









RESEARCH ARTICLE

Smartphones for community health in rural Cambodia: A feasibility study [version 1; peer review: 1 approved, 2 approved with reservations]

Pengby Ngor^{1,2}, Lisa J. White ^{2,3}, Jeremy Chalk², Yoel Lubell ^{2,3}, Cecelia Favede²,
Phaik-Yeong Cheah ^{2,3}, Chea Nguon¹, Po Ly¹, Richard J. Maude ²⁻⁴,
Siv Sovannaroeth¹, Nicholas P. Day ^{2,3}, Susanna Dunachie ^{2,3,5}

¹Cambodian National Malaria Center, National Centre for Parasitology, Entomology and Malaria Control, Phnom Penh, Cambodia

²Mahidol-Oxford Tropical Medicine Research Unit, Faculty of Tropical Medicine, Mahidol University, Bangkok, Thailand

³Centre for Tropical Medicine, Nuffield Department of Medicine, University of Oxford, Oxford, UK

⁴Harvard TH Chan School of Public Health, Harvard University, Boston, USA

⁵Peter Medawar Building for Pathogen Research, University of Oxford, Oxford, UK

V1 First published: 12 Jun 2018, 3:69
<https://doi.org/10.12688/wellcomeopenres.13751.1>
 Latest published: 12 Jun 2018, 3:69
<https://doi.org/10.12688/wellcomeopenres.13751.1>

Abstract

Background: Village Malaria Workers (VMWs) are lay people trained to provide a valuable role in frontline testing and treatment of malaria in rural villages in Cambodia. Emergence of artemisinin-resistant malaria highlights the essential role of such VMWs in surveillance and early treatment of malaria. Smartphone technology offers huge potential to support VMWs in isolated and resource-poor settings.



Methods: We investigated the feasibility of issuing established VMWs with a smartphone, bespoke Android application and solar charger to support their role. 27 VMWs in Kampong Cham and Kratie provinces participated.

Results: 26/27 of the smartphones deployed were working well at study completion twelve months later. Interviews with VMWs using quantitative and qualitative methods revealed pride, ease of use and reports of faster communication with the smartphone. VMWs also expressed a strong wish to help people presenting with non-malarial fever, for which further potential supportive smartphone applications are increasingly available.

Conclusions: As a result of this pilot study, two smartphone based reporting systems for malaria have been developed at the Cambodian National Malaria Center, and the programme is now being extended nationwide. The full code for the smartphone application is made available to other researchers and healthcare providers with this article. Smartphones represent a feasible platform for developing the VMW role to include other health conditions, thus maintaining the relevance of these important community health workers.

Open Peer Review

Approval Status 

	1	2	3
version 1 12 Jun 2018	 view	 view	 view

- Gerry F Killeen** , Ifakara Health Institute, Dar es Salaam, Tanzania
Liverpool School of Tropical Medicine, Liverpool, UK
- Roma Chilengi** , Centre for Infectious Disease Research in Zambia (CIDRZ), Lusaka, Zambia
- Jannie Hugo** , University of Pretoria, Pretoria, South Africa

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

Keywords

malaria, smartphone, technology, m-health, community



This article is included in the [Mahidol Oxford Tropical Medicine Research Unit \(MORU\) gateway](#).

Corresponding author: Susanna Dunachie (susie.dunachie@ndm.ox.ac.uk)

Author roles: **Ngor P:** Conceptualization, Data Curation, Formal Analysis, Investigation, Methodology, Project Administration, Software, Supervision, Validation, Visualization, Writing – Review & Editing; **White LJ:** Conceptualization, Formal Analysis, Funding Acquisition, Investigation, Methodology, Project Administration, Resources, Supervision, Validation, Visualization, Writing – Review & Editing; **Chalk J:** Conceptualization, Data Curation, Investigation, Methodology, Project Administration, Software, Supervision, Validation, Writing – Review & Editing; **Lubell Y:** Conceptualization, Investigation, Methodology, Supervision; **Favede C:** Data Curation, Formal Analysis, Writing – Original Draft Preparation, Writing – Review & Editing; **Cheah PY:** Methodology, Validation, Writing – Review & Editing; **Nguon C:** Investigation, Supervision, Writing – Review & Editing; **Ly P:** Investigation, Supervision, Writing – Review & Editing; **Maude RJ:** Supervision, Writing – Original Draft Preparation, Writing – Review & Editing; **Sovannaroeth S:** Investigation, Supervision, Writing – Review & Editing; **Day NP:** Investigation, Resources, Supervision, Writing – Review & Editing; **Dunachie S:** Conceptualization, Formal Analysis, Investigation, Methodology, Project Administration, Supervision, Writing – Original Draft Preparation, Writing – Review & Editing

Competing interests: No competing interests were disclosed.

Grant information: The work was supported by the Wellcome Trust Major Overseas Programme in Southeast Asia [106698], the Wellcome Trust Intermediate Fellowship grant to SD [100174]; and the Bill and Melinda Gates Foundation (OPP1110500). *The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.*

Copyright: © 2018 Ngor P *et al.* This is an open access article distributed under the terms of the [Creative Commons Attribution License](#), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

How to cite this article: Ngor P, White LJ, Chalk J *et al.* **Smartphones for community health in rural Cambodia: A feasibility study [version 1; peer review: 1 approved, 2 approved with reservations]** Wellcome Open Research 2018, 3:69 <https://doi.org/10.12688/wellcomeopenres.13751.1>

First published: 12 Jun 2018, 3:69 <https://doi.org/10.12688/wellcomeopenres.13751.1>

Introduction

More than 3 billion people, including 70% of the world’s poorest people, live in rural areas¹, where access to skilled medical care may be difficult², especially during the rainy season. Trained lay people in target communities can offer, via supported schemes, a valuable contribution to diagnosis and management of medical conditions such as malaria, childbirth and childhood diarrhoea³. However, giving sufficient support to such community workers, including training updates, diagnostic support, stock control and data collection is challenging. Mobile phone technology provides the potential to improve the range and quality of services delivered by community health workers⁴, but the majority of published literature on feasibility in developing countries is focussed on standard mobile phones (“feature phones”) rather than the next generation of smartphones.

The Cambodian National Malaria Center (CNM) has an established network of Village Malaria Workers (VMWs) across 19 provinces covering a population of approximately 1.5 million people⁵. VMWs review villagers with fever, test them for malaria with a rapid test (SD Bioline Malaria Ag Pf/Pan; *Standard Diagnostics Inc*, Gyeonggi-do, Republic of Korea) and treat those with positive results with artemisinin-based antimalarial therapy. Rapid case reporting by coded text message (short message service; SMS) from feature phones has been established by CNM. We set out to evaluate the feasibility of replacing the feature phone part of this reporting system with smartphones and a bespoke Android-powered app (smartphone application).

Methods

A new smartphone application (“app”) was designed and built for Android phones using the [Open Data Kit platform](#) version 1.3^{6,7}. All instructions for installation, configuration, implementation and operation are explained in detail with examples on the [Open Data Kit website](#). The minimum system requirements for the smartphone are Android devices 4.0 and above, and the phone should be connected to the Google App Engine hosting platform. Code is available¹⁸. The app was designed to be simple to use, not require current network access to be operational, and allowed the VMW to enter case report data in an intuitive way using Khmer language ([Figure 1](#)). The information recorded by the app and sent to CNM was as shown in the screenshots in

[Figure 1](#), namely gender, age, malaria rapid test result, and residency status (permanent villager or mobile migrant). Experienced VMWs in Kampong Cham and Kratie provinces ([Figure 2](#)) were trained to use the new smartphone system. The numbers were limited by the cost of the phones. This was a service improvement project for the VMW network and ethical permission was not sought by the authors.

VMWs were called to a meeting and the proposed study explained by CNM staff. All VMWs gave verbal consent to participate in the study, and then VMWs received one smartphone (Acer Liquid Z3, *Acer*, Virginia, USA) and one solar power charger (model LG-FD12D10, *TBS Solar Solution Center*, Phnom Penh, Cambodia) each (total cost \$175 per VMW), alongside a 3-hour training session delivered at the local Health Centre by CNM staff. A coded SMS was generated automatically and sent to CNM using 2G or 3G telecommunications networks, which have an estimated 99% coverage in Cambodia⁸, including all the villages under study. The project ran for twelve months from September 2014.

Prior experience of smartphones for each VMW and their experiences in the role of VMW was established by in-person questionnaire at the outset of the study using closed questions (Pre-implementation questionnaire, [Supplementary File 1](#)). Survival of the smartphone at 12 months was determined by inspection by CNM staff, and quantitative and qualitative data on VMW’s experiences were collected by in-person questionnaire conducted by CNM health workers using open questions, translated from Khmer to English language and analysed for key emerging themes ([Supplementary File 2](#)). The information captured by the smartphone app and sent to CMN was available to the researchers. Outcome measures were 1) Survival of smartphones and chargers over twelve months and 2) Acceptability of smartphone use by VMWs using verbal questionnaires administered in-person by CNM staff.

Results

Twenty-seven experienced VMWs in Kampong Cham and Kratie provinces were trained to use the new smartphone system ([Figure 3](#)). VMWs in Kampong Cham province had previous experience with feature phones, while those in Kratie province had no experience of using phones in their work. Populations



Figure 1. Screenshots of bespoke app for data collection allowing data entry. Screenshots show gender (a), age (b), malaria rapid test result (c), residency status (permanent villager or mobile migrant) (d), and exit screen to send data including GPS signal (e).

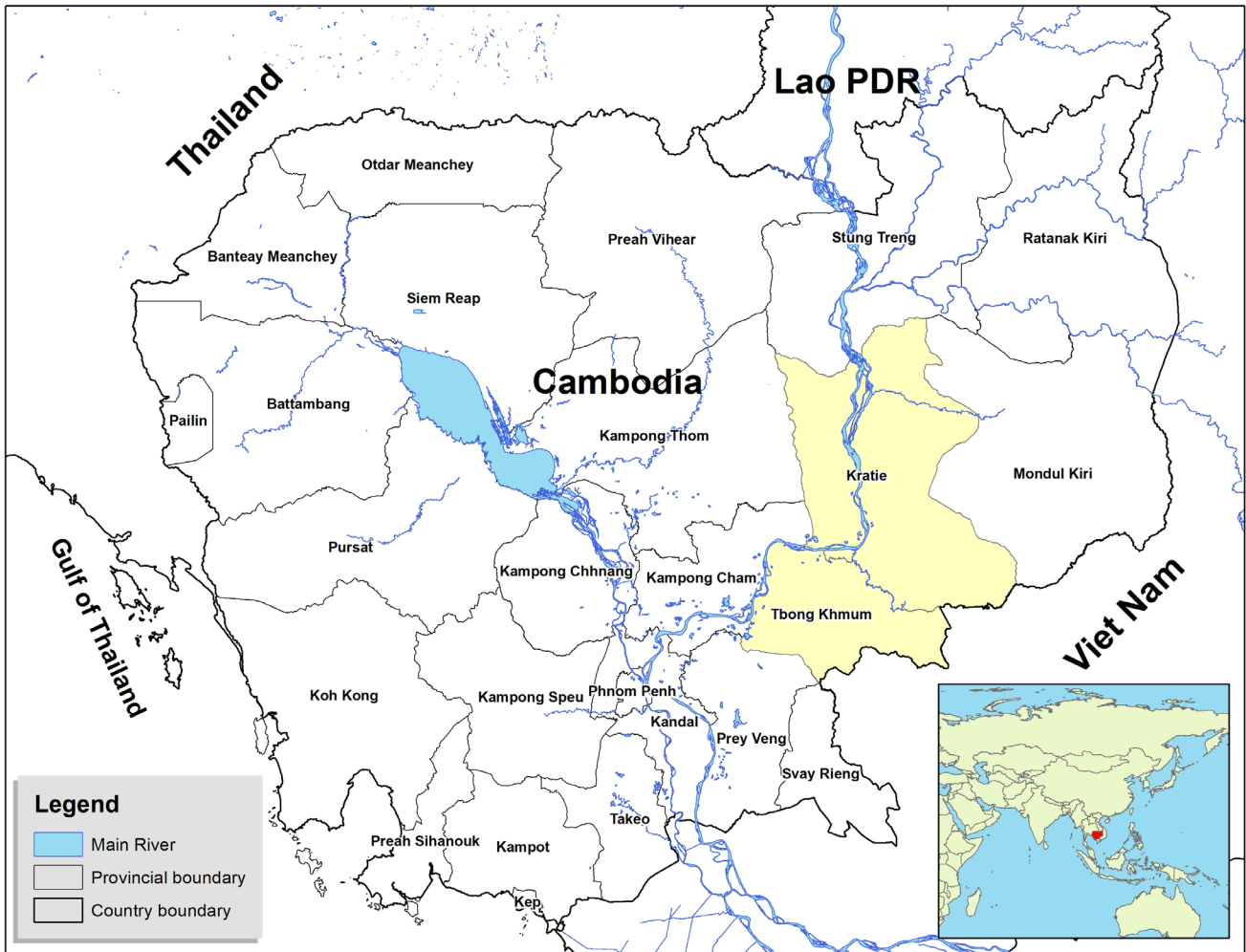


Figure 2. Map of Cambodia showing location of research. Kampong Cham and Kratie provinces are shaded yellow (source: Cambodia National Malaria Center, adapted from <http://www.un.org/Depts/Cartographic/map/profile/cambodia.pdf>. The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of the Ministry of Health of Cambodia concerning the legal status of any country, territory, city, or area or of its authorities, or concerning the delimitation of its frontiers or boundaries).



Figure 3. Village Malaria Workers (VMW) receive training. A group of VMWs in Kratie Province receiving training in the use of smartphones for the project at Sambo Health. All individuals gave their consent for the publication of this image.

were broadly similar in the two provinces in demographics and socio-economic factors. The average distance of each village to the nearest health centre was 7.53km (range 2.9–10.3 km) for Kampong Cham province, and 16.9km (range 4.57–39.1 km) for Kratie province. Road access to the health centre during the rainy season was typically considered impossible or extremely difficult.

The results of the pre-implementation in-person questionnaire at the outset of the study are shown in [Table 1](#) and [Dataset 2](#).

15/27 (56%) of the VMWs were female and the mean age was 39 years (range 20 – 62). 100% were literate (a requirement for being a VMW) with the highest level of education completed being primary school level only for 81%, and all had been in post for more than three years. 85% already owned a feature phone, but only three VMWs (11%) owned a smartphone and the majority (85%) had never used one. The baseline survey of expectations showed 78% were expecting the smartphones to make their work easier and 70% were excited/proud to be using them. Motivations for being a VMW were to help others (78%), stop malaria (63%),

Table 1. Baseline demographics and views of Village Malaria Workers in the study.

	Kampong Cham	Kratie	Total
Demographics			
Total, n	14	13	27
No. female, n (%)	7 (50)	8 (62)	15 (56)
Mean age in years (range)	38 (20 – 60)	40 (21 – 62)	39 (20 – 62)
Education beyond primary, n (%)	1 (7)	4 (31)	5 (19)
Prior phone use			
Already own feature phone, n (%)	13 (93)	10 (77)	23 (85)
Have used feature phone before, n (%)	14 (100)	10 (77)	24 (88)
Already own smartphone, n (%)	3 (21)	0 (0)	3 (11)
Have used smartphone before, n (%)	4 (29)	0 (0)	4 (15)
Expectations			
Thinks it will make VMW role easier, n (%)	14 (100)	7 (54)	21 (78)
Excited, n (%)	8 (57)	1 (8)	9 (33)
Proud, n (%)	5 (36)	5 (38)	10 (37)
Worried about losing it, n (%)	4 (29)	3 (23)	7 (26)
Worried about difficulties charging it, n (%)	0 (0)	1 (8)	1 (4)
Worried about difficulties operating it, n (%)	0 (0)	1 (8)	1 (4)
Motivation for being a VMW			
To help others, n (%)	11 (79)	10 (77)	21 (78)
To contribute to malaria control, n (%)	13 (93)	4 (31)	17 (63)
To gain respect within their community, n (%)	9 (64)	0 (0)	9 (33)
To access free health care, n (%)	7 (50)	0 (0)	7 (26)
Financial / other incentives, n (%)	7 (50)	2 (15)	9 (33)
To attain new skills, n (%)	8 (57)	2 (15)	10 (37)
Challenges faced as a VMW			
Long distance to travel to a patient's home, n (%)	1 (7)	5 (38)	6 (22)
Lack of transport, n (%)	2 (14)	4 (31)	6 (22)
Not enough time, n (%)	6 (43)	1 (8)	7 (26)
Lack of incentives, n (%)	4 (29)	1 (8)	5 (19)
Poor patient adherence / co-operation, n (%)	8 (57)	1 (8)	9 (33)
Misunderstanding about malaria, n (%)	3 (21)	1 (8)	4 (15)
Too many other tasks	3 (21)	1 (8)	4 (15)
Not enough support from the Health Centre, n (%)	5 (36)	1 (8)	6 (22)

attain new skills (37%), gain respect from their community (33%), financial/other incentives, with payment of \$20 USD per month (33%), and to gain access to free health centre services (26%). Problems faced by VMWs included poor adherence or cooperation from patients (33%), not enough time (27%), long distance to the patient's home (22%), lack of transportation (22%), not enough support from the Health Centre (22%), lack of incentives (19%), too many other tasks (15%), and misunderstanding about malaria in the village (15%).

At study completion 12 months later, a follow-up survey (Dataset 3) showed 26/27 smartphones (96%) and 27/27 solar chargers (100%) issued to VMWs were working well. One USB connector on the smartphone was broken so it could not be charged. In addition, one smartphone was stolen during the training session prior to issue. CNM reported that training was quicker and easier to conduct than for paper or feature phone data collection methods. 20/27 (74%) VMWs reported cases using smartphones - 14/14 (100%) VMWs from Kratie province (no previous feature phone experience) and 6/13 (46%) from Kampong Cham province (with previous feature phone experience) reported data. For the 7 VMWs who did not report cases using smartphone, 2 recorded malaria cases by paper records, while for the remaining 5 there were no malaria cases reported. Negative test results were not routinely reported by SMS in accordance to CNM policy (due to funding limits on the number of SMSs allocated to the scheme).

All 27 VMWs were interviewed by CNM health workers at the end of the study using a semi-structured format with a topic guide, to evaluate experience and attitudes (Supplementary Data 3). Three main themes emerged: enjoyment and pride of owning the smartphone, finding it easier to use than a feature phone for their role (Kampong Cham province), and thinking that it allowed faster communication. VMWs were asked about what people in their village said about the smartphone and the key themes were curiosity, envy, surprise and being aware of the phones attracting a lot of attention in the village.

The pre-implementation questionnaire found evidence that in villages with much reduced malaria incidence, many villagers who have fever are no longer consulting VMWs. 59% of VMWs reported that only 'some' villagers would see them with a fever. In a 3-month period (Sep-Nov 2014) the information captured by the smartphone app showed tests on 89 febrile villagers were reported in the 13 villages in Kampong Cham province (mean 7 per village, range 3–10) including 19 malaria positive cases. In contrast, in the same period in Kratie, 688 tests on febrile villagers were reported (mean 49 per village, range 25–75) including 371 malaria positive cases. We also found evidence of frustration amongst VMWs that they were unable to help those with non-malarial fever, with 17/27 (63%) wanting to learn more about healthcare.

Discussion

This pilot study demonstrates the feasibility of using a smartphone with a bespoke app to support community health workers in rural villages in low-income countries. VMWs reported pride and

enjoyment at having use of a smartphone for their role, and felt it allowed faster communication. The smartphone raised the profile of the VMW in their village.

A previous systematic review of 42 studies of using mobile technology in developing countries⁹ has shown the feasibility and some descriptive evidence of effectiveness of delivering healthcare using predominantly feature phones by professional front line workers such as midwives, pharmacists, nurses, doctors and some Community Health Workers (CHWs). Innovative studies are emerging demonstrating the role of smartphone apps delivered by professional healthcare workers in developing countries for health such as hearing screening in South Africa¹⁰ and visual acuity testing in Kenya¹¹. In addition, use of a smartphone-based electronic decision support system by CHWs has shown promise for cardiovascular management in rural Tibet and India¹². The current study expands the literature to demonstrate feasibility and acceptability in an impoverished population of Cambodian CHWs, to support malaria control strategies.

The emergence and spread of artemisinin resistant malaria in Cambodia^{13–15} is a major threat to global health, thus control of malaria in rural Cambodia is of the utmost importance. We identified low numbers of malaria cases detected by the VMWs in this study, with many VMWs feeling frustrated at being unable to help those with non-malaria fever under the current scheme. After a number of 'negative' tests people might not consult the VMW with a fever anymore, thus the sentinel role of the VMW scheme in surveillance for malaria is reduced. This undermines malaria control programs because future outbreaks of malaria could go unnoticed and then spread to surrounding regions.

Based on the evidence of this study and the national capacity built in the relevant coding skills, the co-authors at the national control program in Cambodia are now developing two smartphone based reporting systems for malaria. At the VMW level, the application developed in this study has been extended to record all the case data recorded by VMW in paper records. This information is then uploaded directly to the national malaria database after entry. There is a plan to install this application on 3300 smartphones for introduction in 14 districts, 22 districts, 9 districts in 2018, 2019, 2020, respectively, with a view to paperless reporting in the future. An additional feature of an SMS alerting system has been included in selected pilot areas, which immediately reports every new case to every level of the surveillance system. This system has been integrated into a reactive case detection intervention in the piloted areas. At the health centre level, a similar application has been developed which focuses on case reports and stock-out alerts for treatments and diagnostics. This application has been installed on tablets in 816 health centres covering the entire malaria endemic area of Cambodia.

The limitations of this study are the small numbers of VMW involved, the short duration of follow up and the restricted amount of information collected on follow-up. These restrictions are due to the project being conducted with no extra resources available. In addition, the extension of the project by the CNM

due to excellent informal feedback meant longer follow up was no longer feasible or deemed necessary.

The VMW scheme in Cambodia urgently needs to be enhanced and extended to be the front line in monitoring for drug resistance and future epidemics. To achieve this, and to maintain its relevance to local communities, it should also become a service for other health problems, transforming VMWs into CHWs. These CHWs would treat or refer patients with other health concerns making them the first point of contact in a village. We have demonstrated smartphone technology to be a robust platform for delivery of these services in the local language, enabling use of voice calls, SMS, photography, video, audio and GPS location tracking. As telecommunication network coverage and mobile use expand globally, exploitation of smartphone applications hold growing promise to tackle the world's greatest health issues. This highly successful pilot project of introducing smartphone-based reporting for malaria has allowed the CNM to develop the platform for implementation.

Data and software availability

Dataset 1: Baseline Demographics and Views VMW survey available on Figshare, <https://doi.org/10.6084/m9.figshare.6326723>¹⁶

Dataset 2: Post Implementation Survey VMWs available on Figshare, <https://doi.org/10.6084/m9.figshare.6327221>¹⁷

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

Archived source code of Smartphone App at time of publication: <https://doi.org/10.6084/m9.figshare.6353210>¹⁸

License: [CC0](#)

Supplementary material

Supplementary File 1: Pre-implementation survey: Baseline Demographics and Views.

[Click here to access the data.](#)

Supplementary File 2: Post-implementation survey: VMWs' experience of using smartphones.

[Click here to access the data.](#)

References

1. United Nations DoEaSA, Population Division: **World Urbanization Prospects: The 2014 Revision**. New York, USA; 2015. [Reference Source](#)
2. WHO: **World Health Statistics 2014**. Geneva; 2014. [Reference Source](#)
3. Perry H, Zulliger R: **How Effective are Community Health Workers?** 2012. [Reference Source](#)
4. Braun R, Catalani C, Wimbush J, *et al.*: **Community health workers and mobile technology: a systematic review of the literature**. *PLoS One*. 2013; 8(6): e65772. [PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
5. Cox J, Sovannaroth S, Dy Soley L, *et al.*: **Novel approaches to risk stratification to support malaria elimination: an example from Cambodia**. *Malar J*. 2014; 13: 371. [PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
6. Hartung C, Lerer A, Anokwa Y, *et al.*: **Open data kit: tools to build information**

Consent

All Village Malaria Workers consented to participate in the questionnaires. This study was part of a service improvement project involving Village Malaria Workers working for the Cambodia National Malaria Center, and specific written consent to participate in the study was not deemed necessary.

Author contributions

PN, LJW, PC, JC, YL and SD conceived of the project and oversaw the design. PN and JC wrote and developed the code for the Smartphone app and trained the Village Malaria Workers (VMW) in its use. CN, PT, SS and NPD oversaw the conduct of the study. PC advised on community engagement. CF assisted with analysis of VMW questionnaires. PN, LJW, CF and SD analysed the data. PN, LJW, CF, JC, RM and SD prepared the manuscript. All authors read and approved the final manuscript.

Competing information

No competing interests were disclosed.

Grant information

The work was supported by the Wellcome Trust Major Overseas Programme in Southeast Asia [106698], the Wellcome Trust Intermediate Fellowship grant to SD [100174]; and the Bill and Melinda Gates Foundation (OPP1110500).

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

Acknowledgements

The authors wish to thank the Village Malaria Workers and communities who participated in this study, and the staff of the Cambodian National Malaria Center who assisted with training.

- services for developing regions. *Proceedings of the 4th ACM/IEEE International Conference on Information and Communication Technologies and Development*. London, United Kingdom. 2369236: ACM; 2010; 1–12.
[Reference Source](#)
7. **Open Data Kit**. Accessed 10th August 2017.
[Reference Source](#)
 8. TheGlobalEconomy.com: **Cambodia: Mobile network coverage**. 2016; Accessed 10th August 2017.
[Reference Source](#)
 9. Agarwal S, Perry HB, Long LA, *et al.*: **Evidence on feasibility and effective use of mHealth strategies by frontline health workers in developing countries: systematic review**. *Trop Med Int Health*. 2015; **20**(8): 1003–14.
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
 10. Yousuf Hussein S, Wet Swanepoel D, Biagio de Jager L, *et al.*: **Smartphone hearing screening in mHealth assisted community-based primary care**. *J Telemed Telecare*. 2016; **22**(7): 405–12.
[PubMed Abstract](#) | [Publisher Full Text](#)
 11. Bastawrous A, Rono HK, Livingstone IA, *et al.*: **Development and Validation of a Smartphone-Based Visual Acuity Test (Peek Acuity) for Clinical Practice and Community-Based Fieldwork**. *JAMA Ophthalmol*. 2015; **133**(8): 930–7.
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
 12. Tian M, Ajay VS, Dunzhu D, *et al.*: **A Cluster-Randomized, Controlled Trial of a Simplified Multifaceted Management Program for Individuals at High Cardiovascular Risk (SimCard Trial) in Rural Tibet, China, and Haryana, India**. *Circulation*. 2015; **132**(9): 815–24.
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
 13. Ashley EA, Dhorda M, Fairhurst RM, *et al.*: **Spread of artemisinin resistance in *Plasmodium falciparum* malaria**. *N Engl J Med*. 2014; **371**(5): 411–23.
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
 14. Noedl H, Se Y, Schaefer K, *et al.*: **Evidence of artemisinin-resistant malaria in western Cambodia**. *N Engl J Med*. 2008; **359**(24): 2619–20.
[PubMed Abstract](#) | [Publisher Full Text](#)
 15. Dondorp AM, Nosten F, Yi P, *et al.*: **Artemisinin resistance in *Plasmodium falciparum* malaria**. *N Engl J Med*. 2009; **361**(5): 455–67.
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
 16. Dunachie S, Ngor P, White LJ, *et al.*: **Pre-implementation survey**. *figshare*. Dataset. 2018.
[Data Source](#)
 17. Dunachie S, Ngor P, White LJ, *et al.*: **Post-implementation survey**. *figshare*. Paper. 2018.
[Data Source](#)
 18. Dunachie S, Ngor P, Chalk J, *et al.*: **Code for Smartphone app**. *figshare*. Code. 2018.
[Data Source](#)

Open Peer Review

Current Peer Review Status: ? ? ✓

Version 1

Reviewer Report 27 July 2018

<https://doi.org/10.21956/wellcomeopenres.14942.r33433>

© 2018 Hugo J. This is an open access peer review report distributed under the terms of the [Creative Commons Attribution License](#), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.



Jannie Hugo 

Department of Family Medicine, School of Medicine, University of Pretoria, Pretoria, South Africa

Thank you for the opportunity to review the article.

The article is relevant for the file of community oriented primary care (COPC). The use of smartphones is essential for this work. The study is well designed and clearly reported.

An issue that is not addressed in the article is how the information on the cell phone is used. An important aspect of the use of mobile ICT is the way in which data is used to inform and adapt practice. It is not good enough for data to be used for reporting purposes only, it should guide practice. Another issue is how the system facilitate clinical support for the community based workers.

The authors can consider to mention these issues in the article and state how it is addressed or how a future study can address that.

Otherwise the article is acceptable for indexing.

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

Yes

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

Yes

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

Yes

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

Not applicable

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

No source data required

Are the conclusions drawn adequately supported by the results?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Community oriented primary care, family medicine, health worker education

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Reviewer Report 09 July 2018

<https://doi.org/10.21956/wellcomeopenres.14942.r33291>

© 2018 Chilengi R. This is an open access peer review report distributed under the terms of the [Creative Commons Attribution License](#), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.



Roma Chilengi 

Centre for Infectious Disease Research in Zambia (CIDRZ), Lusaka, Zambia

Overall, I felt the article was well-written and succinct, identifying a relevant improvement to support the work of an important niche health service provider (the VMW). Data collection for the study involved administration of a pre-study questionnaire, and in person questionnaire to collect qualitative and quantitative data on volunteers' experiences. Outcome measures were (1) Survival of smart phones and chargers over 12 months post-study commencement (as determined by inspection of the equipment by CNM staff) and (2) acceptability of smart phone use by VMWs (emerging themes from the in-person questionnaires were collated).

The study made the assertion "**the current study expands the literature to demonstrate feasibility and acceptability in an impoverished population of Cambodian CHWs, to support malaria control strategies.**" In my view, however, the methods were not sufficient to capture some key feasibility and accessibility information. Furthermore, it appears that in some communities, the role of VMW is becoming obsolete in some areas "**In the context of their current role in villages with reduced malaria, villagers presenting with fever are frequently not consulting VMWs.**" The authors acknowledge the limitations posed by the small number of VMWs in the pilot study, the short duration of follow-up, and the restricted amount of information collected on follow-up, and also suggest the necessity to enlarge the role of VMWs to include more CHW responsibilities.

Recommendation: the authors might consider demonstrating how readily the VMW role could be expanded to a more general CHW role, which to me would ably make the case for feasibility. Most developing countries are plagued by a range of infectious diseases and finding broader public health use of technology would be more beneficial.

Assessing feasibility of the proposed implementation

The study was conducted in two health areas in communities that had different malaria profiles, with VMWs who had differing levels of prior exposure to smart phones, which makes the results feel more compelling. Literacy is a requirement for being a VMW, which may not be the case for community health workers in other settings.

Recommendation: the authors might consider discussing the ramifications of deploying the app more generally in the context of the literacy requirement.

Assessing technological and system capabilities/requirements

Implementation required provision of a smart phone, solar-powered smart phone charger and three hours of instruction.

This amount of training seemed to be adequate and effective, even in the cohort which had little prior exposure to smart phones, which suggests good feasibility in terms of skills transfer/capacity building. The study was carried out over a 12-month period, with the majority phones and chargers being found to be in good condition after that interval, further making the argument for feasibility. The authors acknowledged the short time frame (given the high cost, it would be expected that the lifetime of the phone would need to be significantly higher than one year). However, usage and storage conditions were not specifically addressed, and it was not clear to what extent smart phone durability was tested in real world conditions. If the expectation is that the phone systems are kept in a locked cabinet in the clinic the majority of the time, this may affect feasibility.

Recommendation: the authors might consider addressing how and when phones were accessible to the VMWs.

Advantages: The mobile app is simple to use, intuitive and does not require current network access to be operational. The software code open source and available online, making the study intervention accessible and replicable in that respect. The availability of 99% mobile data coverage in the study setting made it feasible for this study, but would perhaps be a concern for other remote health areas interested in trying this model.

Recommendation: the authors might consider discussing the practicalities of implementation in settings with less robust mobile data coverage (however, this may be considered to be outside of the scope of the study)

Concerns

1. The cost of USD175 per VMW seemed prohibitive to scaling. The article reports that **“the numbers were limited by the cost of the phones”** a challenge which lies at the heart of feasibility.

Recommendation: the authors might consider addressing how this cost would be managed (the use of “supported schemes” is mentioned early in the text but not elaborated upon when referring to the plan for staged introduction of phones).

2. The authors chose to combine the findings of pride and excitement/proud to be using the phone. However, this concealed the fact that when disaggregated, the numbers for each category were actually quite low: My concern was that the study may not have adequately captured concerns relating to the use of the smart phone (given the closed nature of the questionnaire), and that problems might therefore be replicated. I would be interested to know why the 2 VMWs used paper records rather than the phones, and whether, if the other 5 VMWs had no cases to report, is introducing an expensive cellphone really feasible? I would further be interested in gaining more specific information about the uptake and use of the technology in the village with high numbers of reporting, and to what extent paper reports were generated in that setting, which is not elaborated in the text.
3. I felt that the study did not capture how the use of phones would/did make the work easier: I assume it would be related to data reporting, but this is not specified in the article. While the study was able to record that VMWs *felt* the smart phones would allow faster communication, it is not specified if that was actually the case. The methods used did not capture this question, and it is not clear if that was assessed or determined in any way.
4. The authors make the assertion: **“we have demonstrated smartphone technology to be a robust platform for delivery of these services in the local language, enabling use of voice calls, sms, photography, videos, audio and gps tracking.”** Recommendation: the authors might consider disaggregating the data from the group which reported a large number of malaria cases using the smartphones to more strongly support this assertion.

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

Yes

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

Partly

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

Partly

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

Not applicable

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

Yes

Are the conclusions drawn adequately supported by the results?

Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Field epidemiology, infectious disease and child vaccines

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have

significant reservations, as outlined above.

Reviewer Report 05 July 2018

<https://doi.org/10.21956/wellcomeopenres.14942.r33292>

© 2018 Killeen G. This is an open access peer review report distributed under the terms of the [Creative Commons Attribution License](#), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.



Gerry F Killeen 

¹ Environmental Health and Ecological Sciences Thematic group, Ifakara Health Institute, Dar es Salaam, Tanzania

² Department of Vector Biology, Liverpool School of Tropical Medicine, Liverpool, UK

Overall, a very well written and useful paper delivering useful and practically-relevant evidence.

Major comment

1. The need to shift from VMWs to CHWs is clearly spelled out in the final paragraph of the discussion, but needs to be more clearly and explicitly stated in the abstract.

Minor comments

1. The following sentence from the second paragraph of the results section is vague: "100% were literate (a requirement for being a VMW) with the highest level of education completed being primary school level only for 81%". Does that mean that 81% had not completed primary school, yet were literate? Or that 81% had primary education and the remainder has secondary or above? I'm guessing the word "only may have been misplaced in this sentence.
2. Third paragraph of the results section: It is a little unclear whether the smart phone with the damaged USB port is the one counted as not working well. If so, I think it would be worthwhile to make it clear that all 27 were still in place.
3. The first sentence of the second paragraph of the discussion is too long. Please split in two and make it read easier.

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

Yes

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

Yes

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

Yes

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

Yes

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

Yes

Are the conclusions drawn adequately supported by the results?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Malaria transmission and control

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