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Acceptability and feasibility of glucose-6-phosphate dehydrogenase (G6PD) testing using SD Biosensor by village malaria workers in Cambodia: a qualitative study

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ABSTRACT

Introduction *Plasmodium vivax* is the predominant cause of malaria in the Greater Mekong Subregion. To ensure safe treatment with primaquine, point-of-care glucose-6-phosphate dehydrogenase (G6PD) testing was rolled out in Cambodia at the health facility level, although most malaria patients are diagnosed in the community. The current study aims to explore the acceptability and feasibility of implementing community-level G6PD testing in Cambodia.

Methods Semistructured interviews and focus group discussions (FGD) were conducted. Across eight study sites in three provinces, 142 respondents, including policymakers, programme officers, healthcare providers and patients, participated in 67 interviews and 19 FGDs in 2022 and 2023. Data were analysed thematically using an adapted framework derived from Bowen *et al*'s feasibility framework and Sekhon *et al*'s acceptability framework.

Results All stakeholders attributed value to the intervention. Acknowledging an intervention's different values can help discern policy implications for an intervention's successful implementation. Building and maintaining confidence in the device, end users, infrastructure and health systems were found to be key elements of acceptability. In general, health centre workers and village malaria workers (VMWs) had confidence that VMWs could conduct the test and administer treatment given appropriate initial training, monthly refresher training and the test's repeated use. More is required to build policymakers' confidence, while some implementation challenges, including the test's regulatory approval, stability above 30°C and cost, need to be overcome.

Conclusion Implementation of G6PD testing at the community level in Cambodia is an acceptable and potentially feasible option but requires addressing implementation challenges and building and maintaining confidence among stakeholders.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Testing for glucose-6-phosphate dehydrogenase (G6PD) deficiency is recommended in Cambodia before administration of radical cure.
⇒ After the first year of the country-wide implementation of G6PD testing using the Biosensor at health centre level, an assessment study at nine health facilities found that 64% (770/1213) of patients were not tested and therefore did not receive treatment.
⇒ The low proportion of patients treated reflects the low referral rate from village malaria workers (VMWs), where most patients are diagnosed with malaria, to the health centre for G6PD testing.
⇒ Policymakers, implementers and researchers are exploring community-based G6PD testing as a solution.
⇒ An initial operational feasibility study in Cambodia's Pursat province found that with appropriate training and supervision, VMWs could perform the test appropriately and there was an acceptable level of agreement between the test results from VMWs as compared with laboratory technicians testing the same patient.
⇒ Our study represents a 'next step' in determining the acceptability and feasibility of community-based G6PD testing by VMWs with important insights for national programmes in the region facing similar challenges.

INTRODUCTION

In 2022, there were an estimated 249 million cases of malaria across 85 countries.[1] The two most prevalent species of malaria in Southeast Asia are *Plasmodium falciparum* and *P. vivax*. As the regional burden decreases, *P. vivax* now accounts for the majority of infections.[1] *P. vivax* contributed 94.6% of infections in 2023 in Cambodia, where the National Malaria Control Program (NMCP) is seeking to eliminate malaria by 2025.[2 3] In contrast to *P. falciparum*, *P. vivax*

WHAT THIS STUDY ADDS

⇒ The study is the first to explore a variety of stakeholders' perceptions regarding the use of the Biosensor for G6PD testing by VMWs, informing the acceptability and feasibility of implementing the intervention.

⇒ We identify the challenges around the use of the test, as well as the practicalities involved with implementation and policy change, including challenges with test supply refrigeration, WHO prequalification and cost of implementation.

⇒ Challenges with test use, such as the complexity of the test and fears about misuse of the test impacting treatment, can be overcome through confidence-building measures.

⇒ Building on existing frameworks of feasibility and acceptability, this study contributes to conceptual frameworks of how to assess interventions and technologies, finding that stakeholders attributed value to the intervention beyond its intended purpose and that building and maintaining confidence is a key component to acceptability.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Our findings suggest that how different stakeholders across the health system attribute value to the intervention has important policy implications and should be examined when exploring an intervention's acceptability.

⇒ Confidence building in the VMWs conducting the test must be ensured and maintained across the health system and includes building confidence in the test device, in VMWs and in the required infrastructure.

⇒ According to VMWs, their self-confidence in performing the test can be built, but policymakers need to value and compensate them for this additional work.

⇒ To overcome infrastructure limitations at the community level, WHO prequalification for the Biosensor should be obtained and policymakers' confidence in using the device without refrigeration needs to be built.

forms dormant liver stages (hypnozoites) that can reactivate, resulting in recurrent infection (relapse). In some areas, up to 80% of acute vivax malaria presentations are caused by relapse.[4] To clear hypnozoites, patients receive radical cure—a combination of schizontocidal drugs and 8-aminoquinolines, such as primaquine and tafenoquine.[5] 8-Aminoquinolines can cause severe haemolysis in patients with the common enzymopathy glucose-6-phosphate dehydrogenase (G6PD) deficiency.[6] Given a high prevalence of G6PD deficiency of up to 19% in Cambodia,[7–10] concerns about the risk of haemolysis in individuals with G6PD deficiency and the lack of point-of-care G6PD testing have resulted in the limited use of radical cure until recently.[11]

To ensure safe access to radical cure and enable malaria elimination, the NMCP rolled out the STANDARD G6PD test (Biosensor, SD Biosensor, Republic of Korea) to high-burden health centres in February 2021. However, a year after the implementation of this policy, most vivax (64%) patients still did not receive radical cure.[12] This is predominantly because of unsuccessful referrals from the community to health centres.[12] Most *P. vivax* patients in Cambodia are diagnosed in the community by village malaria workers (VMWs), but G6PD testing is only done at the health centre level.[12 13] Referral is limited by distance, road conditions, the opportunity cost for patients seeking further care and perceptions around *P. vivax* malaria and its treatment.[12] VMWs have played an important role in the reduction of malaria in Cambodia by implementing 'test and treat' policies for malaria, providing schizontocidal drugs and carrying out prevention strategies.[14] Enabling VMWs to use the Biosensor and provide primaquine treatment is likely to increase access to radical cure treatment.[15–17]

Community-based G6PD testing is discussed among policymakers, implementers and researchers as a means to enable access to radical cure, yet more insights on the feasibility and acceptability of this strategy are required.[13] An initial feasibility study was conducted in Kravanh district, in which 28 VMWs were trained to use the Biosensor. The study found that VMWs were willing and able to conduct the test after training and with monthly supervision that also served as refresher training.[18] Comparison between readings conducted by VMWs and technicians showed good agreement, but VMWs required support in result interpretation and treatment decisions.[19]

Despite these encouraging findings, implementing new diagnostic technologies can be challenging due to numerous factors, including supply logistics,[20–22] absent infrastructure and financial constraints,[20 23–25] acceptability among users and recipients,[21 23] and the dynamics between healthcare providers and patients.[21 22 24 26 27] These challenges can be particularly problematic when implementing a new diagnostic among VMWs with less medical training than health facility workers across a multitude of service points.

This study aims to explore the acceptability and feasibility of implementing community-level G6PD testing in Cambodia, including obstacles to policy change. To adequately do so, a conceptual framework suggesting that the success of implementing a diagnostic depends on how the device interacts with the broader health system was used, highlighting the need to explore the perceptions of the implementer and the recipients, policymakers and other stakeholders that make the health system work.[28] This was supplemented with Bowen *et al*'s feasibility framework and Sekhon *et al*'s acceptability framework.[29 30] The study draws on perspectives and experiences from a variety of stakeholders, including policymakers, subnational malaria officials, health facility workers, VMWs and patients.

METHODS

Study design and participants

This qualitative study employed semistructured interviews (in person and online) and focus group discussions (FGDs, in person). Data were collected as part of a larger research study on the implementation of G6PD testing in Cambodia.[12] Study participants included policymakers,

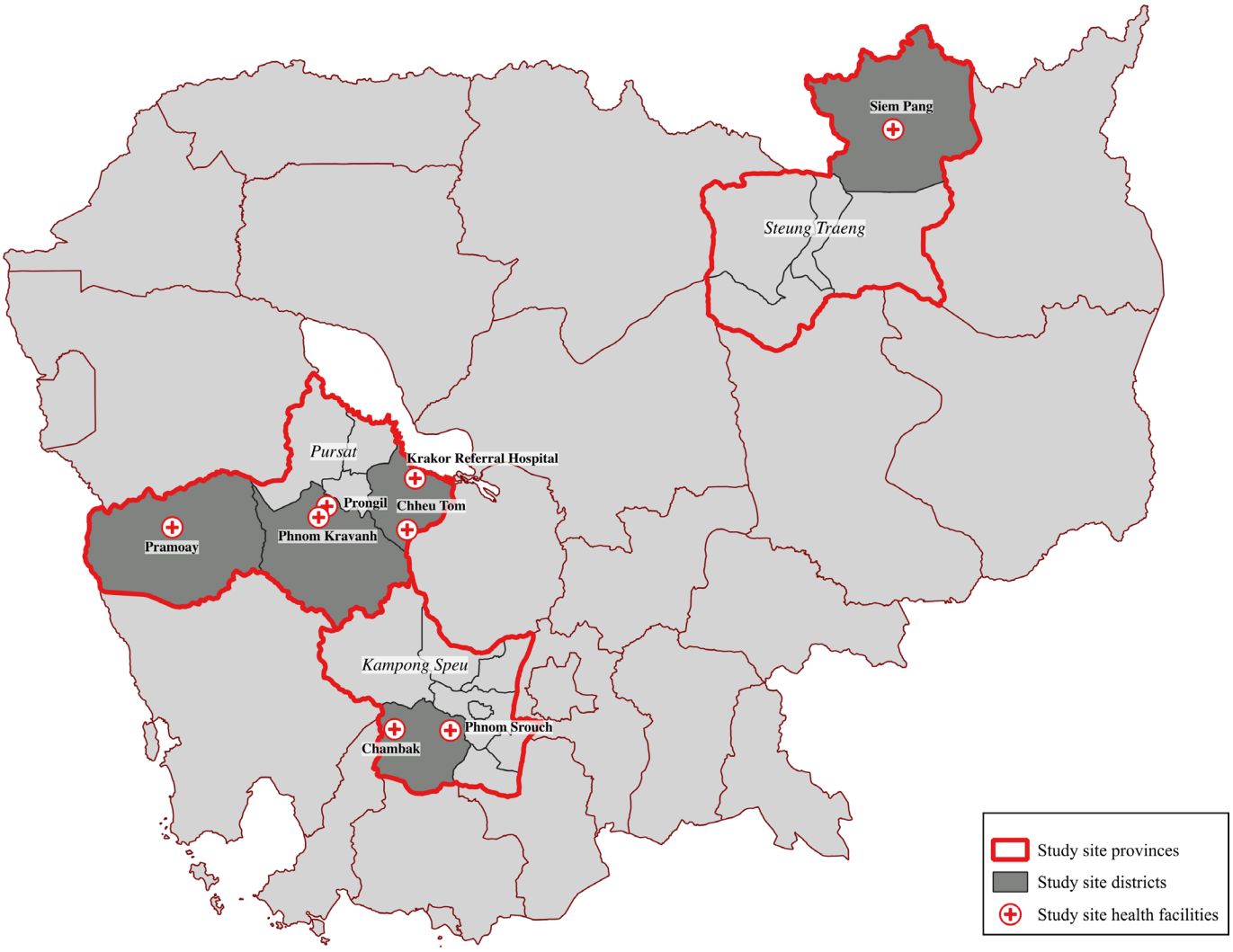

Figure 1 Map of study sites. Created with QGIS Lima and Canva Pro. Subnational boundary shapefiles were obtained from the Humanitarian Data Exchange (https://data.humdata.org/dataset/cod-ab-khm) and are licensed under a Creative Commons Attribution 4.0 (CC-BY 4.0) International licence.

representatives of implementing partner organisations, subnational programme officials, referral hospital workers, health centre workers, VMWs and patients diagnosed with vivax malaria. Participants were recruited at eight sites with varying *P. vivax* burden across three provinces in western and eastern Cambodia (Pursat, Kampong Speu and Steung Traeng) (figure 1). All study sites provided routine care (online supplemental appendix 1). A clinical trial was conducted at two sites (EFFORT trial, NCT04411836) during the study period. Patients were enrolled via convenience sampling in coordination with health workers and community leaders. All other study participants were identified via purposive and convenience sampling. Purposive sampling was conducted for subnational officials and programme staff based on their experience with the malaria programme, as well as among implementation partner organisations. More details on the recruitment and sampling procedures are available in online supplemental appendix 2.

Participants provided written informed consent in Khmer after a briefing with the facilitator and prior to enrolment. Participants were provided with an information sheet about the study in Khmer. All collected data were anonymised.

Procedures

Discussion guides were developed for semistructured interviews and FGDs (SAC-S, KT, NE) and translated into Khmer (PC). Briefing notes on research topics and questions were prepared (SAC-S) and provided to facilitators (KC, PC). Interviewing/facilitating skills, understanding of questions and accuracy of discussion guide translations were confirmed during subsequent workshops (SAC-S, KC, PC), and guides were refined in pilot sessions (SAC-S, KC, PC). Details can be found in online supplemental appendix 3.

Data were collected between April 2022 and 2023 in a private setting. Semistructured interviews with policymakers and representatives of implementation partner organisations were conducted over Zoom in English (SAC-S), except for one in-person interview in Khmer

(KC). Interviews and FGDs with all other participants were conducted in person and in Khmer (KC, PC).

A debriefing among study members (SAC-S, KC, PC) was conducted after each interview and FGD, allowing for key findings and insights to be further explored in subsequent sessions and for an assessment of data saturation. English recordings were transcribed. Khmer recordings were translated and transcribed into English. The study team reviewed the translated transcripts to ensure accurate translation (SAC-S, KC, PC). Follow-up interviews or FGDs were conducted when possible and warranted based on debriefings and review of transcripts, allowing for in-depth exploration of the research question.

Data analysis

An iterative, inductive and deductive coding approach using NVivo V.12 (Lumivero, USA) was applied (SAC-S). The codebook was developed based on reviewing and re-reading transcripts and components of the larger study's conceptual framework (SAC-S with support from KT, NE, AM).[12] Themes were revealed through the process of coding and memo writing (SAC-S) and were discussed among study team members (SAC-S, KT, NE, AM). Achievement of data saturation was confirmed at the end of data analysis.

Building on the theoretical framework that guided the larger study's data collection and analysis,[12] conceptual and theoretical frameworks were retrospectively applied after data collection in the analysis phase. Drawing from a conceptual framework devised by Pai *et al*,[28] the success of a point-of-care rapid diagnostic test, in this case, the Biosensor used at the community level, is not merely about the test itself but how it interacts with the users, recipients and the health system. Using this lens, Sekhon *et al*'s acceptability framework and Bowen *et al*'s feasibility framework were combined to explore the potential implementation of the Biosensor by VMWs, and a new framework was derived (figure 2).[29 30] The derived framework includes Sekhon *et al*'s acceptability components of affective attitude, ethicality and the modified components of confidence building and added value (figure 2). Through and after data analysis, Sekhon *et al*'s components of self-efficacy (implementers' confidence) and coherence (extent of understanding of the intervention) were redefined as confidence building and added value. Confidence building was defined as what is needed to build and maintain confidence, enabling an intervention to work, including confidence in the health system, in the infrastructure, in the device and in its users. Added

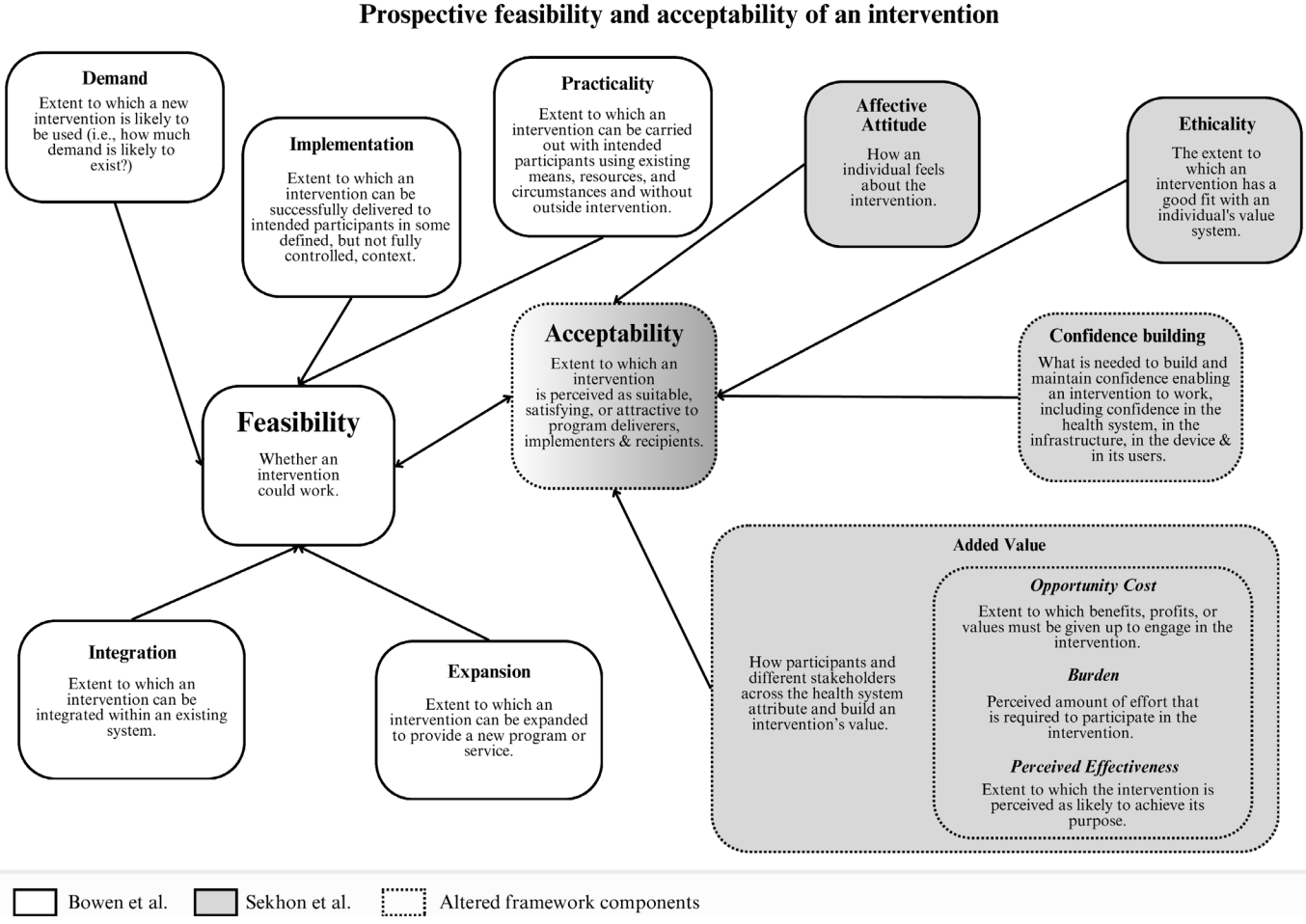

Figure 2 Revised framework for the combined, prospective assessment and exploration of an intervention's feasibility and acceptability.

Table 1 Sociodemographic characteristics of key informant interviews and FGDs

Participant type*	Primary method	n	Male	Female	Median age (IQR, total range)	Villages	Occupation
Patients (pp)	Interviews	35	29	6	30 (20–39, 18–68)	32	Farmer (19), forest product gatherer (7), daily labourer (2), forestry administration (2), teacher (1), environmental officer (1), construction worker (1), school director (1), environmental NGO staff (1)
Patient spouse (ps)	Joint interviews with patients	4	0	4	31.5 (23.5–31.5, 20–39)	4	Farmer (2), grocery seller (2)
Village malaria workers (vmw)	FGDs	49	21	28	50 (39–57, 23–71)	46	Farmer (42), grocery seller (4), housewife (1), online seller (1), unknown (1)
Health centre workers (hc)	Interviews	12	8	4	45 (33–54, 26–55)	10	Malaria point person (4), doctor (1), nurse (2), midwife (2), laboratory (2), administrative (1)
Referral hospital workers (rh)	FGDs	12	7	5	31 (29–52, 26–57)	10	Doctor (1), nurse (7), laboratory (2), administrative (2)
District malaria officials (do)	Interviews	5	5	0	33 (30–50, 29–70)	4	Operational district director (2), operational district malaria supervisor (3)
Provincial malaria staff (po)	Interviews	4	2	2	50 (39–50, 28–50)	3	Provincial health department director (2), provincial malaria supervisor (2)
Policymakers (cnm)	Interviews	3	3	0	–	–	NMCP officials (3)
Implementation partners (cnmp)	Interviews	3	3	0	42 (34–50, 34–50)	3	Central-level partner (1), district-level partner (2)
EFFORT study staff (et, etd, etl)	Interviews	15	7	8	31 (28–34, 24–57)	10	Doctor (4), nurse (4), laboratory (4), administrative (3)
Total	–	142	85	57	36 (29–51, 18–71)	108	–

*Participant codes in parentheses are used in the remainder of the Results section to link presented results to participant type. For EFFORT study staff, et denotes EFFORT trial general staff, etd denotes EFFORT trial doctor, etl denotes EFFORT trial lab technician. When participant ID is not known for FGDs, participant type and FGD number are specified.
FGD, focus group discussion; NGO, non-governmental organisation; NMCP, National Malaria Control Program.

value was defined as how participants and different stakeholders across the health system attribute and build an intervention's value, which includes Sekhon *et al*'s acceptability components of opportunity cost, burden and perceived effectiveness. In the derived framework, these components of acceptability inform feasibility, which also includes Bowen *et al*'s other feasibility framework components of implementation, practicality, integration, expansion and demand.

RESULTS

Participants

Across the two rounds of data collection, 142 respondents participated in 67 interviews and 19 FGDs (table 1). 22 participants were included in follow-up interviews or discussions. The median age of respondents was 36 (IQR: 29–51, range: 18–71), and 59.9% of participants were male. Respondents came from 108 different villages. Of the 84 patients and VMWs, 72.6% (61/84) were farmers.

The results are presented according to the acceptability and feasibility framework components and divided into six main sections: (1) value of the VMWs conducting G6PD testing, (2) affective attitudes, (3) confidence building for VMWs to conduct G6PD testing, (4) implementation and practicality, (5) integration and expansion, and (6) demand (table 2).

Value of and value creation for VMWs conducting G6PD testing

Respondents across participant type attributed value to VMWs conducting G6PD testing. In line with the intervention's intended purpose, they foresaw it as a means to providing testing and treatment at initial point of care (vmw10,26,29,32,36, cnm3, rhl2, etd3) and ensuring access to radical cure and accelerating malaria elimination (hc5, etd2).

> In fact, the goal of eliminating malaria at the national level is 2025. If the principle of eliminating malaria fails or is unstoppable, it can be done with what you have mentioned about providing a VMW G6PD device to help with the complete treatment, which is even better. (hc5)

Valuing the intervention as a means to enable malaria elimination means that respondents believed the intervention would work and reflects what Sekhon *et al* define as the intervention's perceived effectiveness (hc5, etd2). For it to work, have value and enable malaria elimination, the intervention would need to include both G6PD testing and administration of primaquine. Yet, some VMWs did

Table 2 Factors impacting the acceptability and feasibility of VMWs conducting G6PD testing based on the revised feasibility and acceptability framework

Revised framework component	Findings
(Added) value Adapted from Sekhon *et al*'s coherence	Stakeholders attribute value to the intervention beyond its intended purpose: ► Perceived effectiveness for patient outcomes and malaria elimination (intended purpose). ► Reducing opportunity costs for patients and VMWs (added value). ► Reducing burden on health centres (added value). ► Trust building with community (added value).
Affective attitude	Fears around VMW's knowledge rooted in fears of haemolysis: ► Concerns about test performance. ► Concerns about incorrect treatment provision.
	Fears were surmountable for health providers and VMWs outweighed by VMWs wanting to help their community and make it easier for patients: ► Commitment to community. ► Desire to support the national programme.
	Fears more pronounced among policymakers.
Confidence building Adapted from Sekhon *et al*'s coherence self-efficacy	Acceptability includes building and maintaining confidence in the intervention, including the diagnostic and user: ► Confidence could be built for patients, VMWs and health providers. ► More is required to build policymakers' confidence.
	Factors affecting confidence in the G6PD test (Biosensor): ► Test's limitations and intricacies. ► Monthly quality control at PoC. ► VMW follow-up of patients. ► Discussions of G6PD testing results with colleagues.
	Factors affecting confidence in VMWs: ► Training on G6PD and treatment provision. ► Refresher training. ► Practice. ► Attentiveness and work diligence. ► Previous exposure to blood collection procedures. ► Trust-building activities with the community.
Implementation and practicality	Regulatory and infrastructural barriers prevent implementation, need for more resources and approvals: ► Refrigeration of Biosensor test supplies (infrastructural). ► WHO prequalification (regulatory). ► Cost of community G6PD testing (economic). Device-level and supporting factors can facilitate implementation: ► Simplification of user steps (device level). ► Monitoring, supervision and open communication (supporting).
Integration and expansion	Intervention can be integrated: ► Leveraging existing VMW network and knowledge. ► Expanding VMW scope work. ► VMW health system integration and compensation.
Demand	Factors impacting demand: ► Cost. ► Alternative options not needing confidence building.

G6PD, glucose-6-phosphate dehydrogenase; PoC, Point of care; VMW, village malaria worker.

see value in providing G6PD testing without the administration of treatment. From their point of view, testing in the community would spare G6PD-deficient patients from travelling to the health centre (vmw16,22,26).

Beyond this intended purpose of increasing access to radical cure, many participants identified an added value that G6PD testing in the community would bring, namely reducing the opportunity cost for patients who have to travel to the health centre (vmw29,32,35,31, et5, rh8, rh(fgd7), cnmp1, etd3, hc8,9, cnm3) and reducing the workload for health centre workers (vmw8,31, rh8). Although VMWs would have to G6PD test and treat, some VMWs perceived the intervention as time-saving since they would have to accompany fewer patients to health

centres (vmw26,32). Lastly, the value of the intervention for some VMWs was in its contribution to trust building in the community (vmw19,18,20,23, vmw(fgd3)).

> If we have this machine, the patients will trust us more, so it is very good. If we go to the forest and we have this machine, the patients will think that we test them well and accurately. The villagers will trust us more and more. (vmw23)

Affective attitudes

Most respondents reported positive attitudes towards VMWs' conducting G6PD testing; however, some stakeholders expressed concerns about VMWs' limited knowledge (cnm1,2, po2,4, vmw14, etl1, et4, etd1, hc1,5,12). These concerns included fear about test performance but also extended to fear about incorrect treatment provision, either because of mistakes in the testing process or incorrectly interpreting test results (cnmp2,3, vmw8,15,17, cnm1,2, po2,3, etd1, hc2,3,5, rh5, rh(fgd7)), which could ultimately lead to haemolysis (cnmp2,3, vmw8,11,15,17, cnm1,2, po2,3, etd1, hc2,3,5, rh5, rh(fgd7)). One VMW alluded to VMWs' limited knowledge preventing them from providing treatment by stating, "*We are not bachelor doctors*" (vmw15), when asked about VMWs being allowed to provide primaquine.

For several policymakers and implementation partners, the risks were perceived as significant (cnm1,2, cmpn2,3), given that patients could die if G6PD activity were not tested correctly (cnm1). This fear was shared by an implementing partner who suggested that providing VMWs with a lower dose of primaquine would facilitate VMWs administering treatment (cnmp3). VMWs also feared haemolysis if they were to provide treatment after using the Biosensor (vmw8,15,17).

> The patients are in different conditions, so I am so scared to provide the treatment. Sometimes, I had a bad dream the whole night because I am so scared that they have haemolysis or something like that. It is not that easy, I think. I am afraid that the patients will be in serious danger […]. (vmw8)

However, for many VMWs, their fear was outweighed by their commitment to their community and desire to support the national programme (vmw8,15,17). More broadly, except for two participants (cnm1, hc12), all participants stated that these fears could be overcome, and confidence could be built in VMWs conducting G6PD testing.

Confidence building for VMWs to conduct G6PD testing

The acceptability of VMWs conducting G6PD testing and overcoming the described fears requires building confidence in both the G6PD test and VMWs as end users of the test.

Confidence in the G6PD test (Biosensor)

Confidence in the Biosensor could be built among current end users despite being aware of the test's limitations. Biosensor users at referral hospitals and health centres understand that small differences in the testing procedure can impact the results (online supplemental appendix 4) (cnm1, po4, etl1,2,4, et5, etd2,3, hc2,3,5,6,7,9,12, vmw3, cnmp1,2, rh4,5, do4,5). This was described by a health centre worker as "*[…] it would be errors a lot, for us, even I do it and he does it the same but sometimes the result not the same, it's slightly different*" (hc12).

Knowing the test's margin for error, however, does not prevent the health centre workers from using the test results to administer treatment. This is because there are established mechanisms to build confidence in the results, including monthly quality control at the point of care and VMW follow-up of patients (po4, hc). Additionally, some referral hospital nurses, who are less involved in routine malaria case management, experienced in a research study context that G6PD numerical results can vary, requiring an extra step of discussing G6PD results before providing treatment (rh4,5). They highlighted that since VMWs work alone, this discussion and confirmation regarding test results and appropriate treatment is not possible (rh4,5).

Similarly, a central-level official emphasised there is always the chance of false results and adverse events that a volunteer would not be able to manage: "*The machine is not 100% perfect. There will be something is wrong. So if something wrong [adverse event] happens at the community level, it's very hard because the volunteer cannot manage it*" (cnm2). This policymaker's concerns stem from their fear of primaquine-induced haemolysis, which is perceived as not manageable at the community level. The policymaker did emphasise that their confidence in the test and VMWs' ability to perform it could be built through more evidence generation on the ground regarding their ability (cnm2).

Confidence in VMWs

Acceptability is influenced by the confidence that different actors (VMWs, providers and patients) have in VMWs.

For VMWs, the key to building confidence in their own ability to conduct G6PD testing and provide radical cure was training on testing procedures and administration of treatment (vmw16,17,20). A VMW who had previously been trained to use the Biosensor also emphasised the importance of practice in reaching proficiency with the test (vmw4). Therefore, with the appropriate initial training per suggestions by VMWs (table 3), frequent refresher training and repeated use of the test, VMWs could build confidence in their own ability to perform the G6PD test and provide primaquine (vmw14,17–20,23–26,29,30–32).

For healthcare providers, formal training of VMWs prior to a scale-up was central to building confidence (hc1,3,4,7, rh3,4, et5,6, etd1,2). Additionally, conducting monthly refresher training would assuage some of their fear around the management of adverse events and haemolysis when VMWs perform the test and prescribe

Table 3 Participant training recommendations

Training characteristic	Recommendation	Participant(s)
Content	Not just G6PD testing procedure but equal focus on result interpretation and treatment administration	vmw16,17,20
Length	Range from 1 day to 1 week	vmw10–13,17,18,26, hc9, etd2
Support mechanisms	Provision of VMW job aids	vmw16,17,19,20
	Provision of VMW job aids in Khmer	vmw15,16
Trainer	Effective and able trainer	etl2

These recommendations would build the confidence required for the implementation of the Biosensor.
G6PD, glucose-6-phosphate dehydrogenase; VMW, village malaria worker.

radical cure (hc7, rh(fgd7), po4, cnmp3). Some healthcare providers' confidence in VMWs performing G6PD testing was lowered because they perceived a lack of attentiveness and work diligence in VMWs (hc2,3,5,12, rh5, etl1).

On the other hand, VMWs' previous exposure to blood collection procedures enhanced the confidence that both VMWs and providers had in VMWs' ability to perform G6PD testing. In Cambodia, VMWs are often recruited to participate in research projects, given that they are community members trained in malaria case management and are close to patients (vmw29). As part of these projects, VMWs have been trained in different blood collection techniques, including dried blood spots and blood smears (hc1, vmw8,13,29); and some have been trained to test for glucose levels as part of diabetes care provision (vmw18, hc7). This prior knowledge of and exposure to diagnostic devices and testing instils confidence (hc1). Means of building confidence in VMWs' knowledge were not identified among policymakers (cnm1,2,3).

For patients, confidence in VMWs has been built through prior experience with VMWs' ability to conduct prevention activities, diagnose malaria and provide schizontocidal treatment. However, confidence in VMWs' ability to implement a new device, such as the Biosensor, would also need to be built (rh4) since community members might not immediately trust VMWs with added responsibilities. Some patients, especially if they live close to the health centre, suggested that they prefer seeking care from the health centre given the health centre workers' more advanced knowledge and understanding of health and ability to provide more comprehensive care (pp25,26,28, ps2). To expand patients' trust and confidence in VMWs conducting G6PD testing, referral hospital workers suggested that local authorities be part of trust building between patients and VMWs. To facilitate this, village authorities, in the presence of community members, would need to recognise and acknowledge the training and ability of VMWs (rh4).

Implementation and practicality

The feasibility of VMW G6PD testing is characterised by the extent to which it can be successfully delivered to intended participants (implementation) and whether it can be carried out with existing means and resources (practicality). Factors affecting both include expertise building (tables 2 and 3), device level and supporting factors, as well as higher level regulatory, economic and infrastructural considerations.

Device-level factors: complexity of Biosensor user steps

Simplifying the Biosensor testing procedure would ease test use and, therefore, implementation. Doctors, health centre workers and malaria officials have indicated that mixing the blood sample with the buffer would be especially difficult for VMWs (cnm1,2,3, po4, rh(fgd7), hc1, vmw9,14, etd2,4), as it also remains a challenge for health centre workers (po4, hc12). The feasibility and acceptability of the test being conducted by VMWs would improve without this step (cnm1,2,3, po4, rh(fgd7), hc1, vmw9,14). Some specifically mentioned adjusting the G6PD test so that it would be more like a glucose test where the blood sample is applied directly to the sample well without needing a mixing step (rh(fgd7), etd2,4). A VMW also described how the multiple steps involved in the testing process might cause them to make errors (chw14).

Supporting factors: monitoring, supervision and open communication

Respondents identified monitoring, supervision and open communication lines between VMWs and health centre workers as facilitators for the implementation of VMW G6PD testing (cnmp3, do1, hc2). A health centre worker highlighted the importance of monitoring the device, as "*It [VMWs using the Biosensor] is possible, but the device must be checked from the upper level*" (hc2).

A district malaria official identified general support from the health centre as important (do1). Open communication lines between VMWs and health centre workers were seen as essential in mitigating risk and assuaging the fear involved in VMWs providing radical cure treatment, as "*They have to work closely with HC staff and VMWs because if they test and the results are not accurate and they provide the treatment, we will have problems*" (do1). This sentiment was echoed by a VMW who wanted to have support from the health centre to be able to prescribe primaquine treatment given the side effects. He stated, "*It is better to have the clarification from the HC whether we can provide the treatment or not because we don't really trust ourselves*" (vmw8).

Infrastructural factors: refrigeration of Biosensor test supplies

Policymakers, malaria officials, implementation partners and healthcare providers identified the storage requirements of the analyser's consumables as a main challenge

(cnm2,3, cnmp2, po4, hc1, vmw8,9,11–13, rh(fgd7), do1).

Per the NMCP's guidelines, the testing supplies (test devices and buffer) need to be refrigerated to ensure testing quality, given the temperature in Cambodia often exceeds 30°C. The manufacturer recommended test device storage temperature range is between 2 and 30°C.[31]

The concern about maintaining recommended temperatures and keeping the device safe in the community where reliable refrigeration is absent (cnm1,3, cnmp2) was shared among subnational malaria officials and healthcare workers from referral hospital staff to the VMWs. Because of these requirements, VMWs thought it would be inappropriate for them to have the G6PD test at their home (vmw8,9).

A malaria partner thought monitoring storage conditions could ease some of these concerns (cnmp3). When presented with the potential of a test not requiring refrigeration, VMWs were open and interested in performing the G6PD test (vmw8–13) to help their community by '*provide[ing] treatment at our place right away*' (vmw10).

Regulatory factors: WHO prequalification

Among policymakers, a major concern for implementing G6PD testing at the community level, in addition to its current use at the health centre level, was the Biosensor's lack of WHO prequalification. This presents a liability risk to the NMCP if they were to implement this policy without prequalification. According to this policymaker, the risk to the NMCP associated with providing VMWs with the G6PD testing devices outweighs the potential gain of allowing wider access to radical cure (cnm2).

> But you know the current G6PD quantitative test that we use it, is not approved by WHO yet, is not prequalified by WHO […] so that's why for me, hesitate that if we are roll out to the community, firstly, with the product that not pre-qualified with WHO is something wrong, we may get more challenges with the Ministry of Health, with the other health community that they will blame us that product not prequalify why you are start to roll out to the community that may take a bit risk. (cnm2)

Economic factors: cost of G6PD testing at community level

The cost of procuring additional G6PD analysers and test strips for each VMW is an important consideration, according to an implementing partner (cnmp3). They highlighted that G6PD testing in the community can work but would require additional resources to equip hundreds of VMWs in high-burden areas (cnmp3).

A district-level implementing partner also cited the costs of implementation as a barrier, describing high costs that would be involved in facilitating adequate storage and refrigeration for test supplies at VMW's homes (cnmp2).

Integration and expansion

VMWs conducting G6PD testing would leverage the existing VMW network supporting malaria services. It would, however, require the expansion of VMWs' role.

The implementation of testing at the community level would require additional time and responsibility for VMWs (po4, vmw9, vmw(fgd9)). VMWs operate on a volunteer basis with compensation for travel and consumables (vmw27, po2, cnmp2). They do not receive a baseline minimum salary for their routine work and have to make a livelihood with other work, most of them as farmers or forest goers (table 1). Some VMWs highlighted how they cannot and do not want to do more: "*To do more work, I don't really want to do it*" (vmw9) and "*I don't have much free time because I am busy with the work at home, and I am alone at home*" (vmw(fgd9)). A provincial malaria official acknowledged that making VMWs responsible for G6PD testing and radical cure treatment would expand their scope of work from part-time volunteer work to a full-time job, requiring appropriate compensation (po4).

Demand

There was demand at the policymaking level for solutions to promote increased access to radical cure. The demand for enhancing access to radical cure through VMWs conducting G6PD testing is attenuated by the cost and the consideration of alternative approaches that bypass policymakers' fears and do not require the same level of confidence building in VMWs.

Specifically, the NMCP is piloting a 'fingerprinting' programme, which involves assigning patients a digital health ID that would allow VMWs to look up patients' malaria history and previously determined G6PD status (cnm2). Based on this information, VMWs would then be able to provide radical cure. A policymaker suggested that the NMCP may be slightly favouring this option due to its broader benefit of patient tracking, recurrence tracking and continuity of care beyond the provision of radical cure alone (cnm2). The perceived advantages of fingerprinting were also expressed by a provincial malaria supervisor who saw value in making patient history and information easily available (po4).

DISCUSSION

Stakeholders from policymakers to VMWs attributed value to VMW G6PD testing, many of them constructing value beyond the intended purpose of bringing G6PD testing and treatment with primaquine closer to patients and enhancing access to radical cure. The identified added value included decreasing opportunity costs for patients and reducing workload for health centre workers. For VMWs and most health providers, confidence in the intervention could be built despite fears about adverse events. For some policymakers, however, confidence has not yet been built, and fear of haemolysis after incorrect treatment outweighed the value attributed to VMWs performing the test. Other factors contributing

to the hesitancy of implementing this intervention are the complexity of the Biosensor testing procedures, and other practicalities, including costs and infrastructure. The demand for VMW G6PD testing is weakened by alternative strategies that do not require confidence building.

According to Sekhon *et al*'s acceptability framework, intervention coherence is defined as the extent to which participants understand the intervention and how it works.[30] Our data suggest, however, that participants across the health system have different understandings of the intervention and value it differently. For instance, some understood the value of G6PD testing in the community to be its intended purpose of bringing testing and radical cure treatment to patients' initial point of care. However, for others, G6PD testing was a tool to build confidence in their services. Specifically, VMWs saw an added value in providing G6PD testing to build their communities' confidence in them. At the same time, VMWs and health centre workers thought it would help alleviate health centres' workload.

Our findings suggest that when exploring the acceptability of an intervention, the intervention's intended purpose should not be predetermined. Instead, the focus should be on examining how participants and different stakeholders across the health system attribute and build the intervention's value. Our analysis suggests that implementing an intervention can have added value beyond the initial objective of the intervention. Therefore, we suggest that the intervention coherence component of the acceptability framework should be replaced with added value, defined as how different stakeholders (including those designing, implementing and evaluating an intervention) across the health system attribute value to the intervention being explored.

Acknowledging the different values that actors attribute to an intervention can help discern policy implications that are important for the successful implementation of an intervention. In alignment with policymakers' recognised value and added value of the intervention, VMWs would need to be appropriately compensated for their additional work. VMWs play a crucial role in being a link between communities and health facilities.[16 32] Adding G6PD testing to their existing tasks would amount to a full-time commitment. Building on the NMCP's pending VMW integration plans,[33] embedding VMWs into the health system as full-time integrated health workers who are compensated as such would facilitate the expansion of VMWs' role while further improving malaria case management and general health service provision.

The feasibility and acceptability of an intervention are not solely determined by those tasked with conducting the intervention, but it is also influenced by the dynamic interactions between actors across the system, the device and its user. Sekhon *et al*'s framework discusses self-confidence in performing the intervention.[30] Our data suggest that the acceptability of an intervention is not just about self-confidence but rather about building and maintaining confidence that allows the intervention to work, including confidence in the health system, the infrastructure, the device and its users. For health centre workers and VMWs, these different aspects of confidence can be built. For patients, their confidence in VMWs can be built given their previous experiences. However, more is required to build policymakers' confidence. We identified two main concerns for policymakers: policymakers perceived the risk of haemolysis at the community level as unmanageable by VMWs because of weakness in the health system and primary care infrastructure, and they saw the weak infrastructure at the community level for storage of G6PD testing supplies as a main barrier to VMW G6PD testing. When presented with a 'refrigeration-free' option, subnational stakeholders in particular were more receptive to VMWs conducting testing.

Given the relative complexity of the Biosensor procedures, policymakers fear that VMWs would perform the test or interpret the results incorrectly, ultimately leading to haemolysis in some patients. To address the concerns on the management of haemolysis, confidence building in the users is required. Similar to findings in the initial VMW G6PD testing feasibility study, which emphasised the importance of training and monthly supervision,[19] our data suggest that formal training, monthly refreshers and routine monitoring and supervision, among other factors, enable confidence building for some programme officers, health facility workers and VMWs. However, this was insufficient for policymakers. There is potential for confidence building by leveraging the current use of mobile phones for reporting surveillance data to deploy mobile health support.[34] There are existing mHealth applications that could be adapted to support the G6PD testing process, interpretation of results and providing appropriate treatment regimens.[35–37] In other contexts, mobile health support has improved the quality of community health worker (CHW) services and was acceptable to CHWs.[36 37]

Refrigeration of Biosensor supplies has been an NMCP requirement, and refrigerators were provided for all the health centres participating in the Biosensor feasibility and pilot studies.[38] The requirement is based on the manufacturer's recommended temperature range of 2–30°C for the test consumables.[31] However, to our knowledge, none of the other countries using the Biosensor, including Lao People's Democratic Republic and Brazil (Dr Lacerda, personal communication),[39] have implemented such a strict policy. Storing test consumables in temperatures exceeding 30°C would require building policymakers' confidence that the quality of test results is not compromised. Such confidence could only be built with additional evidence to understand if storage requirements can be expanded, including real-world experiences from other countries.

In Bowen *et al*'s feasibility framework, demand is defined as the extent to which a new idea, programme or measure is likely to be used based on expressed interest or intent.[29] Demand for the implementation of VMWs conducting G6PD testing is mediated by the availability

of alternatives that do not require confidence building in the Biosensor and VMWs. Demand is also impacted by the cost and requirements of external and partner support.

An alternative to VMWs conducting G6PD testing currently piloted by the NMCP is 'fingerprinting'. This would require testing of individuals and storing their G6PD results in a database, avoiding testing at the point of care. A similar strategy is used in Malaysia and the Philippines, where G6PD status is determined through screening of newborns and then leveraged for *P. vivax* case management.[40] Such a strategy, however, would be dependent on mass screening and the assumption that G6PD status remains constant.[41] However, G6PD status may not be this constant, with enzyme levels increasing during acute malaria.[42]

The cost of additional analysers and G6PD testing supplies also impacts demand for the intervention. The cost of the Biosensor analyser is estimated at between approximately US$150 and US$380, while the unit cost of test strips at a health centre for a year is between US$3 and US$4.[43 44] Additionally, there are costs related to implementation, such as training and financial compensation for VMWs. Prioritisation of high-burden villages would likely be required. Current funding for G6PD analysers and testing supplies comes from the Global Fund with the objective of malaria elimination in the region.[34] However, given that Global Fund grants have already been earmarked for the current grant cycle (2024–2026), decreased grant size[45] and competing priorities,[46] cost-effectiveness data are likely required to obtain partner support.

Our study has several limitations. First, not all team members spoke Khmer. However, debriefs across the data collection team after each interview and FGD were conducted to ascertain emerging themes and prepare for the following interviews and FGDs. Second, due to the large number of recordings, back translation of transcripts was not possible, and three translators worked on transcribing recordings in Khmer, which could have resulted in different understandings of meaning, affecting the resulting transcripts. The study team mitigated this through an iterative review process of transcripts, which included a discussion of the intended meaning of unclear wording between the study team and translators. Third, interviews and FGDs with patients were shorter and less in-depth, affected by inconsistencies in probing patients about VMWs using the test, resulting in their perspective likely being under-reported in the study results. However, patients were often present as implicated actors in interviews and FGDs with other stakeholders; therefore, insights from patient interviews could be triangulated with data pertaining to patients from other stakeholders. Lastly, changes in malaria transmission may impact the results. Data collection was conducted when *P. vivax* case numbers were higher and referral to the health centre was suboptimal. Since then, the malaria burden has further decreased, and successful referral to the health centre has improved.[47]

CONCLUSION

Overall, our results indicate that the acceptability of an intervention is not just about the confidence of the actor implementing the intervention but requires building and maintaining confidence in the health system, the infrastructure, the device and its users among stakeholders across the health system who enable the intervention to work. Acceptability is also about the additional value the intervention brings beyond its intended purpose. When exploring an intervention's acceptability, its intended purpose should examine how each stakeholder attributes value. Knowing this can help discern policy implications for the intervention's success. All stakeholders attributed value to G6PD testing at the community level, though demand from policymakers was curtailed by alternative options that did not require confidence building in VMWs conducting G6PD testing. Overall, health centre workers and VMWs had confidence that VMWs could conduct the test and administer treatment given appropriate training and support. Additional measures for policymakers to build confidence in VMWs conducting G6PD testing should be investigated.

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REFERENCES

1 World Health Organization. World malaria report. 2023.
2 National Center for Parasitology, Entomology and Malaria Control (CNM). National treatment guidelines for malaria in cambodia. 2022.
3 World Health Organization. *Mekong Malaria Elimination: Epidemiology Summary* 2023.
4 Price RN, Commons RJ, Battle KE, *et al*. Plasmodium vivax in the Era of the Shrinking P. falciparum Map. *Trends Parasitol* 2020;36:560–70.
5 World Health Organization. WHO guidelines for malaria 2023. 2023.
6 Howes RE, Piel FB, Patil AP, *et al*. G6PD deficiency prevalence and estimates of affected populations in malaria endemic countries: a geostatistical model-based map. *PLoS Med* 2012;9:e1001339.
7 Kim S, Nguon C, Guillard B, *et al*. Performance of the CareStart™ G6PD deficiency screening test, a point-of-care diagnostic for primaquine therapy screening. *PLoS ONE* 2011;6:e28357.
8 Roca-Feltrer A, Khim N, Kim S, *et al*. Field trial evaluation of the performances of point-of-care tests for screening G6PD deficiency in Cambodia. *PLoS One* 2014;9:e116143.
9 Matsuoka H, Nguon C, Kanbe T, *et al*. Glucose-6-phosphate dehydrogenase (G6PD) mutations in Cambodia: G6PD Viangchan (871G>A) is the most common variant in the Cambodian population. *J Hum Genet* 2005;50:468–72.
10 Bancone G, Menard D, Khim N, *et al*. Molecular characterization and mapping of glucose-6-phosphate dehydrogenase (G6PD) mutations in the Greater Mekong Subregion. *Malar J* 2019;18:20.
11 Kitchakarn S, Lek D, Thol S, *et al*. Implementation of G6PD testing and primaquine for *P. vivax* radical cure: Operational perspectives from Thailand and Cambodia. *WHO South East Asia J Public Health* 2017;6:60–8.
12 Cassidy-Seyoum SA, Chheng K, Chanpheakdey P, *et al*. Implementation of Glucose-6-Phosphate Dehydrogenase (G6PD) testing for Plasmodium vivax case management, a mixed method study from Cambodia. *PLOS Glob Public Health* 2024;4:e0003476.
13 Adhikari B, Tripura R, Peto TJ, *et al*. Village malaria workers for the community-based management of vivax malaria. *Lancet Reg Health Southeast Asia* 2023;9:100128.
14 Lek D, Tsai Y-C, Hirano J, *et al*. Radical cure for Plasmodium vivax malaria after G6PD qualitative testing in four provinces in Cambodia, results from Phase I implementation. *Malar J* 2024;23:56.
15 Chhim S, Piola P, Housen T, *et al*. Malaria in Cambodia: A Retrospective Analysis of a Changing Epidemiology 2006-2019. *Int J Environ Res Public Health* 2021;18:1960.
16 Canavati SE, Lawpoolsri S, Quintero CE, *et al*. Village malaria worker performance key to the elimination of artemisinin-resistant malaria: a Western Cambodia health system assessment. *Malar J* 2016;15:282.
17 U.S. President's Malaria Initiative. Cambodian village workers increase access to quality and timely malaria diagnosis and treatment for vulnerable forest workers. US Pres Malar Initiat; 2018. Available: https://www.pmi.gov/cambodian-village-workers-increase-access-to-quality-and-timely-malaria-diagnosis-and-treatment-for-vulnerable-forest-workers/
18 Adhikari B, Tripura R, Dysoley L, *et al*. Glucose 6 Phosphate Dehydrogenase (G6PD) quantitation using biosensors at the point of first contact: a mixed method study in Cambodia. *Malar J* 2022;21:282.
19 Adhikari B, Tripura R, Dysoley L, *et al*. Glucose-6-Phosphate Dehydrogenase (G6PD) Measurement Using Biosensors by Community-Based Village Malaria Workers and Hospital Laboratory Staff in Cambodia: A Quantitative Study. *Pathogens* 2023;12:400.
20 Miller E, Sikes HD. Addressing Barriers to the Development and Adoption of Rapid Diagnostic Tests in Global Health. *Nanobiomedicine (Rij)* 2015;2:6.
21 Boadu NY, Amuasi J, Ansong D, *et al*. Challenges with implementing malaria rapid diagnostic tests at primary care facilities in a Ghanaian district: a qualitative study. *Malar J* 2016;15:126.
22 Asiimwe C, Kyabayinze DJ, Kyalisiima Z, *et al*. Early experiences on the feasibility, acceptability, and use of malaria rapid diagnostic tests at peripheral health centres in Uganda-insights into some barriers and facilitators. *Implement Sci* 2012;7:5.
23 Ivanov A. Barriers to the Introduction of New Medical Diagnostic Tests. *Lab Med* 2013;44:e132–6.
24 Engel N, Ganesh G, Patil M, *et al*. Barriers to Point-of-Care Testing in India: Results from Qualitative Research across Different Settings, Users and Major Diseases. *PLoS One* 2015;10:e0135112.
25 Beisel U, Umlauf R, Hutchinson E, *et al*. The complexities of simple technologies: re-imagining the role of rapid diagnostic tests in malaria control efforts. *Malar J* 2016;15:64.
26 Na'uzo AM, Tukur D, Sufiyan MB, *et al*. Adherence to malaria rapid diagnostic test result among healthcare workers in Sokoto metropolis, Nigeria. *Malar J* 2020;19:2.
27 Hutchinson E, Reyburn H, Hamlyn E, *et al*. Bringing the state into the clinic? Incorporating the rapid diagnostic test for malaria into routine practice in Tanzanian primary healthcare facilities. *Glob Public Health* 2017;12:1077–91.
28 Pai NP, Vadnais C, Denkinger C, *et al*. Point-of-care testing for infectious diseases: diversity, complexity, and barriers in low- and middle-income countries. *PLoS Med* 2012;9:e1001306.
29 Bowen DJ, Kreuter M, Spring B, *et al*. How we design feasibility studies. *Am J Prev Med* 2009;36:452–7.
30 Sekhon M, Cartwright M, Francis JJ. Acceptability of healthcare interventions: an overview of reviews and development of a theoretical framework. *BMC Health Serv Res* 2017;17:88.
31 SD Biosensor. STANDARD g6pd analyzer. SD Biosensor. 2021 Available: https://www.sdbiosensor.com/product/product_view?product_no=183
32 Medhanyie A, Spigt M, Kifle Y, *et al*. The role of health extension workers in improving utilization of maternal health services in rural areas in Ethiopia: a cross sectional study. *BMC Health Serv Res* 2012;12:352.
33 Dysoley L, Callery JJ, Bunreth V, *et al*. Expanding the roles of community health workers to sustain programmes during malaria elimination: a meeting report on operational research in Southeast Asia. *Malar J* 2024;23:2.
34 U.S. President's Malaria Initiative. U.s. president's malaria initiative cambodia malaria operational plan fy 2023. 2022.
35 Ngor P, White LJ, Chalk J, *et al*. Smartphones for community health in rural Cambodia: A feasibility study. *Wellcome Open Res* 2018;3:69.

36 Skjefte M, Cooper S, Poyer S, *et al*. User Perceptions of a Smartphone-based Malaria Rapid Diagnostic Test (RDT) aid for Community and Private Clinic-based Health Workers in Western Kenya. 2023.
37 Laktabai J, Platt A, Menya D, *et al*. A mobile health technology platform for quality assurance and quality improvement of malaria diagnosis by community health workers. *PLoS One* 2018;13:e0191968.
38 Kheang ST, Ridley R, Ngeth E, *et al*. G6PD testing and radical cure for Plasmodium vivax in Cambodia: A mixed methods implementation study. *PLoS One* 2022;17:e0275822.
39 Center of Malariology, Parasitology and Entomology. Lao pdr national guidelines for the treatment of malaria. 2022.
40 Adhikari B, Awab GR, von Seidlein L. Rolling out the radical cure for vivax malaria in Asia: a qualitative study among policy makers and stakeholders. *Malar J* 2021;20:164.
41 Ley B, Alam MS, Kibria MG, *et al*. Glucose-6-phosphate dehydrogenase activity in individuals with and without malaria: Analysis of clinical trial, cross-sectional and case-control data from Bangladesh. *PLoS Med* 2021;18:e1003576.
42 Ley B, Alam MS, Satyagraha AW, *et al*. Variation in Glucose-6-Phosphate Dehydrogenase activity following acute malaria. *PLoS Negl Trop Dis* 2022;16:e0010406.
43 Alam MS, Kibria MG, Jahan N, *et al*. Field evaluation of quantitative point of care diagnostics to measure glucose-6-phosphate dehydrogenase activity. *PLoS One* 2018;13:e0206331.
44 Aung YN, Tun STT, Vanisaveth V, *et al*. Cost-effectiveness analysis of G6PD diagnostic test for Plasmodium vivax radical cure in Lao PDR: An economic modelling study. *PLoS One* 2022;17:e0267193.
45 RAI Regional Steering Committee. The regional artemisininresistance initiative (rai) - eliminating malaria in the greater mekong sub-region. 2024.
46 Sirimatayanant M, Hein PS, Anderson LF, *et al*. Gaps in research and capacity development for malaria surveillance and response in the Asia-Pacific: meeting report. *Malar J* 2023;22:91.
47 Lek D, Hughes J, Narann TS, *et al*. Enhancing adherence and expanding coverage of p. vivax radical cure through point of care g6pd testing in cambodia. 2024.