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Research article

Advantages of using voiced questionnaire and image capture application for data collection from a minority group in rural areas along the Thailand–Myanmar border

Siriporn Monyarit
Department of Tropical Hygiene (Biomedical and Health Informatics), Faculty of Tropical Medicine, Mahidol University, Thailand

Wirichada Pan-ngum
Department of Tropical Hygiene (Biomedical and Health Informatics), Faculty of Tropical Medicine, Mahidol University, Thailand

Saranath Lawpoolsri
Department of Tropical Hygiene (Biomedical and Health Informatics), Faculty of Tropical Medicine, Mahidol University, Thailand
Center of Excellence for Biomedical and Public Health Informatics (BIOPHICS), Faculty of Tropical Medicine, Mahidol University, Thailand

Surapon Yimsamran
Department of Tropical Hygiene (Biomedical and Health Informatics), Faculty of Tropical Medicine, Mahidol University, Thailand

Suporn Pongnumkul
National Electronics and Computer Technology Center (NECTEC), Thailand

Jaranit Kaewkungwal
Department of Tropical Hygiene (Biomedical and Health Informatics), Faculty of Tropical Medicine, Mahidol University, Thailand
Center of Excellence for Biomedical and Public Health Informatics (BIOPHICS), Faculty of Tropical Medicine, Mahidol University, Thailand

Pratap Singhasivanon
Department of Tropical Hygiene (Biomedical and Health Informatics), Faculty of Tropical Medicine, Mahidol University, Thailand

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Author address for correspondence:
Pratap Singhasivanon
Department of Tropical Hygiene,
Faculty of Tropical Medicine,
Mahidol University, 420/6 Ratchawithi Road,
Ratchathewi Bangkok 10400, Thailand
E-mail: pratap.sin@mahidol.ac.th

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ABSTRACT

Aims To compare the quality of data collection via electronic data capture (EDC) with voiced questionnaire (QNN) and data image capture features using a tablet versus standard paper-based QNN, to assess the user's perception of using the EDC tool, and to compare user satisfaction with the two methods.

Study design Randomised cross-over study.

Study sites This study was conducted in two villages along the Thailand–Myanmar border.

Methodology This study included 30 community health volunteers (CHVs) and 120 Karen hill tribe villagers. Employing a cross-over study design, the CHVs were allocated randomly to two groups, in which they performed interviews in different sequences using EDC and QNN.

Results Data discrepancies were found between the two data-collection methods, when data from the paper-based and image-capture methods were compared, and when conducting skip pattern questions. More than 90% of the CHVs perceived the EDC to be useful and easy to use. Both interviewers and interviewees were more satisfied with the EDC compared with QNN in terms of format, ease of use, and system speed.

Conclusion The EDC can effectively be used as an alternative method to paper-based QNNs for data collection. It produces more accurate data that can be considered evidence-based.

Keywords: data collection, ethnicity, mobile health, perception, questionnaires, satisfaction

INTRODUCTION

Paper-based questionnaires (QNNs) are commonly used for data collection in public health surveys, and though they are simple to use and practical, they have several drawbacks and problems. Due to the poor handwriting of data collectors, incomplete filling and damaged or lost forms, the method can be time-consuming and error-prone. Once data have been collected, more errors are introduced during subsequent data entry into a relational database. These obstacles during data collection risk producing low data quality and lead to decisions based on the wrong information. An alternative is to collect data electronically, a method that could reduce errors commonly found in QNN. Electronic data capture (EDC) instruments for data collection have become more recognised due to the falling cost of devices and continued enhancements to their performance.

The benefits of using EDC for data collection have been demonstrated in several previous studies around the world,[1–7] and include reduced time for data collection,[2] more complete data,[6] direct data entry and direct data transfer,[10] programmed error checking by transparent decision algorithms, forced data entry, automated skip patterns and reduced time from study implementation to manuscript submission.[11] However, disadvantages of using EDC remain, including higher equipment costs, extensive time and programming needed to develop EDC systems and a lack of ability to verify miscoded data against paper records, once data have been entered.[11] One study in an office-based patient interview survey revealed that although EDC could produce more complete data than the paper method, numerous data went missing due to technical difficulties with handheld computers, and loss/theft of equipment.[6]

Many kinds of devices have been developed for EDC, including personal computers (PCs), notebook PCs, personal digital assistants (PDAs) and mobile devices. In a study in Africa, researchers used PDAs for field research data collection and reported that using PDAs removed the typical time-consuming and error-prone process of data entry and validation.[8] A study that conducted a health-related survey using PDAs for data collection, among a hard-to-reach population in China, also assessed its acceptability and adoption in the field; the study results suggested that the PDA was a favourable method for use in survey-based research.[4] Although some technical problems had occurred during the data-collection process, it remained a feasible, acceptable and preferred method for the interviewers.[4] However, a study in South Africa suggested that use of mobile phones as a data-collection tool was better than PDAs due to less data loss and fewer uploading difficulties.[9] These developing countries represent the fastest growing mobile-technology markets in the world, due to ease of network expansion, cheaper relative costs, high demand and a willingness of companies to invest.[12,13] One study in Thailand combined web-based technology with mobile technology and implemented it into routine work. The project aimed to improve antenatal care and the services of the Expanded Programme on Immunisation. The project was successful and revealed the feasibility of using electronic devices for data collection in a low-resource setting, as well as the extent to which community health care personnel in this setting could efficiently utilize technology to perform their duties.[14] Another project in Thailand aimed to improve the management of malaria cases by establishing a module for monitoring disease and treatment. This would replace the paper-based workflow previously used for the treatment and care of malaria patients. This study also demonstrated the advantages of mobile devices for disease prevention and control, and their impact on enabling effective communication.[15] Various studies argue that mobile technology is the fastest growing sector of the communications industry in low-income countries.[16] Even in resource-poor settings, the availability of mobile phones and wireless networks creates a possible alternative mechanism for data collection by using EDC instead of traditional paper-based methods.

One of the main challenges when conducting health surveys among minority groups is the language barrier – indeed several ethnic groups have no formal written language. Translating the QNN either in writing or through spoken language by the interviewer/translator runs the risk of translation error; incorrect translation, misunderstanding or using unclear wording and inconsistency in explaining the questions to different study participants. Moreover, for those parts of the QNN that may require recollection of historical and/or secondary data available in medical records or data logbooks, there may also be bias in the information collected, such as incomplete/missing information, transcription errors by the data collectors and/or recall bias of the study participants. Thus, this study proposed to collect data using an EDC tool with two functionalities – a voiced QNN and secondary data image capture. The EDC tool was developed specifically to collect data related to malaria vector control among Karen hill tribes, a minority group who speak Karen language. The main aims of this study were to compare the quality of data collected via EDC and QNN, to assess the user's perception of using the EDC tool, and to compare user satisfaction with the two methods.

MATERIALS AND METHODS

Study sites

The study was conducted in two villages in Suan Pheung District, Ratchaburi Province, Thailand, on the Thai–Myanmar border. A majority of the people who live in these areas are Karen hill tribe people and most residents do not speak Thai.

Participants

Data were collected using both the developed EDC tool and QNN from 120 households by 30 community health volunteers (CHVs). All of participants live in the study area and they mostly use Karen language in their daily lives. A simple random sampling technique was used to select the 30 CHVs from the list of all CHVs working in the study areas. The CHVs were then randomly allocated to two groups, in which they would perform their interviewing tasks in different sequences using the two data-collection methods (EDC and QNN). A convenience sampling technique was employed for selecting households that were under the responsibility of the selected CHVs. An adult (preferably the head of the household) in each household was selected as a study participant who gave information about malaria prevention and control within his/her house.

EDC application development

The QNN was developed to collect data on malaria prevention and control by a set of experts who work in the field. Based on the items on the QNN, the EDC was developed on a Samsung Galaxy Tab 7.0 plus with the 7 in. display. The EDC application ran on Android SDK, and was built using the Eclipse open-source software. The application was installed on the tablet and provided to CHVs to collect data in the study areas. The EDC application consists of four main features. Examples of EDC screens are shown in Figure 1.

Voiced questioning feature

All items in the QNN were translated twice by two local experts who could both speak and read Thai and Karen languages. The verified version of the translation was used in the EDC application for interviewing the Karen participants, removing the need for the CHVs to translate the questions and answers when performing the interview. The aim of this feature was to reduce the risk of misunderstanding, reduce interviewer bias, as well as establish concordance with the standardised QNN.

Data image-capture feature

This feature was created to collect secondary data regarding brands of bed net and indoor residual spraying records, which are part of the essential data collected by the malaria authorities during their routine surveys. As the brands of bed net (usually distributed by the health care authorities for free and/or bought by the villagers by themselves) are all in English, both villagers (interviewees) and CHVs (interviewers) with a limited education may have difficulties reading, recalling or writing such information. For this, and the indoor residual spraying record (usually written on the household pole or wall), the interviewers could simply take a photo of the spraying counts rather than asking for the number and entering it into the QNN. The goal of this image capture was to reduce workload and mistakes in form filling by the interviewers.

Automated skip patterns

Some questions in the QNN involved skip patterns. The interviewer needs to skip some questions should the respondents answer a certain option of the leading question. This feature aimed to reduce human error in skipping or not skipping the question that could lead to incomplete data.

GPS feature

This built-in tablet feature could be used for capturing household locations of the study participants automatically. It is anticipated that such features could be useful for health care providers to see the distribution of malaria resource allocation (e.g. bed net or spraying coverage) geographically.

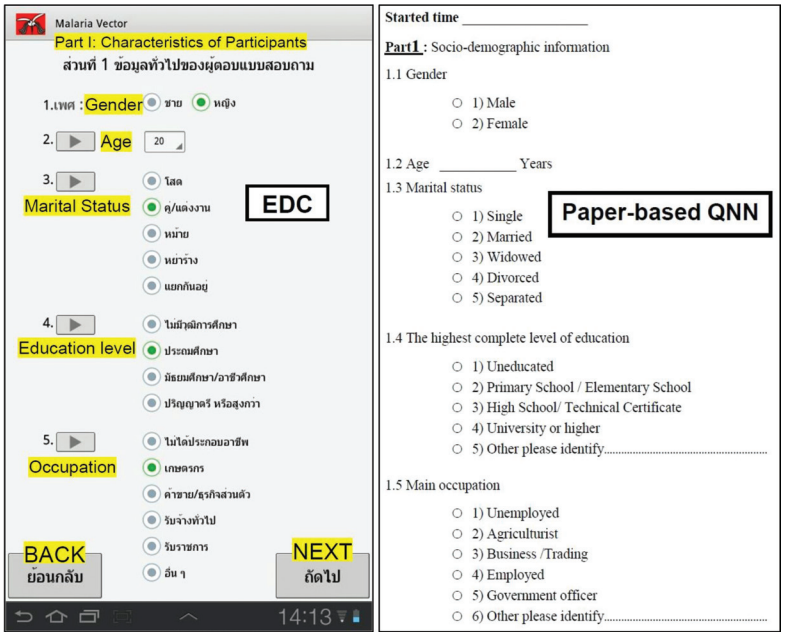
Study design and data collection

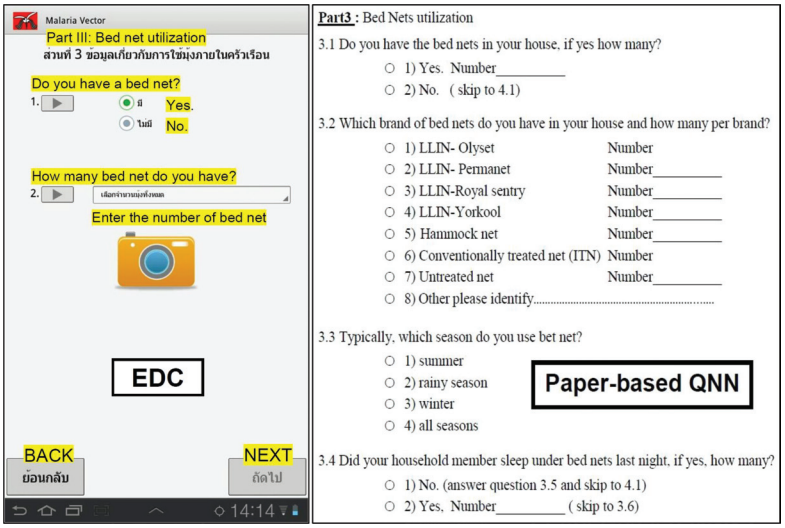
A randomised cross-over design was employed for this study. The CHVs were randomly allocated to two groups with different sequences of the two data-collection methods. Each CHV collected the same data using either the EDC application before QNN, or vice versa. By using each method, each of CHVs collected data from four different Karen participants. To prevent the carry-over effect, a washout period of about 2 weeks was set up after initial data collection. The data-collection process is summarised in Figure 2. The data for the QNN were collected by CHVs in both Thai and Karen languages during the interview depending on the degree of understanding by the Karen participants; all data were subsequently entered into the database manually. When collecting data with the EDC tool, the CHV interviewers used voiced questions and answers programmed on the tablets instead of asking the questions by themselves. The CHVs simply pressed a button in the application; then each question and answer(s) were provided in the Karen language. When it came to questions regarding bed net brand or indoor residual spraying records, the interviewers took photos instead of requesting information from the interviewees. If the picture was not sharp/clear, the CHV could re-capture it. The data were collected and recorded automatically on the EDC tablet as an off-line system, and subsequently synchronised with the server when an internet connection or cell phone signal was available. Images were checked for completeness once they were downloaded into the system.

After the cross-over study was complete, user satisfaction regarding the two data-collection methods was measured in both the Karen participants and the CHVs, using a QNN. In addition, the user perception of working with the EDC was assessed among the CHVs.

Training of interviewers

Training workshops were arranged for all CHVs who were to interview participants, to ensure that the two data-collection





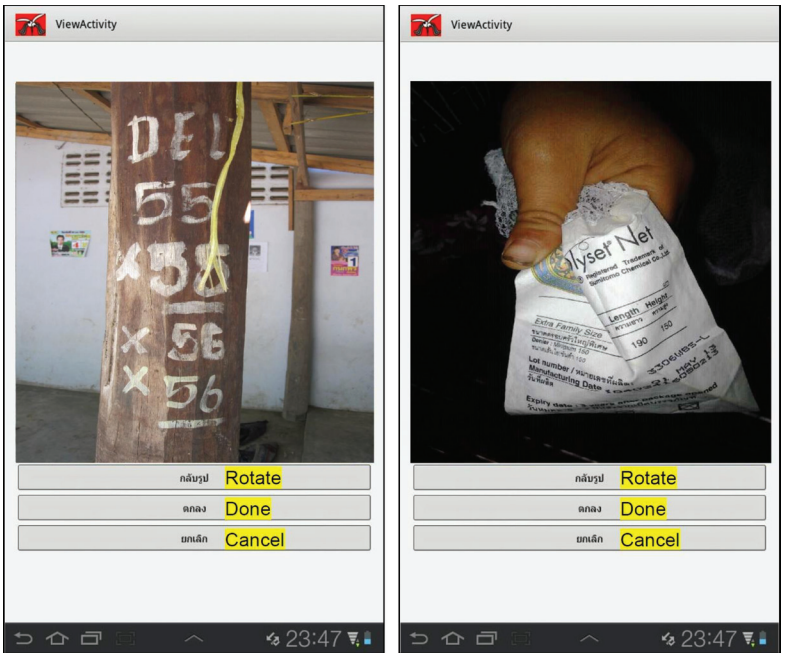


Figure 1 **Examples of EDC forms and paper-based QNN.**

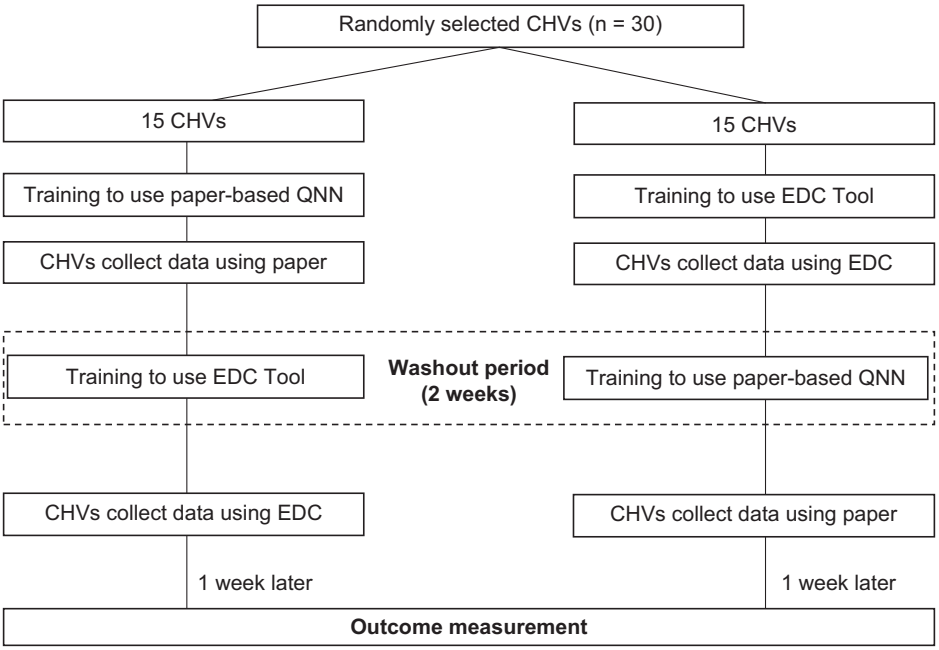


Figure 2 Data-collection process.

methods were performed properly. Most interviewers had never had any experience with tablets before. All were trained to perform data collection using both EDC with tablets and paper-based methods. According to the cross-over design, the CHVs were randomly allocated to two groups, where each group was trained separately and in the reverse order. The training sequence is shown in Figure 2. The training lasted around 3 h, and included the basics of using the tablet and QNN. A mock-up of the data-collection process was set up for all interviewers to practise with the two data-collection methods.

Study variables and data analysis

The QNN consisted of five items of socio-demographic data about the household participants and 13 items related to malaria vector-control information. In the QNN, the questions were usually multiple-choice but in the EDC they were dropdown choices following the voice-translation application in the Karen language. Two questions in the QNN regarding brand names of bed net and insecticide residual spraying (IRS) were redesigned as image capture features on the EDC tool.

The data regarding malaria vector control obtained from the structure QNN was used for further data analysis by public health personnel. However, this study focused on the use of two data-collection methods. Therefore, the main outcomes of interest were data discrepancy, user perception, and user satisfaction with the data-collection methods. Data discrepancy was identified from comparisons between self-reporting information (through QNN) regarding brand names of bed nets and numbers of IRS against captured images (via EDC tool) of the bed nets and spraying records in the households. The skip pattern of a certain question on the QNN was compared against the automatically skipped question on the EDC tool. User perception about the EDC was measured by adopting the technology acceptance model (TAM)[17] in terms of perceived usefulness and perceived ease of use.

After using the two data-collection methods, user satisfaction was assessed in both CHVs and Karen participants. Satisfaction was measured in three constructs – format, ease of use and system speed. The three dimensions of user satisfaction were based on the information application concept.[18,19]

RESULTS

Demographic characteristics of the participants

A total of 30 CHVs and 120 household participants took part in this study. The majority of both CHVs and household participants were female, aged 30 years old or younger. About 70% of household participants had no formal education, whereas most CHVs had graduated primary or high schools. Approximately, one-third of household participants were employed. However, about 30% of CVHs were unemployed (including house wives and students). The demographic characteristics of the participants are presented in Table 1.

Data discrepancy

The data discrepancy between the two methods was analysed by comparing the results of two questions about the brand of bed net and IRS. As shown in Table 2, the results obtained through the two collection methods were different; with QNN, a number of the respondents wrongly reported the brand of bed net they used, as compared with pictures of the bed net captured from the tablet. For instance, about 90% of respondents reported that their bed nets were regular bed nets, while only 77% of bed net pictures in fact were. In addition, the respondents tended to underestimate the number of IRS records; about 15% of respondents reported that their houses had been sprayed six times, while the pictures of IRS records showed that 27% of households had been sprayed six times.

Data discrepancy was also compared for a question involving a skip pattern. Question 3.4 in the QNN has a skip

Table 1 Demographic characteristics of the participants

Characteristic	Household participants (*n* = 120)		CHVs (*n* = 30)	
	n	%	*n*	%
Gender				
Male	36	30.0	10	33.3
Female	84	70.0	20	66.7
Age (years)				
≤30	44	36.7	13	43.3
31–40	38	31.7	7	23.4
41–50	22	18.3	9	30.0
>50	16	13.3	1	3.3
Education				
No formal education	83	69.2	2	6.7
Primary school/elementary School	18	15.0	17	56.7
High school/technical	17	14.2	11	36.7
Certificate				
University or higher	1	0.8	0	0
Others	1	0.8	0	0
Occupation				
Unemployed	21	17.5	9	30.0
Small-scale farmer	9	7.5	5	16.7
Business/trading	5	4.2	1	3.3
Unskilled labourer	80	66.7	14	46.7
Government officer	4	3.3	1	3.3
Other	1	0.8	0	0

Table 2 Data discrepancy between using the EDC and the QNN for data collection

Answers	Number of bed net			
	Paper		EDC	
	n	%	*n*	%
Brand of bed net (*n* = 112)				
1) LLIN-Olyset	7	2.8	15	6.4
2) LLIN-Permanent	24	9.5	32	13.6
3) LLIN-Royal Sentry	0	0.0	7	3.0
4) LLIN-Yorkool	2	0.8	1	0.4
5) Regular Bed net	219	86.9	180	76.6
Total response	252	100	235	100
No. of IRS record (*n* = 112)				
0	2	1.7	3	2.5
1	11	9.2	15	12.5
2	38	31.7	21	17.5
3	21	17.5	17	14.2
4	10	8.3	16	13.3
5	15	12.5	16	13.3
6	19	15.8	32	26.7
Total response	116	100	120	100
Skipping pattern				
Skip Q 3.5	82	74.5	117	100
Did not skip Q.3.5	28	25.5	0	0
Total response	110	100	117	100

Regular Bed net = ITN + Untreated Net,
Omit eight cases did not take a picture
Q.3.4) Did your household members sleep under bed nets last night?
Q.3.5) What are the reasons for not using a bed net last night?
Q.3.6) Did the net that was used last night have any holes?

pattern, and those who answered '*slept under a bed net last night'* should skip question 3.5 (*reasons for not sleeping under a net*) and go straight to question 3.6. A total of 117 study participants answered question 3.4 as '*slept under a bed net last night'*, and in the QNN about 75% of respondents skipped the question 3.5 properly but 25% did not. This contrasts the result of the EDC where 100% of those who answered '*slept under a bed net last night'* in question 3.4 had skipped question 3.5.

User perception among CHVs

User perception was assessed in two dimensions: perceived usefulness and perceived ease of use. The results for perceived usefulness are shown in Figure 3. Over 90% of CHVs perceived that the EDC was useful for data collection. However, one CHV chose '*strongly disagree'* on two items: '*using EDC enables me to accomplish the tasks more quickly'* and '*using EDC improves my job performance'*. For perceived ease of use, >90% of the CHVs selected '*agree'* or '*strongly agree'* but again there was one CHV who answered '*disagree'* on two items: '*learning to operate the EDC is easy for me'* and '*overall, I find the EDC easy to use'*. Two CHVs chose '*disagree'* on '*it would be easy for me to become skilful at using the EDC'*. The results of perceived ease of use are shown in Figure 4.

User satisfaction

User satisfaction with the two methods was assessed in both groups, interviewers and interviewees. The average satisfaction ratings for both methods were above the midpoint for both interviewers and interviewees, indicating that they were satisfied with both methods of data collection. In the case of the EDC, the highest mean score for both study groups was satisfaction with system speed. For QNN, the highest mean score was satisfaction with ease of use. Significant differences in satisfaction between the two data-collection methods were found in each group. The results indicate that participants in both groups were more satisfied with the EDC than with QNN in all dimensions: format, ease of use, system speed and overall satisfaction. The results are shown in Table 3.

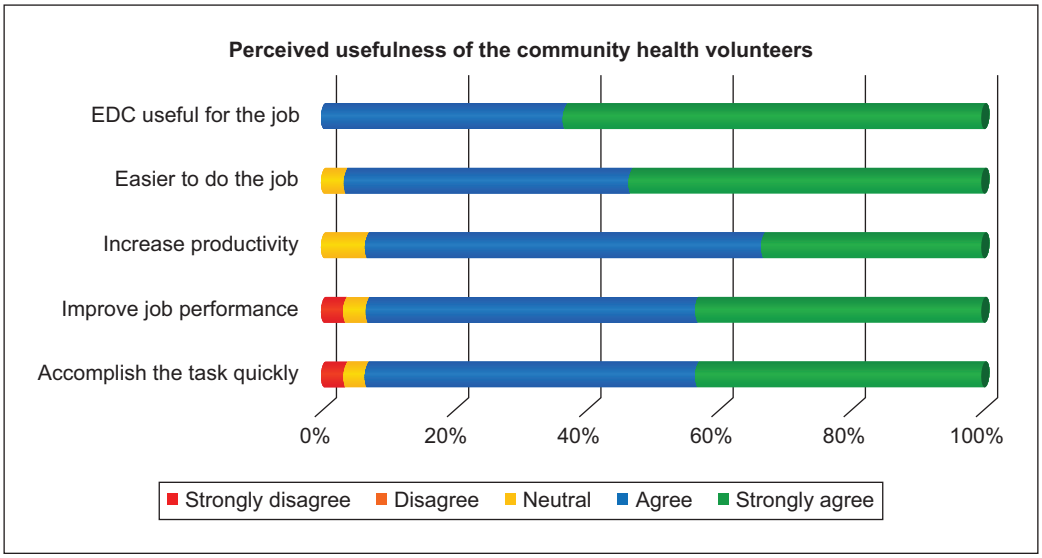


Figure 3 **Perceived usefulness of EDC among CHVs.**

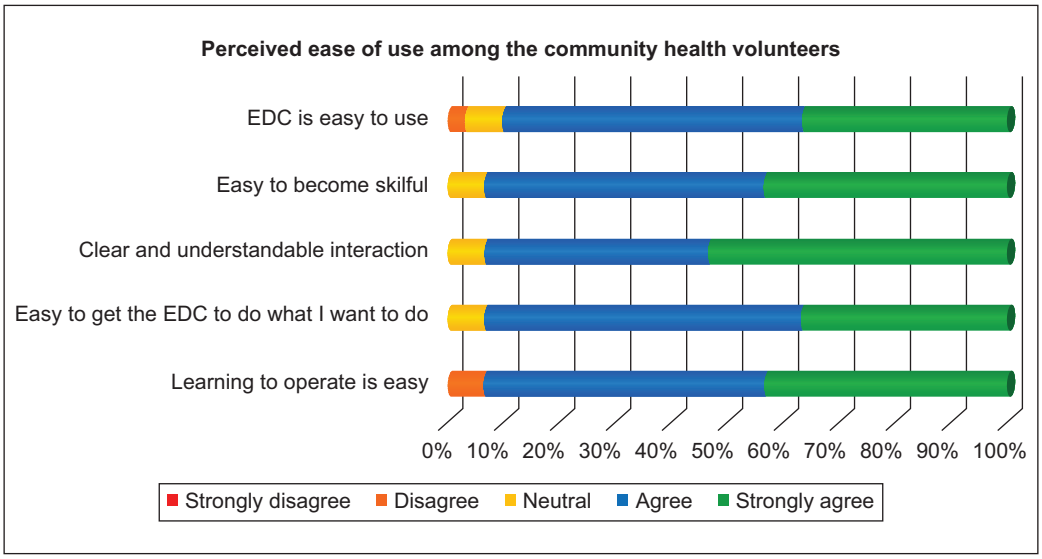


Figure 4 **Perceived ease of use of EDC among CHVs.**

DISCUSSION

Implementing EDC in data collection could facilitate more effective data collection. The advantages of using the EDC developed in this study confirm the results of previous studies.[1–7] The results of this study indicate that the voiced QNN is a novel method in EDC, and there is also a novel reason for image capture for community surveys, particularly in minority groups that do not speak mainstream language. EDC can help minimize common data-collection problems and allows direct data entry in the field. A particular strength of the EDC in this study was the pre-set standardised translation of questions and answers into Karen languages, which established more effective communication between interviewers and interviewees, and avoided the risk of translation errors. Compared with paper-based data capture, the use of EDC significantly reduced subsequent manual data entry, since the surveyed data are automatically uploaded into the electronic database. Transcription errors arising while copying data from paper forms to relational database (often done by persons who did not collect the data directly) can thus be avoided. The image capture feature of the EDC tool developed in this study emerged as a very good method for collecting evidence-based data. When using QNN, the CHVs need to read, write and sometimes guess the brand names of the bed nets (which are in English – a language CHVs rarely speak) and they need to count and write down the number of IRS records in each house. Due to unclear data on paper, errors can occur during data entry into the database. In contrast, image capture features allow the CHVs who usually cannot read English to collect data regardless of educational level – although they require proficiency in camera use. If the picture is unclear, it might lead to error or incomplete data, making training essential in new tool implementation.

Table 3 Comparison of user satisfaction

Dimensions of satisfaction	Household participants (*n* = 120)			CHVs (*n* = 30)		
	EDC	Paper	*p-Value**	EDC	Paper	*p-Value**
Format						
(1) Not too satisfied	1 (0.8)	4 (3.3)		0 (0.0)	1 (3.3)	
(2) Moderately satisfied	35 (29.2)	74(61.7)		9(30.0)	20(66.7)	
(3) Very satisfied	84 (70.0)	42(35.0)		21(70.0)	9(30.0)	
Mean ± SD	2.69 ± 0.48	2.32 ± 0.53	< 0.001	2.70 ± 0.47	2.27 ± 0.52	0.001
Ease of use						
(1) Not too satisfied	2 (1.7)	5 (4.2)		1 (3.3)	2 (6.7)	
(2) Moderately satisfied	26 (21.7)	58(48.3)		8(26.7)	16(53.3)	
(3) Very satisfied	92 (76.6)	57(47.5)		21(70.0)	12(40.0)	
Mean ± SD	2.75 ± 0.47	2.43 ± 0.58	< 0.001	2.67 ± 0.55	2.33 ± 0.61	0.016
System speed						
(1) Not too satisfied	2 (1.7)	5 (4.2)		0 (0.0)	1 (3.3)	
(2) Moderately satisfied	22 (18.3)	62(51.7)		8(26.7)	20(66.7)	
(3) Very satisfied	96 (80.0)	53(44.1)		22(73.3)	9(30.0)	
Mean ± SD	2.78 ± 0.45	2.40 ± 0.57	< 0.001	2.73 ± 0.45	2.27 ± 0.52	< 0.001
Overall satisfaction						
(1) Not too satisfied	1 (0.8)	4 (3.3)		1 (0.0)	0 (0.0)	
(2) Moderately satisfied	16 (13.3)	62(51.7)		6(20.0)	16(53.3)	
(3) Very satisfied	103 (85.7)	54(45.0)		24(80.0)	14(46.7)	
Mean ± SD	2.85 ± 0.38	2.42 ± 0.56	< 0.001	2.80 ± 0.41	2.47 ± 0.51	0.002

*Pair sample *t*-test.

Two elements of the EDC tool affected the data discrepancy between the two methods of data collection. First, the image capture feature to capture evidence-based data highlights the differences between the two data-collection methods. It could be said that the assurance of data correctness by EDC is higher than the data collected by the QNN, as it shows photographic evidence of the data. The data image capture feature also helps to get more information about both the brand names of the bed net and the number of IRS records. The second feature that has proved effective is the automated skip patterns which also produce different data from the paper-based method. With the QNN, data collection depends on interviewers understanding the logical flow of questions and skip patterns.[8] By using the automated skip patterns on the EDC, the questions were asked in the correct order and followed the expected logical flow, avoiding interviewer errors, such as skipping questions. The results from this study confirm the findings of better data quality from EDC use reported in many other studies.[1,4,10]

Successful implementation of this new tool can not only consider technical dimensions, but the background, training and interviewing experience of the users must also be considered. This study assessed the perception of the CHVs who were the users of the EDC. The results indicated that most CHVs recognised the usefulness of EDC and perceived the tool as easy to use. This suggests that there is acceptance for using the EDC for data collection. Similar results were found in a health-related survey among a hard-to-reach population in China.[4] A pilot study among breast cancer patients in the United States also displayed the feasibility and acceptability of using tablet PCs for collecting research-quality data, as well as patient-reported outcome data in outpatient academic oncology.[3,5] Interestingly, a study assessing the acceptability and feasibility of using a mobile phone application for health care delivery among health care workers found conflicting results. The study found that while health care workers expressed positive perceptions towards mobile health, the results demonstrated poor uptake in their actual practice.[20] This should be one of the concerns for future implementation of EDC tools, as practical adoption of the technology may be more indicative of its usefulness than reported perceptions.

User satisfaction was high among both interviewers and interviewees, indicating that they were more satisfied with the EDC than the QNN in all measured dimensions (format, ease of use and system speed). This reflects the results reported in other studies which concluded that most end users are satisfied with computerised systems.[19]

Limitation of the study

Although it was shown that the EDC was a successful method for data collection, we should be cautious that the current study was conducted in a specific population and the EDC

was particularly designed to collect data regarding malaria vector control survey in Karen hill tribe language. Moreover, the data interviewers used in this study were also those of Karen minority population residing in the same community, so that the study participants could be more willing to collaborate with the interviewers. According to the Thailand Ministry of Public Health, however, the volunteered village health workers are normally of the same tribe taking care of their designated responsible villages/households. Thus, it is possible that the EDC concept could still be applied among minority populations in similar low-resource public health settings.

Furthermore, introducing any tool with new and promising appearance and features could create high satisfaction after the first use. More important is how to maintain the user acceptance and continued intention to use the equipment. The ideal tool needs to have functionalities that could ease users' routine activities and reduce their workload.

CONCLUSION

This study revealed that EDC can be used effectively for data collection as an alternative method to QNN. The functions of mobile devices, such as camera and voice recording, can support building new applications, which are useful for data collection (i.e. image capture, voiced questions–answers and automated skipped pattern). The advantages of using EDC for data collection found in this study are: it can help reduce the workload of the CHVs and enhance the human performance as there is no requirement for having highly trained interviewers. Compared to QNN, EDC results are more accurate, evidence-based data. The CHVs who conduct the interviews also show a higher acceptance of the EDC in terms of its ease of use and usefulness. In addition, this study found that both interviewers and interviewees are more satisfied with the EDC than with QNN in all aspects (i.e. format, ease of use, system speed and the overall satisfaction).

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Competing interests

The authors have declared that no competing interests exist.

Authors' contributions

Siriporn Monyarit and Pratap Singhasivanon designed the study, wrote the protocol and wrote the first draft of the manuscript. Siriporn Monyarit and Jaranit Kaewkungwal designed and programmed the survey on tablet. Wirichada Pan-ngum, Saranath Lawpoolsri, Surapon Yimsamran and Suporn Pongnumkul managed the literature search as well as performed the statistical analysis. Siriporn Monyarit, Surapon Yimsamran and Pratap Singhasivanon supervised data collection and monitored activities at the study sites. All authors read and approved the final manuscript.

Ethical approval

This study was conducted in Ratchaburi Province, Thailand, and involved vulnerable research participants. Comprehensive information concerning this study was provided to all participants using either their dialect language or the Thai language. Written informed consent was obtained from each participant. The Ethics Committee of the Faculty of Tropical Medicine, Mahidol University, approved this project.

Abbreviations

CHVs: Community health volunteers
EDC: Electronic data capture tool
PDAs: Personal digital assistants
TAM: Technology acceptance model
BIOPHICS: Center of excellence for biomedical and public health informatics
GPS: Global positioning system
IRS: Indoor residual spraying
LLINs: Long-lasting insecticidal nets
RTIC: Rajanagarindra tropical disease international centre

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