Creating an EMR System to Support Mobile Clinics in Haiti

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ABSTRACT

While mobile clinic services have been tremendously helpful to patients in the under-developed areas, they often suffer from poor quality of patient management due to lack of capability for continuity of care. Collaborating with VillageMED, a US-based nonprofit that provides periodic medical services to Haiti communities, we investigated implications for the design of an EMR to support mobile clinics. Key design considerations we found include: (1) simplicity and ease of use, (2) seamless support of the existing clinical workflow through feature segmentation, and (3) flexibility to accommodate organizational and operational variability. Using the findings, we designed and implemented, through an iterative process, an EMR suitable for use in mobile clinics. We conclude by discussing design implications to improve quality of care in mobile clinics.

CCS CONCEPTS

• Human-centered computing → **Interface design prototyping**

KEYWORDS

Mobile clinic; EMR; Health Information Technology; Haiti

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1 INTRODUCTION

Many under-developed regions of the world suffer from limited or no access to healthcare services. Thus, organizations in developed countries offer volunteer medical missions to provide temporary healthcare services [3]. These missions are usually through mobile clinics, conducting general health assessments, preventive care, health education, and management of acute and chronic conditions [5]. Medical record keeping practices of these missions are variable in different settings, but paper-based charting is prevalent. Although these missions have proven successful in saving lives, they were not able to provide effective patient management due to lack of capability for continuity of care. Using paper charts as a patient documentation system makes it difficult to manage patient data effectively [11].

Patient management systems are available to afford effective patient care. Many of these systems, however, cannot be deployed effectively in the developing regions due to technical, cultural, and environmental obstacles [13]. Furthermore, these systems usually encompass a variety of functionalities that may be unnecessary or prone to failure in mobile clinics [2]. In addition, the nature of under-developed regions may make these systems unaffordable [11]. What is needed is an affordable, easily deployable, and culturally relevant system that supports patient documentation activities in a challenging environment.

Collaborating with VillageMED, a US-based nonprofit that provides periodic medical services to Haiti communities, we investigated the current practices and needs of mobile clinics by interviewing its staff members and observing their mobile clinics. Key design considerations we identified include: (1) simplicity and ease of use to support both first-time users and the operation in busy situations, (2) seamless support of the existing workflow of the clinical process, and (3) flexibility to accommodate various organizational and operational conditions to support scalability. Based on the findings, we created and tested an EMR specific to the impending needs of VillageMED's mobile clinic services. Overall, our system was well received by all stakeholders of the mobile clinic team. Several suggestions were made, which we applied to the system design through an iterative design process to accommodate user needs. We are currently beta-testing our system and plan to deploy it in Haiti during VillageMED's upcoming medical trip. Contributions of this paper include: understanding the practices and challenges associated with quality patient management in mobile clinics for continuity of care; identifying design considerations that pertain to the needs of a mobile clinic; and implementation of an EMR system to deploy in the wild to support medical service trips.

2 MOBILE CLINICS IN HAITI

Haiti, located approximately 600 miles southeast of the continental United States, is one of the poorest countries in the western hemisphere [16]. In 2010, a 7.0-magnitude earthquake struck Haiti, which caused extensive destruction of healthcare facilities and public health infrastructure. Since then, many

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nonprofit organizations responded to appeals for humanitarian aid, pledging funds and dispatching rescue and medical teams, including VillageMED, a US-based nonprofit organization that provides residents of Haiti with quality pediatric healthcare pro bono four times a year. A team consists of medical and non-medical volunteers from both the US and Haiti depending on availability and resources. One of the challenges the VillageMED medical team has been experiencing is lack of an effective way to manage patient data and share it across different teams. Because members of a team often change in each trip, patient handoffs are inevitable in every diagnosis. Because the teams currently rely on a paper-charting system to record patient data, it is difficult to manage patient data systematically.

3 LITERATURE REVIEW

Benefits of using EMRs in resource-limited settings are well documented in the literature, including reducing medical errors [7], legible documentation [8], data accessibility by multiple users [18], continuous data processing [17], and automatic data backup and storage [13], just to name a few. Thus, the need for EMR in mobile clinical settings is as great as its use in stable, well-structured clinics, if not greater [19]. However, EMR implementation in such environments has been slow due to technical, environmental and cultural challenges associated with the adoption of healthcare technology [9][12][6][13]. Several off-the-shelf EMR systems exist specifically designed for use in mobile clinics. Arguably, Open MRS, a flexible, open source software project with the aim of removing barriers to EMR implementation in developing countries, has the broadest user base. Open MRS has been used in more than 50 developing countries to produce over 1 million patient records [15]. DreameSE and iSante are also free software programs that require minimal hardware requirements [10]. Many such systems provide tablet compatibility, which may be helpful given the environment and low resource context [4]. However, these existing EMRs remain in their early stages, and further research is required before reaching the stage of widespread adoption.

The research sector has made relatively less effort to the design and use of EMRs for mobile clinics. One among the few is by Anokwa, which studied the design of a phone-based clinical decision support system for resource-limited settings [1]. In addition, Nwosu et al. created an EMR for reliable patient identification in mobile clinics [11], and Lober et al. reported their ongoing effort to develop an EMR's framework that works under significant technology barriers [9]. The last two studies focused on developing network architecture or database modeling to enable its use in resource-limited settings. While technology challenges ought to be overcome, equally important is a practical challenge for clinicians working in mobile clinics to find a system suitable for their work process that provides key functionalities for care practice. Therefore, this paper aims to acquire a deeper understanding of the context within which mobile clinic care occurs, which will inform the design of a system that is usable, useful, and culturally relevant.

4 METHODS

4.1 Interviews with Mobile Clinic's Staff

A VillageMED's mobile clinic consists of staff serving various roles, including physician, physician's assistant, nurse, non-medical volunteer, and organizer. Because different stakeholders might hold different perspectives, we conducted semi-structured interviews with all stakeholders. Interviews lasted approximately an hour and followed a semi-structured interview protocol. Four interviews were conducted face to face and one using video conferencing due to geographical distance. Interviews focused on soliciting perspectives, obstacles, and needs in performing their tasks, as well as understanding the overall workflow. All interactions were audio recorded and transcribed.

4.2 On-Site Observation

The second author of this paper joined a VillageMED's medical service trip to Haiti for one week in Spring 2018 to conduct direct observation of a mobile clinic and to get feedback of our design probes on site. In this trip, VillageMED conducted two mobile clinics in two cities. Both clinics were set up at a local church. In the first clinic 106 patients received medical services and in the second clinic 185 patients received medical services. All activities throughout the day were captured through observation. All necessary events were recorded in notes. The team in this trip consisted of 9 volunteers, a usual size of a VillageMED's mobile clinic team. The team included the chief director, three non-medical volunteers, one Haitian-American nurse from the US, and two Haitian doctors and two Haitian nurses who joined on site. In this trip all doctors were Haitians, but this varies depending on the availability of doctors in the US and Haiti. After finishing the mobile clinic on the last day, we demonstrated our design probes to volunteers and asked for feedback reflecting on their duties and activities during this trip.

4.3 Data Analysis

The transcripts and field notes from observations were coded and analyzed using an inductive thematic analysis to reveal patterns across data sets [14]. First, we coded concepts significant in the data as abstract representations of events and objects. Next, we categorized the related concepts into higher conceptual phenomena and themes that emerged as patterns within the data. Then, we integrated all concepts into a single storyline, iteratively building relationships across phenomena. The first author led the data analysis. The themes that emerged were continuously discussed with other members to identify less prominent themes, which were dropped from further analysis.

5 FINDINGS

All presented quotes are from the interviews. Prototypes were created in between interviews and observations, but we report the findings from both interviews and observations here for the structure of the paper. Additional findings from observations were applied to the system implementation.

5.1 General Practices of a Mobile Clinic

All interviewees attended the medical service trip on a regular basis, and thus they revisit the same sites and see the same patients again. When they were asked about the problems they consider about how a mobile clinic currently operates, they mentioned not being able to review previous treatments, which confirms the literature about lack of capability for continuity of care in mobile clinics [11]. While a repository of basic patient information can lead to improved provider handoffs and continuity of care [3], it is not the case in VillageMED's mobile clinics because they do not have a patient management system.

"When we go back we tend to see the same kids. But normally it's a year after. Right now, we don't have any way of pulling up a chart. You could ask the parent and the parent might say 'yeah this is our second or third time' but other than that there is no way of knowing past visits and treatments. It would be much easier to pull up the chart to see history and treatment from last time." (A nurse)

One thing we were not aware until observing the clinics was a need for language support. We did not know that Haitian volunteers from the local community would join the team until we attended the trip. Because we assumed that all volunteers would come from the US, we thought that the primary language for the system ought to be English. Thus, we did not ask any questions about language in the interviews. In the observations, we found that local Haitians also volunteer to join the clinic. Haitian doctors were fluent in English and used English to fill out the paper chart, whereas Haitian nurses used English to write on a patient chart but were more comfortable with using Haitian Creole, one of the official languages of Haiti. Since doctors in this trip were all Haitians, they did not have any language issues when examining patients. But a bilingual volunteer who speaks both English and Haitian Creole attends the exam station to support interacting with a patient if a doctor cannot speak Haitian Creole, the chief director explained.

5.2 Workflow of a Mobile Clinic

A mobile clinic's workflow consists of four stages: check-in, vitals and triage, physical exam, and medicine dispensary. Patients move from one station to another to receive clinical service carrying the paper chart. Before the clinic starts, all volunteers get together at a church, including local volunteers, assigning duties and zoning the space. Then, they set up four separate stations using tables and walls made out of tarp, three of which — check-in, vitals, medicine dispensary — are adjacent to one another, while the physical exam station is set up distant from other stations (e.g., the choir loft) for privacy.

The clinical process, however, was flexible depending on the situation both throughout the day and across clinics on different days. For example, there were times when the queue was backed up in a particular station due to some patients' check-up taking longer. When this happened, patients were asked to go back to the waiting area and wait until a number would be called rather than moving directly from one station to the next. Also, because the expertise and the number of volunteers vary in different trips, one staff would serve different roles on different trips based on constituents of a team. For example, when they do not have enough non-medical volunteers, the first two steps, check-in and vitals, are merged, and in the opposite cases the vitals steps are split up to vitals and triage steps.

5.2.1. Check-in. A clinical process begins with a volunteer calling out a number at the check-in desk. The patient who holds this number would approach the triage station, which is the first point of direct contact of a volunteer with the patient. The volunteer then fills out the beginning part of a paper chart, which includes a patient's name, a guardian's name, and contact information (e.g., phone number) if available. However, we found that this practice would change. As the clinic becomes busier and less organized as the day progresses, a volunteer left the desk and walks around the pews with a pile of blank paper charts to fill out the information more quickly. This implies that an EMR needs to support portability. After checking in by filling out the beginning part of the paper chart, the patient carries the chart and is guided to the vitals station.

5.2.2. Vitals and Triage. At the vitals station, a nurse checks the vital signs and asks general questions for triage (e.g., why are you here today?). Based on the information gathered, the nurse fills out the second section of a paper chart, including basic vital signs like blood pressure and temperature and a few words to indicate sickness or a stated problem.

5.2.3. Physical Exam and Assessment. This station is set up with the same number of tables as the number of doctors, each of which is separated using a small white screen. For assessment, a doctor conducts the examination and fills out the third section of the patient chart, including checking review of symptoms (ROS) by circling options for positive or negative and checking symptoms that applied to the patient. Then, the doctor fills out the last section of the chart: Plan for medicine dispensary. In this trip, there was no physician's assistant so that a doctor managed the entire physical exam and assessment steps alone. But when the team has a physician's assistant, s/he would fill out some sections as the chief director explained. Interestingly, we never noticed that a doctor signed a paper chart while it has a section for a doctor's signature at the bottom.

5.2.4. Medicine Dispensary. Three or four non-medical volunteers and the chief director run the medicine dispensary station. This station has a large table with an array of buckets that contain medicine. Throughout the day, volunteers prepared medicines by making certain mixes, putting vitamins in small personal bags or cream in small personal containers. In addition, they prepared gift bags that include a hygiene kit, and a snack to give to each patient. When the patient approached the medicine dispensary station, s/he handed the paper chart back to a volunteer. The volunteer looked at the note on the paper chart and dispensed the appropriate medicine to the patient. Then, the paper chart would be placed in a stack of papers by the side of the medicine table, which indicates completion of a service. After the trip, s/he brings these papers back home for storage.

"I just stack it (paper charts) and hold onto it. Old ones are in my custody. I do not bring them back. We start anew and so there's no follow-up... There really isn't a system. We just capture the information to move the patients to the medicine and dispersing the medicine. That's really what it's used for." (A chief director)

6 SYSTEM DESIGN: PROTOTYPING

Based on the findings, we considered the following factors important: (1) simple and easy to use both by first-time users and in busy situations, (2) effective monitoring of patient status in each station and the entire clinical progress, and (3) separating but allowing smooth transition between stages of the workflow. To serve these needs, we designed a home screen as a dashboard to show the queued patients at different stations. The dashboard displays a list of waiting patients and their current status by indicating completed steps with a checkmark, the next step with a clickable icon, and following steps with inactive icons.

For patient charting, we divided data in the current paper chart into four separate pages corresponding to each stage by segmenting relevant functions. It will allow a volunteer at a particular station to manage only what s/he is in charge of. Clicking the upcoming-step icon on the dashboard will lead to the page where a volunteer can fill out relevant patient data (e.g., clicking "vitals" icon leads to the page where you can enter the patient's vitals), with an exception of the prescription page where you can only review patient data. Because a doctor fills out the prescription section and a non-medical volunteer at the prescription station reviews the doctor's prescription for medicine dispensary, we made it to fill out both assessment and prescription on one page and review it on another page.

While you can access only the page of a patient's upcoming clinical service from the dashboard, we made it easy to switch between pages once you view any section of a patient chart by displaying a tabbed list of patient information below a summary of the patient's general information. This will afford the flexibility and variability of the workflow to support easily switching between pages through chunking segmented features. Lastly, we displayed a ticket number of a patient on the top left corner of each page to support the current operating practice of using numbered tickets for clinical process management.

We brought a prototype on the trip to collect feedback from volunteers. All volunteers were excited about having an EMR to manage patient records. In particular, volunteers liked seeing the number of waiting patients on the home screen. Because the clinic is often overwhelming due to the number of people present at the clinic, some of whom are not patients, it will help volunteers to know how many patients are waiting at different stations. In addition, the chief director asked to display the number of completed patients to give volunteers a feeling of achievement. We applied most feedback that the volunteers provided into the design of a final system design (Figure 1). Added features include: the number of seen patients, a patient's photo at the patient's information section, and features to switch measurement units and language (English and Haitian Creole).

7 DISCUSSION

Three implications should be considered in the design of an EMR to support mobile clinics: seamless support of the existing clinical workflow, supporting flexibility for operational and organizational variability through feature segmentation, and integration of cultural factors by chunking similar features. First,

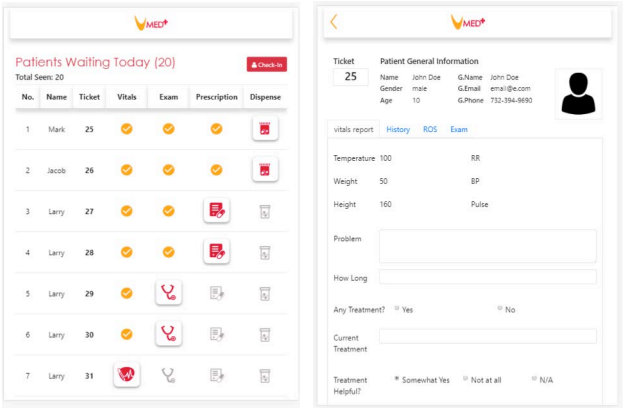

Figure 1: a final UI: a home-screen and patient

an EMR should fully support how a mobile clinic currently operates. This requires deeper understanding of existing practice through investigations in-situ and applying the findings to the design of an EMR. We identified four distinct stages of a clinical workflow relating to patient charting and carefully turned each stage into a feature of an EMR through segmentation. Also, we made sure of smooth transition between and across different stages to address operational and organizational variability.

Second, operational and organizational variability refers to the inconstant nature of the structure of mobile clinics, such as the changing number of volunteers in each trip, varied expertise in different teams, availability of local volunteers, and changes in location, season, and duration of a mobile clinic. An EMR needs to be flexible to accommodate operational variables. Smooth transition between and across different stages of a workflow will ensure the use of an EMR in various circumstances.

Lastly, culture, and language in particular, has been known as an important component for EMR systems in developing countries [4][15]. Language diversity exists in many developing countries where an EMR will be used. In the case of this study, we initially did not consider cultural factors because we assumed that an EMR would be used only by visiting volunteers fluent in English. Contrasting to our expectation, language is found to be an important factor, since locals might interact with it. This provides a lesson that the multilingual support is an important design consideration for healthcare technology for developing countries regardless of the characteristics of the primary users.

8 CONCLUSION

This paper investigates the needs and challenges of patient management faced by mobile clinics that provide temporary healthcare services to patients in under-developed regions, with the aim of developing an EMR system. We found that it is important to support the current clinical workflow, while at the same time affording flexibility to accommodate organizational and operational conditions for scalability. We also identified specific design features for successful adoption of an EMR from cultural and practical standpoints. We are currently beta testing our system and plan to deploy it at the upcoming mobile clinic site in Haiti. We believe our system will improve the quality of patient care in VillageMED's mobile clinics.

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