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## A USABILITY STUDY OF A MOBILE HEALTH APPLICATION FOR RURAL GHANAIAN MIDWIVES

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### Abstract

Midwives in rural Ghana work at the frontline of the healthcare system, where they have access to essential data about the patient population. However, current methods of data capture, primarily pen and paper, make the data neither accessible nor usable for monitoring patient care or program evaluation.

Electronic health (eHealth) systems present a potential mechanism for enhancing the roles of midwives by providing tools for collecting, exchanging, and viewing patient data as well as offering midwives the possibility for receiving information and decision support. Introducing such technology in low-resource settings has been challenging due to low levels of user acceptance, software design that does not match the end-user environment, and/or unforeseen challenges, such as irregular power availability. These challenges are often attributable to a lack of understanding by the software developers of the end-users' needs and work environment.

A mobile health (mHealth) application, known as mClinic was designed to support midwife access to the Millennium Village-Global Network (MVG-Net), an eHealth delivery platform that captures data for managing patient care as well as program evaluation and monitoring, decision-making and management. We conducted a descriptive usability study comprised of three phases to evaluate an mClinic prototype: 1) hybrid lab-live software evaluation of mClinic to identify usability issues; 2) completion of a usability questionnaire; and 3) interviews that included low-fidelity prototyping of new functionality proposed by midwives. The heuristic evaluation identified usability problems related to four of eight usability categories. Analysis of usability questionnaire data indicated that the midwives perceived mClinic as useful but were more neutral about the ease-of-use. Analysis of midwives' reactions to low-fidelity prototypes during the interview process supported the applicability of mClinic to midwives' work and identified the need for additional functionality.

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#### Conflict of Interest:

The authors have no conflicts of interest to disclose.

User acceptance is essential for the success of any mHealth implementation. Usability testing identified mClinic development flaws and needed software enhancements.

## Keywords

mHealth; eHealth; Usability; Sub-Saharan Africa; Ghana; Global Health; International Health; Midwifery; Telemedicine; Cellular Phones

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## INTRODUCTION

Midwives working in rural Ghana often work in remote clinics with high patient volumes, extensive administrative duties, and little opportunity for professional development and collegial interaction.<sup>1</sup> Such clinics rely heavily on paper-based registers for collecting data, which are time-consuming to use and limited as a tool for analyzing patient population health.<sup>2</sup> Midwives need tools that allow them access to accurate and complete data regarding their patients.<sup>3</sup>

Electronic health (eHealth) tools, such as electronic health records (EHRs), can aid in the collection, application, and visualization of patient data. Mobile health (mHealth), a subset of eHealth, is the use of mobile technology, such as cellular phones, for the exchange of health information. With Sub-Saharan Africa's rapidly expanding cellular infrastructure, mHealth is being increasingly used as a means for health care providers to rapidly collect and exchange health data in ways that were not previously possible.<sup>4</sup> To date, however, few tools have been developed to support the work of midwives.<sup>5,6</sup> Designing such tools can be challenging as it requires developers to understand the day-to-day practicalities of clinical practice while meeting the needs of multiple stakeholders, including clinicians, patients, administration.

User-centered design methods—in which techniques such as interviewing and shadowing are used by software designers for both needs assessment and evaluation to understand clinicians work flow and information needs—have been promoted as a mechanism for improving the usability and applicability of eHealth tools.<sup>7</sup> Such usability studies can be used to identify misunderstandings between end-user needs and the developers' perceptions of the clinical practice and are an important component of the pre-pilot phase of eHealth deployment.

In this usability study, we presented midwives working in rural Ghana with an mHealth application, known as mClinic, and asked them to evaluate its usability and applicability in their practice.

### Midwifery in Ghana

For the purpose of this study, we define a midwife as a skilled birth attendant who has received some type of formalized training in midwifery versus a traditional birth attendant (TBA) who is trained through apprenticeship. The pre-service training of midwives in Ghana varies widely, with technical, baccalaureate and graduate training available as pathways to entry-to-practice.<sup>8</sup> This variation means that midwives may enter practice with three years of previous training as a nurse plus work experience or with no previous nursing training or clinical work experience.<sup>1</sup> Furthermore, studies of rural healthcare workers in developing countries have found most workers to be young and/or inexperienced, with little computer skills and high turnover rates.<sup>9</sup> Inconsistencies in training and continuing education practices highlight the need for ensuring rural midwives have access to appropriate information to supplement their training and clinical knowledge.

## eHealth in Sub-Saharan Africa

EHealth can be designed to provide decision support at the point-of-care and in-context information resources that may be useful to clinicians. For example, decision support functions could include reminding the midwife when prophylactic anti-malarials should be given to a patient or providing dosing guidelines for medications. In-context information could include a link to locally appropriate nutritional guidelines when a midwife diagnoses anemia in pregnancy. This could be particularly useful in developing countries that have variable standards for training and lack adequate staffing. However, several reviews have found that most eHealth implementations in developing countries lack published reports on patient outcomes and/or quality improvements.<sup>10–13</sup> This is partially due to the complexity in aggregating data using paper-records. In addition, the rapidly evolving healthcare systems in the developing world due to concurrent local government initiatives being conducted in conjunction with the World Health Organization, the United Nations Development Programme (UNDP), and other nongovernmental organizations (NGOs) make establishing baselines difficult.<sup>14</sup> Most eHealth projects have faced challenges in establishing long-term sustainability.<sup>10</sup> Projects often require data collection standards to meet the needs of national or international donors that often fail to address local needs.<sup>15</sup> These projects are further challenged by short-term funding mechanisms and failure to provide adequate training and support once foreign experts leave.<sup>16</sup>

A key factor to success of eHealth implementations in developing countries is user acceptance.<sup>4,17</sup> Methods for increasing user acceptance include providing adequate support and training for learning the new system, encouraging local ownership and data use, cultivating local leadership and project champions, and sensitivity to local culture.<sup>17,18</sup> Additional studies have shown that alignment of the eHealth intervention with user needs and provider technical self-efficacy are also significant factors in technology acceptance.<sup>19</sup>

### Project Context

The Millennium Villages Project (MVP) is an integrated rural development program to achieve the Millennium Development Goals (MDGs) in low-income rural Africa by the year 2015. The program operates in more than a dozen countries in rural Africa, including major clusters of villages in 10 countries. The Millennium Village strategy is based on simultaneous and integrated investments in five key sectors – agriculture and environment, health, education, infrastructure, and business development – in order to raise household incomes, reduce disease burden, and cut food insecurity and chronic hunger. The MVP is community-led, and works in close cooperation with the local and national governments, as well as with NGOs and development actors in the community. All interventions are science-based, and are carefully monitored and evaluated.

The Millennium Village Health System (MVHS) is a major component of the project. The MVHS strives for universal health coverage (UHC) of primary health services to achieve the MDGs in health, including a two-thirds reduction in child mortality and a three-fourths reduction in maternal mortality relative to baseline. The core strategy is to ensure universal access to services free of charge at the point of care, with a continuum of services from the household to the clinic and the referral hospital. Trained and professional Community Health Workers (CHWs) are assigned to each household, and connect the village population to the clinics, which are staffed by skilled birth attendants. The clinics in turn are connected by transportation, telephone, and protocols to referral hospitals to ensure seamless access to emergency obstetric care and/or other urgent care. The MVHS promotes the continuous collection and feedback of real-time health data, including the recording of all vital events and verbal autopsies, to allow the continuous adaptation and improvement of interventions to optimize health outcomes.

MVP is currently implementing the Millennium Village Global Network (MVG-Net). The goals of this network are to: facilitate the coordination of care between CHWs and the MVP clinical facilities, improve the continuity of care of patients, increase the efficiency of data collection and reporting, and contribute to the evaluation of MVP's progress towards improving the health of MVP community sites. MVG-Net is an open-source electronic health delivery platform that captures data for managing patient care, program evaluation and monitoring, decision-making and management. It will enable: the facility-based data capture of individual-level information; community-based data capture of individual-level information; data storage of individual patient health records; and, an automated mechanism for aggregating data and generating reports and feedback to healthcare providers and managers.<sup>20</sup>

The mClinic software (Figure 1) tested for this study was designed for use by midwives in the Bonsaaso, Ghana cluster of MVP to provide an application that allows midwives to access MVG-Net. mClinic was developed through user-centered design methods, in which end-users actively participate in the design process, in order to best assess the needs of the midwives and understand their work environment. Observation and contextual interviews—in which clinicians are shadowed and interviewed while performing their daily tasks—were used to determine the needed functionality of the application, mClinic.<sup>21</sup> mClinic works on low-cost Android smart phones or tablets and allows midwives to collect form-based data that can be transmitted to an EHR (OpenMRS). Data entry forms can be designed to provide point-of-care decision support and in-context health information for the midwife. The version of mClinic used for testing was a prototype and not intended to be implementation ready.

## METHODS

### Study Design

The descriptive usability study comprised three phases: 1) hybrid lab-live software evaluation of mClinic to identify usability issues; 2) completion of usability questionnaire; and 3) interviews that included low-fidelity prototyping of new functionality proposed by midwives (Figure 2). Usability studies are typically small sample studies. Nielsen et al. report that five users will detect 85% of usability problems particularly when users are homogeneous as is the case of midwives who will be using mClinic.<sup>22</sup>

### Subjects and Setting

All midwives working in the Bonsaaso, Ghana Cluster of MVP at the time of data collection (May 2011) were invited to participate in the study. The Ghana Cluster consists of six villages with a population of 30,000. The villagers are primarily employed in small-scale, open-pit mining operations or through family and cooperative farms. There are a total of 7 clinics in the cluster, each staffed by one midwife, one community health nurse, and two health extension workers. In a previously conducted needs assessment study in Bonsaaso, midwives reported: unmet information needs, inefficient documentation processes, and low technical self-efficacy.<sup>23</sup>

The Columbia University Institutional Review Board (IRB) approved the study protocol with an option for midwives to decline tape recording or answering questions that they felt might result in a loss of anonymity. Midwives approached for participation had the alternative not to participate and were informed that there is no penalty or other repercussions of not participating. Patients were not considered subjects for the purposes of this research.

## Procedures

mClinic testing was conducted in the midwives' actual work environment outside of regular clinic hours, rather than in a non-clinical setting. In some instances, patients were attended to in the facilities at the same time. This type of hybrid lab-live testing helps identify real-world issues that could be problems for the use of eHealth tools, such as poor cellular signals, bad lighting, and frequent work-flow interruptions.<sup>24</sup>

### **Hybrid Lab-Live Software Evaluation of mClinic to Identify Usability Issues—**

Heuristic evaluation is a commonly used method for identifying usability issues. A usability heuristic is a principle for how software should be designed that makes it easier to use and learn. For example, if a button labeled “Dx” brought up a list of diagnoses in one screen and in another brought up a list of diagnostic tests, it would violate the consistency usability heuristic.

To identify usability problems including violations of mobile usability heuristics, participants were given three tasks based on goals and the intended use-cases for mClinic. The first task was to register a new patient into mClinic, the second and third tasks were to record patients who had come into the clinic with a fever and suspected malaria. Both touch-screen and QWERTY keyboard phones were used in testing. The midwives selected the phone they wanted to use for the first task and alternated between the phones for the second and third tasks. Real data collected in the clinic was used for testing and deleted afterwards. Participants were asked to provide verbal feedback while using mClinic. Testing protocol included voice recording midwives while completing tasks. A researcher also took field notes.

**Completion of Usability Questionnaire—**After finishing the three tasks, participants completed the previously validated Health-Information Technology Usability Survey (Health-ITUES).<sup>25</sup> Health-ITUES was developed as a customizable questionnaire to subjectively measure usability of eHealth tools. To evaluate a specific eHealth tool in context, each question is customized to address the type of eHealth tool, type of user, and type of tasks that users are expected to perform using the system. Three question domains were customized for the mClinic evaluation, perceived usefulness, ease-of-use, and user control. Perceived usefulness refers to the midwives' perception of the tools ability to help them perform their job better.<sup>26</sup> Perceived ease-of-use is the midwives' perception of how difficult it will be to learn to use the system in relation to its expected benefit.<sup>26</sup> User control concerns the ease by which a user can correct or navigate back from an error.<sup>27</sup>

**Applicability Checks Using Interviews and Low-Fidelity Prototyping—**We also conducted an interview with each midwife that included low-fidelity prototyping of planned or requested forms and applicability checks. Midwives were asked their thoughts about the usability and usefulness of mClinic. Low-fidelity prototyping involves sketching on paper potential designs and workflows with end-users to get immediate feedback. This method also provides a means for applicability checks, in which end-users identify whether the prototype design or function would actually be useful to them in practice. For example, the designer may develop a screen that shows every dose of iron received while the midwife only wants to know about the last dose. Use-cases, diagrams depicting how the midwife would interact with mClinic to perform a particular task, were developed for a number of scenarios such as entering an ANC visit and retrieving the date of the last IPTp dose. Prototypes were drawn while reviewing use-cases and paper data collection tools from the clinic. Each box represented a new screen on the mobile device while arrows represented swiping to next screen. An example of a low-fidelity prototype is shown in Figure 3.

## Data Analysis

Usability problems identified during midwives' completion of the three tasks and during interviews were categorized using a list of usability heuristics for mobile devices, which were based upon Nielsen's heuristics.<sup>28</sup> Each problem identified was ranked on a scale of 0 to 4 with the following values: 0 = I don't agree that this is a usability problem at all; 1 = Cosmetic problem only, 2 = Minor usability problem: fixing this should be given low priority, 3 = Major usability problem; and, 4 = Usability catastrophe.<sup>29</sup> Descriptive statistics were used to summarize the usability questionnaire data. Midwives' reactions to the low-fidelity prototypes were thematically summarized and used to refine the prototype design.

## RESULTS

A total of 7 midwives participated in the evaluation of mClinic; representing all the midwives currently working in the MVP-Ghana cluster. Midwives ranged in years of clinical practice from 2 to 42 years. All of the midwives in this study had previously trained as nurses.

### Heuristic Evaluation

Key usability problems were categorized under the following heuristic categories: match between the system and the real world; good ergonomics and minimalist design; ease of input, screen readability, and glance-ability; and, aesthetic, privacy, and social conventions (Table 1). With regards to the match between the system and the real world, mClinic worked well with existing patients and adding new patients. However, once a new patient was added, he or she would have to be appended to the patient list in the EHR, and that list would need to be downloaded to the phone again before encounter data could be added. This was given the highest ranking on the severity ranking scale since it would be disruptive to workflow.<sup>29</sup>

Good ergonomics and minimalist design applied primarily to the QWERTY (keyboard) phone selected for testing. The keyboard was small and the midwives had difficulty pressing one button at a time, reading the keyboard, and using the function key to select number. There was greater success with the touch-screen phone. A minor ease-of-input flaw was noted in that radio buttons were occasionally difficult to select, though this occurred more often on the phone with the smaller screen.

Finally, in regard to aesthetic, privacy and social conventions, interviews revealed we must consider application level password protection since it is common for cellular phones to be shared among staff and family members and therefore phone level locking would be inadequate.

### Usability Questionnaire

Midwives strongly agreed that mClinic was useful and were in agreement-to-neutral about ease-of-use and user control (Table 2).

### Applicability Checks

In the interviews, some midwives indicated that they believed that mClinic will be helpful to them and reduce time they spend creating monthly reports. One midwife stated:

“Look at the number of reporting formats we have to complete. The end of the month is so hectic for us. If this will help, I will use it.”



After being shown the low fidelity prototypes, several midwives expressed concern that the prototype maternal health form set would be too time intensive and cumbersome to use. One participant stated,

“Last week I was up for 48 hours delivering babies, seeing patients, and then more deliveries. This will be too much. Someone else should do it”.

All of the midwives were dismissive of designs that included extensive free-text fields, such as those that captured subjective patient data. As articulated by one:

, “We just need the data for the reports, this other stuff we do not need, I would not look at that”.

More positive interest was generated for expanding the register-type forms and expanding it to capture monthly reporting data:

“We really need that for PMTCT [Prevention of Maternal to Child Transmission], Morbidity and the Midwife Monthly. That would help. I would like to use that.”

## DISCUSSION

Mobile technology presents an opportunity to transform the clinical practice of midwives in developing countries and to better engage them within the healthcare ecosystem. mHealth can increase the speed of data collection for use in monitoring and evaluation while providing resources for feedback, clinical decision making, and other information needs.

A mobile platform for mClinic was selected for several reasons. Mobile phones require much less electricity than computers, making them preferable in rural clinics that rely on solar power for energy.<sup>30</sup> Secondly, the sale of mobile SIM cards, as a percentage of population, in Ghana increased from 23.30% in 2006 to 63.38% in 2009, indicating a rapid increase of penetrance and supporting infrastructure of this technology.<sup>31,32</sup> Other potential benefits include lower startup and maintenance costs and improved accuracy and timeliness of data collection.<sup>4,33</sup> Finally, it was believed that midwives’ familiarity with mobile phones, rather than desktop computers, would lead to greater perceived usability and subsequent acceptance of the technology.<sup>23</sup>

Studies have found that midwives in developing countries view mobile phones as having positively impacted their clinical practice by allowing them improved communication with colleagues.<sup>34</sup> However, few published studies have engaged midwives in user-centered design of mHealth applications, particularly in developing countries.<sup>12</sup> In the 2012 State of the Evidence Report on mHealth for Maternal Child Health published by the mHealth Alliance, the author was only able to identify six studies, mostly unpublished, that addressed usability of mHealth tools and only one in which midwives were the targeted users.<sup>13</sup>

In the area of maternal child health, mHealth tools are being developed for urgent care during deliveries, to alleviate human capacity issues, for health promotion, and data collection.<sup>13</sup> For example, the Parto Pen is a digital pen which provides real-time audio feedback on partograph forms to birth attendants during labor.<sup>35</sup> These tools have the potential to positively benefit midwives in developing countries; however, engagement with the midwifery community in their design, development, and use is needed.

The first step in this process is to design sustainable, scalable systems in which the targeted midwives are closely involved in the design and development process. The usability evaluation of mClinic showed that midwives perceived the tool could be important to their daily work provided that it matched their approach for documenting and evaluating clinical care.

Midwives identified usability problems through task-based mClinic software evaluation, completion of the Health I-TUES, and interviews. While the results of the usability questionnaire were generally positive, the heuristic evaluation based on mClinic software evaluation and interviews suggests there are still some important usability problems that need to be addressed prior to implementation. This, however, is to be expected in the first round of end-user testing. Some of the usability problems observed, such as frequent typos or difficulty entering numbers due to small buttons, were related to the hardware selected for the project rather than the software. This stresses the importance of the careful selection of hardware in addition to the attention and detail paid to the actual software development.

Midwives' perceptions of usefulness of mClinic were higher than their perceptions of ease-of-use. The latter may be attributed to the midwives' low technical self-efficacy and reinforces the need for hands on training in general technology in addition to the mClinic software itself.<sup>23</sup> Moreover, a substantial body of literature on technology acceptance suggests that perceived usefulness more strongly predicts intention to use and actual use of technology than perceived ease-of-use.<sup>26,36,37</sup>

Interviews complemented the results of the Health I-TUES survey as midwives were able to express what features they found easy to use and which they found difficult. As is consistent with the literature, the midwives preferred when the screen contained less data and did not require scrolling.<sup>38</sup>

The midwives in this study were very interested in collecting data that related to reporting and less interested in documenting data for clinical decision making. Overall, midwives indicated they felt the use-cases in development reflected their clinical practice while some of the prototypes that called for more narrative note documentation would not be useful to them or too cumbersome to use. They indicated that the need to collect registry data was a top priority and that electronic documentation of clinic notes may be too burdensome given their high patient loads. Further study with a larger and more diverse, such as non-MVP midwives, should be done as this could impact the perceived usefulness of other eHealth implementation used by midwives.

Completing the usability tests prior to the applicability checks provided a technical baseline whereby the midwives became familiar with the potential of mobile technology. This allowed the midwives to provide richer feedback about the functional requirements and use-cases developed in this research. This work provides further evidence for the appropriateness of low-fidelity testing for developing country eHealth projects as proposed by other researchers.<sup>24,39</sup>

The strength of this study lies in the use of multiple evaluative methods, which allowed for the triangulation of our usability results, improving credibility and validity. Additionally, this provided a rich picture for how mClinic could be used and gave greater insight to the cultural and organizational challenges that the future implementation might face. Furthermore, interviews with midwives took place at least once at each MVP-Ghana facility, allowing us to reach our entire target end-user population of midwives in this community.

Our study was limited by several factors. Poor recording quality and background noise in the clinic facilities made analysis of audio recordings challenging. Secondly, the study site, as a part of MVP, is a unique initiative that may limit generalizability of the results to non-MVP clinic sites as well as being unique to Ghana. Thirdly, only one observer was used to collect data. Additionally, there was some indication that the clinic staff perceived the researcher to have some type of managerial role within MVP and this may have affected their behavior or willingness to share information.



## CONCLUSIONS

Midwives are the primary skilled clinicians serving patients in rural Ghana. The use of mHealth can provide mechanisms for improving the efficiency and effectiveness of care provided by midwives by supporting clinical decision making and providing information resources while reducing their administrative burdens. The opportunity to rapidly collect and aggregate data will improve our understanding of patients and allow for rapid targeting of needed resources and interventions. The design of usable mHealth systems in Ghana and around the world requires input and feedback on needed functionality and an in-depth understanding of the realities of day-to-day clinical practice. The midwives had previously voiced high levels of frustration regarding reporting requirements and the lack of feedback, information, and support available to them.<sup>23</sup> eHealth and mHealth tools, such as mClinic, can address some of these issues; however, careful and thoughtful design is essential for successful implementation, scalability, and long-term sustainability of the project. This study documents the importance of engaging midwives in the design of eHealth systems. Moreover, the methods applied provide an evaluation approach that may be useful to others. Supporting the work of rural Ghanaian midwives is essential for maintaining the country's progress towards the reduction of maternal mortality and improvement in rural primary healthcare services.

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## Biographies

Olivia Vélez, PhD, MS, MPH, RN is a National Library of Medicine Postdoctoral Fellow in Biomedical Informatics at Columbia University and is in clinical practice as a Women's Health Nurse at Hudson River HealthCare in Peekskill, NY.

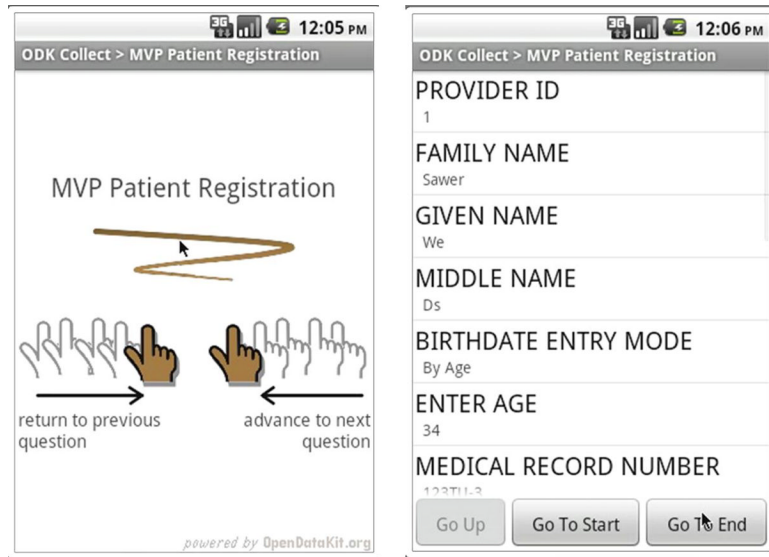
Portia Boakye Okyere, BSc, HND is the Database Manager for the Millennium Villages Project in Bonsaaso, Ghana.

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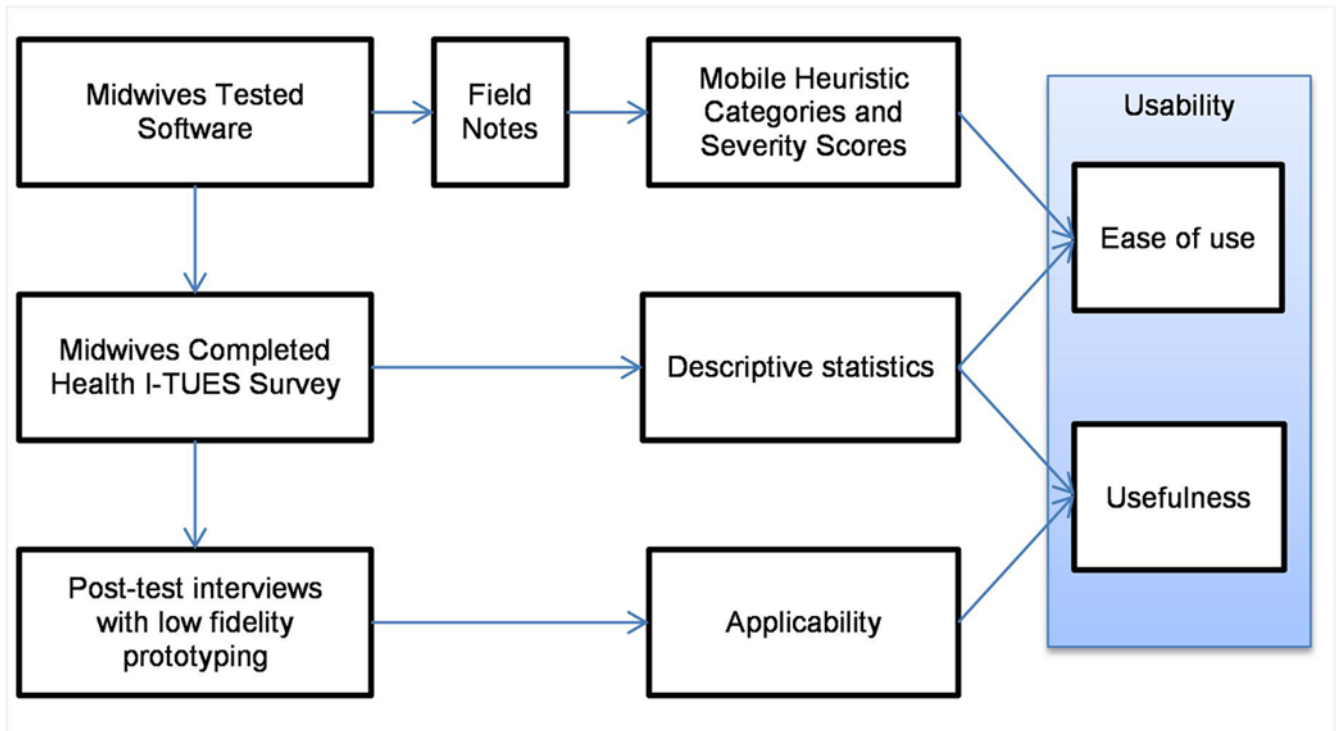
Suzanne H. Bakken, PhD, RN, FAAN, FACMI is the Alumni Professor of Nursing and Professor of Biomedical Informatics at Columbia University and the Director of the Center for Evidence-based Practice in the Underserved.

### Quick Points

- There has been a rapid explosion of Mobile health (mHealth) tools to address the health needs of people in developing countries.
- Midwives are critical, and sometimes the only, providers of care in many developing countries, however, few mHealth projects have targeted midwives as end-users or included their input in the design of appropriate technologies.
- Midwives in our study were interested in data collection tools that would alleviate reporting burdens.
- Methods used in this study may be useful for others planning mHealth interventions with midwives.



**Figure 1.**  
Screen Shots of mClinic



**Figure 2.**  
Overview of Usability Evaluation.



ANC Progress Record

Encounter Date	→	Weight <input type="checkbox"/> BP <input type="checkbox"/>	→	Gestational Age <input type="checkbox"/> in weeks Fundal Height <input type="checkbox"/> in cm
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# of IFA tablets given <input type="checkbox"/>	→	HAS Quickening occurred <input checked="" type="checkbox"/> ----- If yes, SP Doses Date 1 <input type="checkbox"/> Date 2 <input type="checkbox"/> Date 3 <input type="checkbox"/>	→	Complaints Text entry box
---	---	---	---	------------------------------

↑  
date ranges calculated

**Figure 3. Sample low-fidelity prototype**

An example of a low fidelity prototype for collecting Antenatal care data with decision support for malaria treatment.

**Table 1**

## Usability problems and severity rankings

Heuristic Category	Problem	Severity Ranking
Visibility of system status Match between system and the real world	None identified Adding patients required uploading, then re- downloading patient list to add new encounters	4 – Usability catastrophe
Consistency and mapping	None identified	
Good ergonomics and minimalist design	Small keyboard made buttons difficult to press	3 – Major usability problem
Ease of input, screen readability and glance-ability	Radio buttons were occasionally difficult to select	2 – Minor usability problem
Flexibility, efficiency of use and personalization (User Control)	None identified	
Aesthetic, privacy and social conventions	No application level password required, mobile phones are often shared among staff	3 – Major usability problem
Realistic error management	None identified	

**Nielsen's Severity ranking scale**

0 = I don't agree that this is a usability problem at all

1 = Cosmetic problem only: need not be fixed unless extra time is available on project

2 = Minor usability problem: fixing this should be given low priority

3 = Major usability problem: important to fix, so should be given high priority

4 = Usability catastrophe: imperative to fix this before product can be released

**Table 2**  
**Summary of Health I-TUES Survey**

<sup>a</sup> Midwives were asked to rank their agreement with each statement on a scale of 1 to 5 where 1 = “Strongly Agree” and 5 = “Strongly Disagree”.

Statement	Concept	Rank Mean (SD)
1. I think mClinic will make it easier to find information about my patient	Perceived usefulness	1.5 (0.55)
2. I think mClinic will save time spent on monthly reports	Perceived usefulness	1 (0)
3. mClinic will be an important part of documenting patient care	Perceived usefulness	1.2 (0.41)
4. I am comfortable with my ability to use mClinic	Perceived ease-of-use	2.2 (0.98)
5. Learning to operate mClinic is easy for me	Perceived ease-of-use	2.3 (0.82)
6. It is easy for me to become skillful at using mClinic	Perceived ease-of-use	1.7 (0.52)
7. I find mClinic easy to use	Perceived ease-of-use	1.8 (1.17)
8. mClinic gives error messages that clearly tell me how to fix problems	Perceived ease-of-use /User control	2.8 (0.96) <sup>b</sup>
9. Whenever I make a mistake using mClinic, I recover easily and quickly	Perceived ease-of-use /User control	1.8 (0.41)
10. The information (on-screen messages) provided in mClinic is clear	Perceived ease-of-use /User control	1.3 (0.52)

<sup>a</sup>The full Health I-TUES survey includes questions on impact on quality of work-life, perceived usefulness, perceived ease of use, and user control. Only the questions categorized in perceived usefulness, perceived ease of use, and user control were included for this study since the others are relevant only in the post-pilot phase. Analysis of user control items were included with perceived ease-of-use for consistency with heuristic evaluation.

<sup>b</sup>Two midwives skipped this question because they did not receive error messages during the testing.