quantitative data were collected from five sites. Available national aggregate data relevant to the implementation of VMW follow-up were included in this study.

Table 2
Summary of study sites and methodology and methods employed at each site

Province	District	Health Facility	Data Collection Type(s)	Methods	Participant Type
Pursat	Kravanh	Health Center 1	Qualitative	FGD	Health center workers, VMWs
			Quantitative	Surveillance data	
Pursat	Kravanh	Referral Hospital 1	Qualitative	Interviews, FGDs,	Clinical trial study staff, referral hospital doctors and nurses
Pursat	Kravanh	Health Center 2	Qualitative	FGD	VMWs
			Quantitative	Surveillance data	-
Pursat	Veal Vieng	Health Center 3	Qualitative	Interviews, FGDs	Health center workers, VMWs, and patients
			Quantitative	Surveillance data	-
Pursat	Krokor	Health Center 4	Qualitative	Interviews, FGDs, observations	Health center workers, VMWs, and patients
			Quantitative	Surveillance data	-
Pursat	Krokor	Health Center 5	Quantitative	Surveillance data	-
Pursat	Krokor	Referral Hospital 2	Qualitative	Interviews and FGDs	District officials and referral hospital workers
Kampong Speu	Phnom Srouch	Health Center 6	Qualitative	Interviews and FGDs	Health center workers, VMWs, patients
Kampong Speu	Phnom Srouch	Referral Hospital 3	Qualitative	Interviews and FGDs	District officials and referral hospital workers
Stueng Traeng	Siem Pang	Health Center 7	Qualitative	Interviews and FGDs	Clinical trial study staff
			Quantitative	Surveillance data	-
Stueng Traeng	Steung Traeng	Health Center 8	Quantitative	Surveillance data	-

Province	District	Health Facility	Data Collection Type(s)	Methods	Participant Type
Stueng Traeng	Sesan	Health Center 9	Quantitative	Surveillance data	-
Stueng Traeng	Siem Bouk	Health Center 10	Quantitative	Surveillance data	-

Qualitative Methods

Study Participants and Sampling

Interviews, focus group discussions (FGDs), and observations were conducted with vivax malaria patients, patient caregivers/spouses, community malaria workers (VMWs and MMWs-*chw*), health facility workers (referral hospital-*rh* and health center workers-*hc*), district (*do*) and provincial (*po*) malaria program officers and officials, policymakers (*cnm*), and implementation partners (*cnmp*) (Table 2). Sampling for patients was convenient based on health center records from the previous month and through peer referral by health facility workers and VMWs. When preferred and feasible, interviews were conducted with the patient and their spouse. VMWs, MMWs and health facility workers were selected through purposive and convenient sampling. Observations of VMW follow-up visits were coordinated with the support of health facility workers. Observation notes documented coordination efforts, travel to patients' houses, and the visit itself. Written informed consent was obtained from all participants for all activities and included consent for photographs taken during the follow-up visit.

Data Collection

Interviews and FGDs were conducted using discussion guides based on the conceptual framework (Appendix 4). Discussion guides were developed in English and translated to Khmer. The guides were discussed among the study team (SCS,KC,PC) to ensure clarity and refined after a pilot round. Interviews with policymakers were conducted in English over Zoom (SCS), except for one in person and in Khmer (KC). All other interviews and FGDs were conducted in Khmer and in person (KC,PC). Interviews and FGDs were audio-recorded. English recordings were transcribed, and Khmer recordings were sent for transcription and translation. After each interview or FGD, the themes relevant for subsequent interviews were discussed among the study team who facilitated the data collection.

Observations were non-participant and conducted overtly by two study team members (SCS,KC), one of whom was local (KC). Prior to the start of the formal visit, the study team had informal conversations with the VMWs and patients to put the participants at ease. Observation notes were recorded on paper using a note-taking grid with predefined themes to aid in guiding the observations. Photographs during the visit were also taken to supplement notetaking.

Data Analysis

Transcripts were reviewed for clarity and meaning and then re-read, upon which initial inductive codes were generated (SCS). A codebook was then developed, combining inductive codes with deductive ones stemming from the conceptual framework. Data was imported into NVivo 12 for coding (SCS). Coding excerpts based on query runs were exported from NVivo; themes were identified in a memo-writing process. Coalesced digital observation notes from each observer were reviewed, and findings from observations were synthesized with findings from the interviews and FGDs in the memo-writing process. Data are reported according to the COREQ checklist where appropriate (Appendix 5) (41).

Quantitative Methods

Data Collection

Patient-specific data pertaining to VMW follow-up from national surveillance forms were collected from nine study sites in two provinces (Pursat and Steung Traeng) between March and May 2023.

Information pertaining to patients presenting for care and diagnosed with vivax malaria between January 2021 and March 2023 were collected from routine health center forms, including outpatient logbooks and health center vivax-specific logbooks, and from routine VMW/MMW forms, such as their malaria logbook and their VMW follow-up forms. Supporting data collection and management, REDCap forms were developed based on combined paper forms. Data from these logbooks were entered into a REDCap database hosted at Menzies School of Health Research, Darwin, Australia (42,43).

Aggregate data was obtained from CNM and consisted of 2021 and 2022 monthly reported surveillance data by health center. Data included information on how many vivax cases were followed up on days 3, 7, and 14 by the health center or VMWs.

Written informed consent from patients for quantitative surveillance data was not obtained, given that the use of routine data was approved by respective ethics committees without the need for further individual consent.

Data analysis

The following proportions were calculated: (1) the proportion of vivax patients who received radical cure and were followed up by VMWs on all three days of follow-up (aggregate data); (2) the proportion of vivax patients who received radical cure and were followed up by health center workers on all three days of follow-up (aggregate); (3) the proportion of vivax patients who received radical cure and were followed up by VMWs or health center workers stratified by day (aggregate and patient-specific data); (4) the proportion of follow-up that was completed in person (patient-specific data), and the proportion of follow-up that was done by phone call (patient-specific data).

Ethics

Ethical approval for this study was obtained from the Cambodian National Ethics Board (# 118), the Institutional Review Board of the Menzies School of Health Research (HREC 2020–3694), the Charles Darwin University Human Research Ethics Committee (H22047), and the Oxford Tropical Research Ethics Committee (Ref. 39 – 20).

Results

Qualitative data, collected through 67 interviews, 19 focus group discussions, and two observations, included 142 participants (Appendix 6). Routine surveillance quantitative data consisted of aggregate data from 2,169 patients and patient-specific data from 244 patients. Findings are presented according to the implementation framework components: expectation, coherence, appropriateness, adoption and fidelity, feasibility, cost, acceptability, and sustainability.

Expectation

Qualitative data indicate that policymakers, subnational malaria program officers, health facility workers, and VMWs expect that VMW follow-up improves adherence to treatment (*pp24,25,26,30,34,ps1,fgd1-chw,chw7,9,14,15,21,25–27,29,30,32,35–38,etd2,po1-3,cnmp1-3,hc1-3,5–7,cmn3,fgd7-rh-do*) and improves safety (*pp25,26,34,fgd1,3-chw,chw7-9,11–14,27,33,38,47–49,hc1-5,7,8,fgd7-rh-do,etd2,etl3,po2-4,cnm1,3,cnmp1,3*). VMWs and one health center worker expressed additional expectations, such as ensuring patients do not relapse, recur, and are cured from vivax malaria through improving treatment effectiveness (*chw7,11,14,26,35,38,hc6*). According to VMWs, treatment effectiveness is achieved by checking whether patients were taking their treatment at the right time (*chw9,14,36,38,po2*), required additional pills (*chw7*), and stored them appropriately (*fgd1-chw,chw35*). One VMW went further to suggest he expected VMW follow-up to support malaria elimination.

“Based on the plan [malaria elimination framework], we want to eliminate malaria by 2025. So, we need to work very hard on this” – chw35

Quantitative data from VMW follow-up forms suggests that 97.5% (238/244) of patients adhered to the schizontocidal treatment, 95.9% (234/244) adhered to their first three days of primaquine, 93.8% (225/240) adhered on the four consecutive days, and 94.5% (223/236) adhered during the second week of treatment (Fig. 2). High treatment adherence through patient follow-up is in line with stakeholders' expectations.

Coherence

The way healthcare providers understand the need for VMW follow-up is rooted in fear that patients might not take the medicine or that patients might experience side effects (*pp30,34,fgd1-chw,chw15,21,29,30,32,33,35,36,37,hc2-4,7,fgd7-rh-do,po2,4,cnm1,cnmp2*). A health center worker described the rationale for VMW follow-up being patients experiencing dangerous side effects.

“[...] he [the patient] does not know how to monitor himself, so we ask the VMWs to follow-up because we are worried, he will have these dangerous side effects” – hc4.

Other reasons that emerged from VMW FGDs were the notions that patient follow-up also provides an opportunity for patient counseling around malaria prevention (*chw28,32*) and comfort to patients (*chw29,32*).

“First, we are afraid they give up the treatment and stop taking medicine. Second, we want to make them feel comfortable and close. Lastly, when we follow up, we educate them about malaria.” – chw32

Patients also experience VMW follow-up as being about VMWs’ fears that patients might not adhere to treatment or experience serious side effects (*pp24,25,26,27,30,31,34*).

“Yes, he came to ask me if I had a fever; he was afraid I would not take the medicine, and he was afraid I would throw the medicine away when I had side effects, so he came to follow up with us” – pp26

Overall, patients described engagement in their follow-up process and understood what they needed to do for their own follow-up (*pp17,20,24,26,28–31,33–35,ps1,chw14,23*). Yet, this understanding did not always translate to adhering to the guidelines (*pp25,24,ps1*).

The interviews with policymakers, sub-national program officers, and partners revealed varied understandings of what activities are part of VMW follow-up—differing from treatment guidelines and impacting perceptions of VMW follow-up success. Some policymakers and subnational program officials expected VMWs to conduct direct observation treatment (DOT) as opposed to ensuring adherence through checking pill counts and patient follow-up cards (*po1,2,cnm3,cnmp3*). Despite real-time urine checks being a part of the policy, there were different expectations as to whether VMWs should conduct a urine check or simply ask patients about their urine color. One policymaker did not think it was feasible or appropriate to ask VMWs to do a real-time urine check (*cnm3*). Lastly, though the guidelines explicitly recommend in-person follow-up, all stakeholders expected that follow-up through phone calls would occur on occasion. Follow-up by phone is an option on VMW follow-up forms, while national aggregate data does not differentiate between in-person or phone follow-up.

Appropriateness

Overall, participants in the qualitative study component thought follow-up by VMWs was appropriate for the malaria program to best reach patients; however, some health facility workers perceived patient follow-up as part of their own responsibilities in line with their original role before this task was shifted to VMWs.

Several key factors, identified across respondent types, influence the perceived appropriateness of VMWs conducting follow-up. These included VMWs’ proximity to patients (*pp18,29,31,chw12,hc3,6,8,10,11,rh3,etl3,etd2,po4,cnmp3,cnm2,3*), the relationship of VMWs with their communities (*hc8,rh2,3,etl1,po4,cnmp2*), health centers receiving accurate and timely information from

patients through VMWs (*hc5,rh2,do1,cnmp2*), health center workload precluding health center workers from conducting those visits (*chw14,hc5,7,etd2,3,do1,po4*), and VMW tasks being in line with their knowledge-level (*hc12,rh3,fgd7-rh-do,etd2,do1,po4*). For some respondents, because of these factors, there was no better option than VMWs conducting follow-up (*po4,cnm2,cnmp2*). A policymaker stated that,

"I think that's the way that the follow-up should be, by VMW. It cannot be done by the health center because the people are in the village. VMWs are very near, so they can easily follow up. For the health center, it is not easy to come across to the village and to follow up patients."— *cmn2*

While many respondents perceived the follow-up of patients in line with VMWs knowledge and capabilities (*hc12,rh3,fgd7-rh-do,etd2,do1,po4*), there were some who thought that it would be more appropriate for health facility workers or even the district program officers to conduct follow-up visits (*hc3,etd2,do5*). A health center worker indicated that it would be better for health centers to do the follow-up *"because the HC staff are the nurses, so they can explain or talk better than the VMW"* but acknowledged the difficulties in health center workers reaching patients (*hc3*). A referral hospital doctor preferred follow-up by health facility workers but explained that staffing limitations did not allow for this (*etd2*).

Adoption and Fidelity

Quantitative national aggregate data indicate that VMW follow-up improved between 2021 and 2022 and by 2022 was well adopted. In 2021, 38.5% (348/903) of patients were reportedly followed up by either the health center or VMWs on day 3, 37.3% (337/903) on day 7, and 34.8% (314/903) on day 14. In 2022, 91.1% (1153/1266) of patients reportedly were followed up either by the health center or VMWs on day 3, 86.8% (1099/1266) on day 7, and 76.1% (962/1266) on day 14. (Table 3).

Table 3
Cambodia national aggregate data on *P. vivax* follow-up from 2021 and 2022

Year	Vivax cases who received PQ	Follow-up Type	Vivax cases who received primaquine and were followed up by months ends		
			Day 3	Day 7	Day 14
			Total	Total	Total
2021	903	Total	348 (38.5%)	337 (37.3%)	314 (34.8%)
	-	VMW	240 (69.0%)	235 (69.7%)	219 (69.7%)
	-	HC	108 (31.0%)	102 (30.3%)	95 (30.3%)
2022	1266	Total	1153 (91.1%)	1099 (86.8%)	962 (76.1%)
	-	VMW	706 (61.2%)	679 (61.9%)	583 (60.6%)
	-	HC	447 (38.8%)	420 (38.2%)	379 (39.4%)

In line with national aggregate data, data from VMW follow-up forms (from 244 patients) from 9 health center catchment areas between 2021 and March 2023 indicate that once VMW follow-up started on day 3, VMWs mostly followed up on days 7 and 14 as well. There was 98.4% (240/244) completion on day 7 and 96.7% (236/244) completion on day 14.

Quantitative and qualitative data suggest that follow-up has been well adopted (*chw17-19,27-29,31,33,hc2,7,cmn1,2,cnmp2*), as one health center worker *"notice[d] that VMW always follows up"* (*hc7*). However, our qualitative findings also show that, there is a large heterogeneity in how and the extent to which VMW follow-up is adopted.

For example, VMWs described instances of an increased number of visits to patients' homes (*pp20,chw8,11,13,27,39,46,47*), including DOT and daily visits (*chw8,13*).

"[...] However, for me I never wait until day 3 to follow up with patients, I follow up with them from day 1 to day 3." – *chw46*

This was echoed by patients (*pp4,20,21,24-29,31-33,35*), though some patients reported that VMW follow-up was not conducted (*pp12,22,28*) or conducted just once (*pp34*). One VMW noted that they no longer had the responsibility to conduct follow-up after their payments were terminated (*chw16*), while other VMWs noted that follow-up was not expected for mobile-migrant populations (*chw25,po2*).

"For me, I mostly meet only the patients who live far away from here, so they will go back to their homes after treatment. Some patients go back to their commune and go to the health center there, so I don't need to follow up. [...]"—*chw25*.

Our interviews, FGDs, and observations also indicate that VMWs do not necessarily conduct the visits on the pre-specified days (days 3, 7, and 14) but might choose other days (*pp26,chw22,26,31,hc5*). This is a result of workload, competing priorities (*pp23,chw22,26,31,32,hc5-8,fgd7-rh-do*), and forgetting (*chw15-17,22,32,hc5*). There is a degree of informality that comes from patients living near VMWs and their proximity to each other as members of the same community or even friends or family members (*pp20,29,31*). Our observation suggests that VMWs tended to conduct follow-up when it was most convenient for them. Two patients described their interactions with VMWs during follow-up, highlighting their relationship.

"We met each other every day, we work together, and we sit together." –*pp31*

"She came to see me several times, and we occasionally drank coffee together." -*pp20*

VMWs understand that follow-up should be in person, but there are times and circumstances when follow-up by VMWs occurs through phone calls (*pp34,chw14,29,32,33,37,38,cnm2*). According to the disaggregated study site-specific quantitative data, 68.9% (496/720) of VMW visits were conducted in person compared to 19.2% (138/720) by phone across follow-up days (Table 4).

Table 4
Study site-specific disaggregated data for VMW follow-up type

VWM follow-up	Total	In-person	Phone Call	No information
Completed Day 3 Follow-Up	244	186	45	13
Completed Day 7 Follow-Up	240	160	48	32
Completed Day 14 Follow-Up	236	150	45	41
Total follow-up visits	720	496	138	86

During the follow-up visit, VMWs are expected to follow procedures outlined in their job aids (Appendix 2), including checking patients' remaining pills and follow-up cards (Appendix 3) and conducting symptom assessment and a real-time urine check using a Hillman color chart. VMWs reported reminding patients to take the treatment at the right time (*chw14,36,42*), asking patients about experienced side effects (*chw14,29,36*), checking adherence through pill counts (*chw8,10,20,36,42*) and patients' follow-up cards (*chw8,10,36*), conducting real-time urine examinations to check for any signs of hemolysis (*chw10,14,28,29,32*), and watching patients take that day's dose of treatment (*chw8,14*). Some VMWs, however, had never seen the Hillman color chart used for real-time urine checks and clarified that they only ask patients about their urine color (*chw15-19*).

Interviews with patients and observation of follow-up visits revealed that follow-up mainly consisted of VMWs asking patients about side effects (*pp29,31*) and how they feel (*pp24-27,33-35*), as well as asking (*pp24,26,27,34*) and checking (*pp29,35*) patient treatment adherence (Fig. 3). With the exception of one patient (*pp29*), real-time urine checks by VMWs were not reported nor observed. Patients also did not report VMWs recording or writing anything during the visit.

Feasibility

While quantitative data suggests that adoption of VMW follow-up is high, the qualitative findings identify a range of different strategies VMWs use to overcome challenges, adapting the policy to local contexts. Among the challenges are distance (*pp23,chw3,7,9,31,47,hc4,9,cmn2,cnmp3*), the price of gasoline (*pp23,hc6*), difficult road conditions and flooding (*pp24,chw8,29,31,36,hc8*), and VMWs' workload and competing priorities (*pp23,chw22,26,31,32,fgd7-rh-do,hc5-8*), including other tasks (*chw22,26,31*) and their main work (*chw32,hc5-7,fgd7-rg-do*).

"Sometimes, I forget because I have a lot of work to do. And we have to go to the forest, so it takes time to go and come back so sometimes, when we come back from the forest, it is late for the follow-up that we have to follow-up them in the village." – *chw22*

Additionally, patients are often not home for follow-up visits as most patients return to their worksites as soon as they feel better (*chw7,9,16-18,hc2-5,8,9,et7,do1,po2,4,cnm1,2,cnmp1,2,3*).

Among the strategies VMWs implement to reach patients are community engagement (*pp30,hc6*), getting support from a backup VMW (*chw24,26,27,fgd7-rh-do,po4,cnmp2*), and phone calls to schedule in-person follow-up (*chw2,9,10,12–14,29–32,38,hc2,4,12,do5,cnm1,cnmp3*).

Alternative locations were used when patients could not be reached at home; some VMWs went to patients' worksites or farms (*chw38*) or met early before leaving for work (*chw22,2631,hc5*). However, at the same time, VMWs also employ fear as a motivator for patients to adhere to their request to be at home at the scheduled visit times (*chw8,24,25,38,hc4,6,po4*).

"I told them about the process of complete treatment face to face. So, they are afraid. They will wait for us on that day." – *chw8*

Another strategy VMWs use to reach patients when in-person follow-up is not possible is phone calls (*hc3,cnm2*). A health center worker highlighted the use of phone calls in their description of VMWs implementing follow-up, while acknowledging difficulties with phone service.

Interviewer: So, what do they do when they meet these kinds of challenges?

Respondent KII31C: If the patients go to the forest, and they still contact them by phone, they will call the patients by phone too, but if they cannot get through to them by phone, they cannot do anything else because in some parts of the forest, there is no service at all, even their family member cannot contact them.

As a result of the difficulties in reaching patients, VMWs often rely on family members to connect to patients and make the follow-up process feasible (*pp25,chw7,32,etd2,po4,cnmp1,2*). In cases where VMWs cannot reach patients, family members relay information to patients.

Cost

The intervention incurs costs for all involved stakeholders. Patients are expected to stay home during the 14-day follow-up period. Therefore, there is a significant opportunity cost for patients that is not compensated (*pp26,33,35,hc9*).

He [patient] called us and told us [health center worker], 'Teacher, I want to go to the forest because I did not have any side effects after taking the medicine,' and we told him that we could not let him go yet, so he has to wait until he is finished taking the medicine for 14 days." – *hc9*

VMWs incur costs for each follow-up visit. Compensation through CNM, which is supported by implementation partners (*fgd3-chw, chw14,20,22,23,25,hc5,9,12,do1,po1,2,4,cnmp1,2, cnm2*), does not cover additional costs for transport to remote homes, for more than the scheduled three visits or for multiple trips if the patient is not at home (*pp23,chw14,cnmp2,hc12*).

Acceptability

Respondents, including patients, healthcare providers, and policymakers, were largely positive towards the policy of VMWs conducting follow-up visits.

From a patient perspective, respondents had a clear appreciation for VMWs coming to check on them (*pp9,32,23–25,26,29,ps1*), which was also acknowledged by VMWs and health providers (*chw8,11,rh8,9,etl4*). One patient noted that having VMWs visit them was useful because “*we can be healed.*” One patient and his wife expressed their excitement with VMWs coming to check on them:

“pp25: It’s good that anyone came to visit us. [...]”

ps1: It’s good to have someone come to ask us if we are better because no one has ever come to ask us like that, and we are usually excited when he comes to ask if we are better.”

Some VMWs expressed that the workload was challenging (*fgd3-chw,chw26*), while others described being worried about potential side effects in patients while conducting follow-up. Nonetheless, this anxiousness about side effects did improve with time and experience.

For the majority of VMWs, these concerns are balanced by their sense of responsibility and duty of care toward serving their communities. This commitment fosters an environment in which VMWs like serving their communities while also alleviating some fears of side effects by checking on patients (*chw8,11,13,14,26,35,47*). Conveying their dedication to their work, one VMW described it as “[...], *we want to be the arms and the legs of the government to help our Ministry of Health to keep people healthy in our villages [...]*” (*chw11*).

Sustainability

The sustainability of the strategy of VMW follow-up depends on funding to compensate VMWs, but more importantly, on the existence of VMWs.

Funding is partially dependent on financial support from partner organizations. A malaria official expressed concern over the long-term sustainability of VMWs and the precarity of funding for their work, stating, “[...] *We think that he helps us a lot, and in the future, we also want him to continue to help with this work, but we do not know what we can do to help him continue because we cannot afford to support him; this is important [...]*” (*po1*).

Though policymakers and program officials value VMWs and see them as essential in the context of malaria elimination (*hc7,po1,4,cmn2,cnmp3*), they are being phased out in low-burden areas (*chw16,hc2,3,8,9,do1,cnm1,2,cnmp1,2*) and instead integrated as part of village health support groups (VHSG) (*chw9,11,35–38,47,48,hc7,9,do1,po1,4,cnm1,2,cnmp1,3*). VHSGs are meant to provide health education and prevention to communities. However, the integration of VMWs’ and VHSGs’ roles and responsibilities is not clear for some respondents, including policymakers (*chw9,11,47,48,35–38,cmn2*).

A policymaker described this integration as ongoing and not yet finalized but crucial to ensure the sustainability of follow-up visits.

“That integration we also do rather than monthly meeting, we do quarterly meeting because we save some money because not very urgent to meet every month because no malaria not really problem, but we keep them as our own system when they have some something to do like follow-up. – cnm2

Discussion

Our study explored an intervention that relies on community health workers following up patients with *P. vivax* malaria treated with primaquine to ensure adherence and safety. Our findings show that the policy of patient follow-up through VMWs was well accepted by VMWs and patients. Despite a lack of clarity in the guidelines and different expectations about the operationalization of the intervention, follow-up was well embedded into VMWs’ roles and responsibilities. How and to what extent VMW follow-up was implemented varied, as VMWs overcame feasibility challenges by implementing adaptive strategies to achieve the intended purpose, as well as the value they attributed to the intervention. These strategies included calling ahead to schedule an appointment, conducting follow-up visits on days other than those stipulated, relying on phone calls or family members, and engaging patients to feel responsible for those visits.

The implementation of an intervention can be hindered by vague or unclear policy, which may result from a lack of official written guidelines (44,45). Patient follow-up by VMWs in Cambodia was not included in the treatment guidelines until 2022 (34). Between February 2021, when G6PD testing-enabled radical cure was rolled out, and May 2023, when the new guidelines were implemented, the only guidance on the interventions was job aids. In the absence of formal guidelines, there was diverging understanding between policymakers and VMWs as to what the intervention included and how it should be operationalized.

A lack of clarity in the guidelines and different understandings of what should be implemented could negatively impact implementation (44). When the purpose, the need, and the value of an intervention are not effectively communicated to patients and healthcare providers alike, acceptability and adoption can be undermined. Such was the case in the implementation of COPD screenings by community health workers in Uganda, where patients did not understand the utility of the screening process, resulting in limited adoption (15). Our findings show that, despite the absence of formal guidance, VMWs accepted and embraced patient follow-up visits because they were aware of the intended purpose and attributed added value to the intervention (e.g. achieving malaria elimination, an opportunity for counseling, and providing comfort). Making follow-up visits part of VMWs’ responsibilities was also facilitated by VMWs’ commitment to their communities. Commitment to community wellbeing and positive contribution to the community have been found to motivate community health workers to adopt interventions in other contexts (46–48).

Our study findings also have implications for theoretical implementation frameworks. In the absence of clear guidelines or policy, what do terms such as adoption and fidelity that are part of acceptability and feasibility frameworks refer to? Is it adoption of the intervention as stipulated in the policy, fidelity to the desired outcomes of the policy, or to what is 'doable' in a specific environment? Science and Technology Studies (STS) stipulate that whether an intervention is 'the right tool for the job' and embedded into practice is dependent on stakeholders and institutions with their own interests, values, constraints, and practices (49). Doability, as introduced by Fujimura *et al.* and built on by other STS scholars, is constituted by the alignment of these elements in different spaces and whether the intervention employs the right tool for the job (50–53). VMWs are expected to implement patient follow-up through in-person visits, which is deemed the right tool to ensure the job of patient adherence and safety. However, follow-up also has additional attributed value for other stakeholders and achieves different jobs, namely making sure patients feel taken care of and an opportunity to provide health education. Different tools—that are adapted to the practical constraints—including going to patients' worksites, calling patients several times between visits, and visiting on days when patients are available, are employed to achieve these jobs. The doability of VMW follow-up is informed by the varied jobs that it achieves and the adaptive strategies and tools that actors employ.

Our study results show that feasibility considerations and what is doable for VMWs to achieve the different jobs alter the definitions of adoption and fidelity (Table 1). Both quantitative and qualitative analyses showed high adoption of the intervention. However, the intervention was implemented in multiple different ways. Adoption is, therefore, not only whether the intervention is part of routine practice (37) but should be conceptualized more broadly as how it becomes a part of routine practice. Similarly, a broadened understanding of fidelity further identifies how the intervention is made to work, referring not only to the intended purpose but also to additional values that stakeholders identify or that the intervention generates for different actors. Exploring the implementation, adoption and fidelity, of VMW follow-up in this way, is describing the adaptation of strategies that make the intervention doable to achieve the intended purpose and value attributed to VMW follow-up.

As a result, making an intervention doable, a component of feasibility, requires i) being able to work out solutions in real-time, ii) situating an intervention in a particular context, and iii) determining whether these adaptive strategies ensure the intended purpose and added value. STS work on standardization introduced the concept of situating guidelines, suggesting that standardization and situating are not mutually exclusive and that policy is a starting point and not an inflexible set of rules (54). Additionally, when making guidelines work in practice, there are core (required) aspects of guidelines that should not be changed, in contrast to other aspects of the guidelines that could be adapted given local context if they are achieving the same intended purpose (55). In our study, the job aids were the starting point, but the reality of implementation on the ground and shared understanding of these realities among stakeholders altered these sets of rules, as well as the expectations of what job they were to achieve (55).

Delineating required (core) and optional (flexible) guidelines could be a mechanism to embed some of the strategies employed by VMWs by making them optional elements in the policy documents. This would validate decisions made by VMWs and optimize implementation by providing potential additional strategies to all VMWs (e.g. calling to make an appointment, visiting prior to patients leaving, and visiting patients at work sites). This requires the provision of relevant resources to implement these adaptive strategies (e.g. compensation for phone calls and multiple visits to one patient's house to complete one visit and empower and equip patient family members). Routine data collection tools would also require more flexibility to accommodate these alternative strategies (e.g. allowing data entry on days other than 3, 7, and 14).

While stakeholders are overall satisfied with the implementation of VMW follow-up, the sustainability of the intervention is likely challenging, particularly due to required funding and decreasing malaria burden, which has resulted in the phasing out of VMWs in low-burden areas and their transition to the Village Health Support Group (VHSG). Though this transition has commenced, it has not been finalized with delineated roles and responsibilities. VHSG's responsibilities have been piloted to include the provision of services for other diseases (56,57), including Dengue, Chikungunya, and non-communicable diseases. Financing of this integration remains unclear (57). Other countries in Southeast Asia, such as Myanmar, have shown VMWs could be sustainably integrated into a horizontal health service provision structure (58) and maintain malaria service provision (59).

Our study has several limitations. Firstly, for the adoption and fidelity analyses, the study team expected to derive additional measures of adoption, fidelity, and effectiveness from disaggregated data from VMW follow-up forms and health center vivax case registries. These included the proportions of follow-up completion by follow-up type (VMW vs health center) and the difference in the rate of recurrences between those who were followed up and those who were not. However, not all VMW follow-up forms were available, and health center vivax case registries were often incomplete. Furthermore, both forms do not report follow-up completion status, often only filling in the questions about follow-up if it was completed. CNM collecting follow-up data that allows to determine the effectiveness of VMW follow-up could be used to inform policy development and adaptation. Secondly, aggregate data from the Excel tracker sheet could not be validated with data from the parallel MIS system. Thirdly, a full cost-analysis was beyond the scope of this study; therefore, the cost section only includes costs that were mentioned in the interviews and FGDs.

Limitations of the qualitative component of the study include limited observations of VMW follow-up that were restricted to one study site and did not allow observational data saturation to be achieved. Lastly, patients interviewed about their follow-up experiences may have been impacted by recall bias.

Conclusion

Patient follow-up by VMWs as part of the case management of *P. vivax* malaria has been implemented in Cambodia. Despite a lack of clear guidance, varied expectations of the intervention, and challenges for

VMWs to reach patients, follow-up was well embedded into VMW's role and responsibilities. This was supported by VMWs' understanding of the intended purpose and added value they attributed to the intervention, as well as their adaptive implementation strategies to make the intervention 'doable'. The ways in which the intervention was made feasible should be integrated into policy and existing infrastructure while encouraging and resourcing problem-solving to achieve the intervention's intended purpose and added value.

Abbreviations

CNM: Center of National Center for Parasitology, Entomology and Malaria Control

COPD: Chronic Obstructive Pulmonary Disease

DOT: Directly Observed Treatment

FGD: Focus Group Discussion

G6PD: Glucose-6-Phosphate Dehydrogenase

HFW: Health Facility Worker

HIV: Human Immunodeficiency Virus

HC: Health Center

MIS: Malaria Information System

MMW: Mobile Malaria Worker

VMWs: Village Malaria Workers

Declarations

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Consent for publication

As part of the consent process for observation, all participants provided informed written consent for the use of individual pictures in dissemination materials and publication. This includes pictures shown in Figure 3.

Availability of data and materials

Raw qualitative data, i.e. transcripts and observation notes, and quantitative data are not available due to identifying patient information. All relevant de-identified qualitative and quantitative data are presented in the manuscript. Data are available upon reasonable request via email at ethics@menzies.edu.au.

Competing interests

No competing interests to declare.

Authors Contribution

SCS, KT, and DL contributed to the study conceptualization. SCS and KC conducted data curation. SCS, KC, NE, KT, and AM were involved in the formal analysis. KT was responsible for the funding acquisition. SCS, KC, and PC conducted the investigation. SCS, KT, and NE developed the methodology. SCS, KC, KT, BA, and RT were involved in project administration. KT, RT, BA, DL, and LvS provided the resources. NE, KT, RP, BL, AM, BA, LvS, and MSH were involved in supervision. KT and NE contributed to validation. SCS, BL, KT, and NE were responsible for visualization. SCS wrote the original draft. All authors reviewed and edited the manuscript.

Ethics declarations

The study adhered to the guidelines of the Declaration of Helsinki. Ethical approval for this study was obtained from the Cambodian National Ethics Board (# 118), the Institutional Review Board of the Menzies School of Health Research (HREC 2020-3694), the Charles Darwin University Human Research Ethics Committee (H22047), and the Oxford Tropical Research Ethics Committee (Ref. 39-20). Written

informed consent was obtained from all participants in interviews, focus group discussions, and observations. Approval to use quantitative surveillance data was obtained from the National Ethics Board. Written informed consent from patients for quantitative surveillance data was not obtained, given that the use of routine data was approved by respective ethics committees without the need for further individual consent.

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Figures

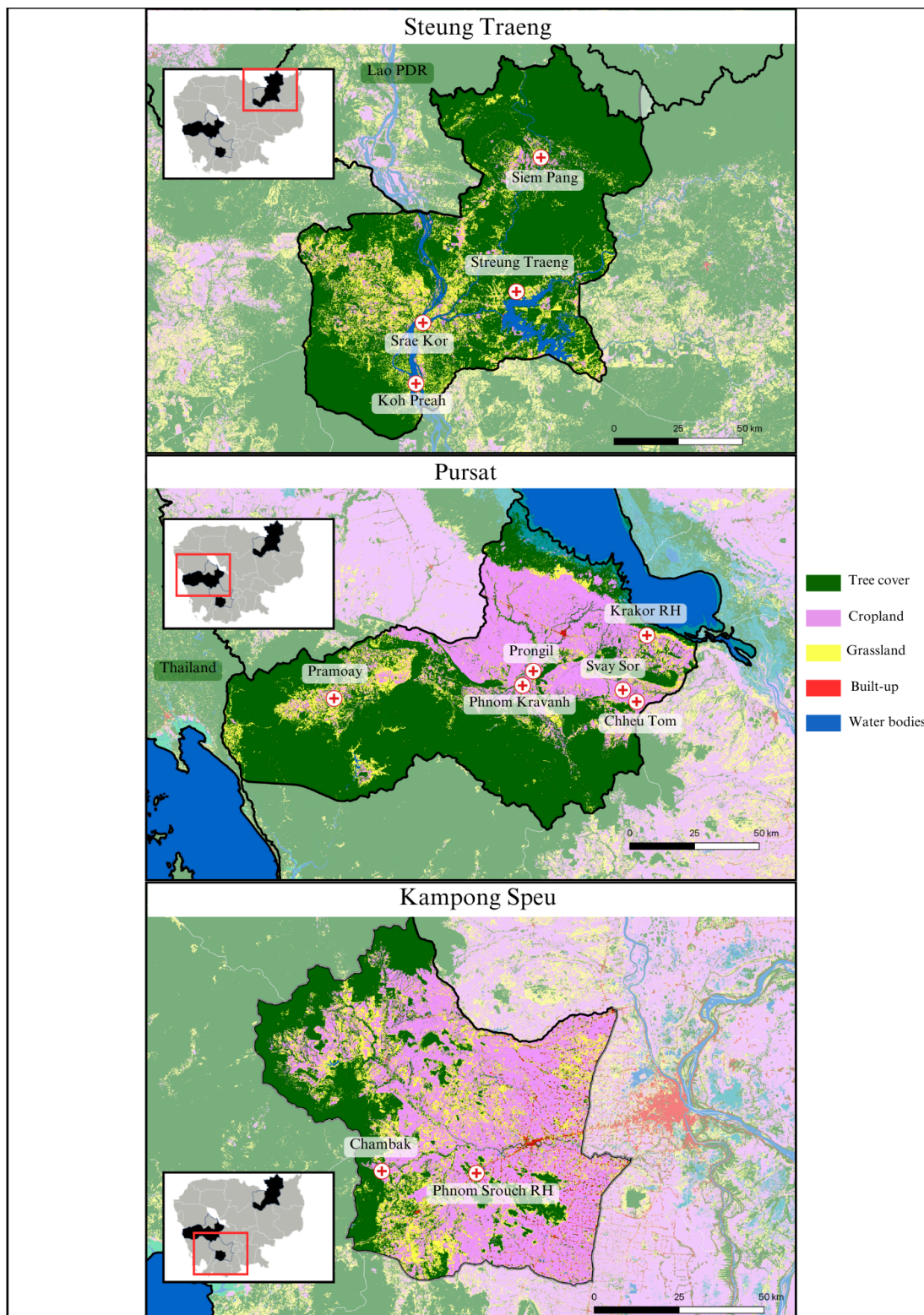


Figure 1

Maps capturing study sites and settings in three provinces in Cambodia. Created with QGIS Lima and Canva Pro. Shapefiles of subnational boundaries were obtained from the Humanitarian Data Exchange (<https://data.humdata.org/dataset/cod-ab-khm>, <https://data.humdata.org/dataset/cod-ab-lao>, <https://data.humdata.org/dataset/cod-ab-tha>) and land cover was obtained from ESA WorldCover (40), both licensed under a Creative Commons Attribution 4.0 (CC-BY 4.0) International license

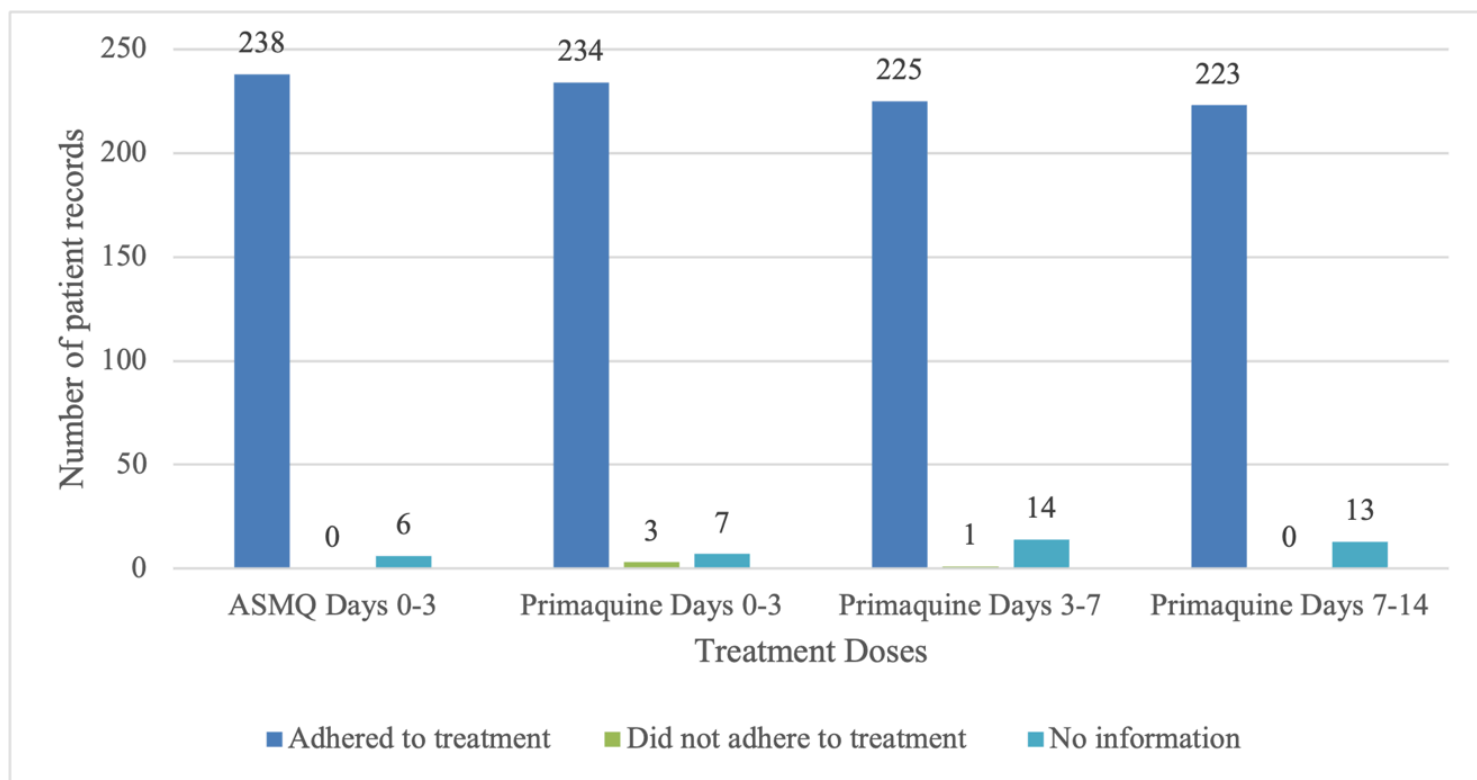


Figure 2

P. vivax patient adherence to Artemisinin-Mefloquine (ASMQ) and primaquine treatment on follow-up days 3, 7, and 14 determined through VMWs checking pill count and patients' follow-up cards in 9 health center catchment areas (January 2021 to March 2023).



Figure 3

Pictures capturing VMW follow-up in Pursat Province, Cambodia in August 2022. A) Road conditions on the way to the patient's house for a VMW follow-up visit: MMW is pictured in the distance on their motorbike. B) MMW checking the patient's follow-up card and comparing it to medicine packaging. C) Completed VMW follow-up form after completion of procedures D) VMW checking patient's follow-up card and comparing it to medicine packaging.

Supplementary Files

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