Original Research

A Mobile Health Data Collection System for Remote Areas to Monitor Women Participating in a Cervical Cancer Screening Campaign

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Abstract

Background: Barriers to efficient cervical cancer screening in low- and medium-income countries include the lack of systematic monitoring of the participants' data. The aim of this study was to assess the feasibility of a mobile health (m-Health) data collection system to facilitate monitoring of women participating to cervical cancer screening campaign.

Methods: Women aged 30–65 years, participating in a cervical cancer screening campaign in Ambanja, Madagascar, were invited to participate in the study. Cervical Cancer Prevention System, an m-Health application, allows the registration of clinical data, while women are undergoing cervical cancer screening. All data registered in the smartphone were transmitted onto a secure, Web-based platform through the use of an Internet connection. Healthcare providers had access to the central database and could use it for the follow-up visits. Quality of data was assessed by computing the percentage of key data missing.

Results: A total of 151 women were recruited in the study. Mean age of participants was 41.8 years. The percentage of missing data for the key variables was less than 0.02%, corresponding to one woman's medical history data, which was not sent to the central database. Technical problems, including transmission of photos, human papillomavirus test results, and pelvic examination data, have subsequently been solved through a system update.

Conclusion: The quality of the data was satisfactory and allowed monitoring of cervical cancer screening data of participants. Larger studies evaluating the efficacy of the system for the women's follow-up are needed in order to confirm its efficiency on a long-term scale.

Keywords: *cervical cancer screening, low-resource settings, m-Health, patient record, telemedicine*

Introduction

Cervical cancer is the second most frequent cancer in women and the fourth most common cause of cancer-related death worldwide.[1] In Madagascar, the latest data confirm that cervical cancer is the most frequent cancer among women, with 3,194 women diagnosed with the disease and 1,804 dying from it every year.[2]

The World Health Assembly identified cervical cancer among the priority interventions in the action plan for the prevention and control of noncommunicable diseases 2013–2020, which was agreed by member states, committing them to include cervical cancer and other noncommunicable disease interventions in national health plans.[3]

Despite the greatest burden of the disease in low- and medium-income countries (LMIC), organized cervical cancer screening programs have not yet been implemented in these settings. Implementing a cytology-based screening program is beyond the capacity and resources of most LMIC, and the current alternative recommended by the World Health Organization (WHO) is visual inspection with acetic acid (VIA) or Lugol's iodine (VILI) or, for those countries having enough resources, human papillomavirus (HPV) testing.

The implementation of an efficient cervical cancer prevention program requires data monitoring as abnormal results require appropriate treatment and follow-up. An increasing number of data need to be registered during the clinical visit, a task that may be difficult to accomplish when data recording is not systematic. For this purpose, electronic medical records (EMR) using computer-based data storage, instead of old handwritten documents, need to be introduced. High-income countries have largely implemented EMR, which has become one of the most important healthcare innovations in the last decade. An alternative EMR approach, adapted to LMIC, would improve the quality of medical records, while allowing the exchange of

medical information between experts in the medical field; yet, to date little is known about the EMR system usage in LMIC.[4–8]

Our team has recently proved the feasibility of a mobile health (m-Health) system to provide high-quality antenatal care for pregnant women in remote areas of Madagascar.[9] The requirements for a m-Health system to be applied to LMIC are ease-of-use, robustness, and efficiency, as it should be easily understandable by healthcare workers having different educational degrees, while enabling them to collect and store all important information related to the cervical cancer screening visit.

We developed an icon-based application for smartphones, named Cervical Cancer Prevention System (CCPS), designed to enable healthcare providers to monitor women undergoing cervical cancer screening, treatment, and follow-up. Our aim was to assess the feasibility and reliability of an m-Health application designed to monitor the data of women participating in a cervical cancer screening campaign conducted in a LMIC.

Materials and Methods

STUDY SETTING

The CCPS study took place in the Saint Damien Healthcare Center in Ambanja, Madagascar and in five dispensaries in the surrounding rural areas during an HPV-based cervical cancer screening campaign between July and August 2016. This is part of a larger study initiated by the St Damien Health Care Center and the University of Geneva. The protocol has previously been published.[10] In brief, women were included if aged between 30 and 65 years and able to comply with the study protocol. Ethical approval was obtained from the Malagasy National Commission for the Ethics of Science and Technology and from the Ethical Cantonal Board of Geneva, Switzerland (CCER 2016-00285). Eligible women were asked to sign a written informed consent form prior to taking part in the present study.

STUDY PROCEDURE

Questions concerning sociodemographic and personal data were collected by healthcare providers. Subsequently, women were instructed on how to perform HPV self-sampling (Self-HPV) using dry cotton swabs. The Self-HPV samples were transported to the Saint Damien center for analysis by the HPV GeneXpert machine (GeneXpert®IV; Cepheid, 2015, Sunnyvale, CA). Using a polymerase chain reaction method, this test detects 14 main types of high-risk HPV responsible for the development of precancerous lesions. The results are divided into three sections: HPV 16, HPV 18/45, and 11 other high-risk HPV types (31, 33, 35, 39, 51, 52, 56, 58, 59, 66, and 68).

HPV-negative women were advised to repeat screening after 5 years. Only follow-up of HPV-positive patients living in the neighborhood of Ambanja was performed; these women were invited to undergo a pelvic examination in Saint Damien Health Center, including VIA and VILI. For the other women, active follow-up was performed after the study period, with medical team going to the dispensaries to recall women requiring follow-up.

For quality control purposes, a set of cervical pictures (native, after VIA, and after VILI) was taken during pelvic examination and added to the patient's file in CCPS. A biopsy of the cervix was performed on the pathological area when

Table 1. Sociodemographic Characteristics of the Study Population

VARIABLE	*n* (%)
Age, mean ± SD, years	41.8 ± 9.1
Parity, mean ± SD	4 ± 3.6
Age at first sexual intercourse, mean ± SD, years	16 ± 2.2
Marital status	
Single	35 (23.3)
Married	116 (77.3)
Employment status	
Housewife	18 (12.0)
Sales assistant	19 (12.7)
Farmer	90 (60.0)
Other	23 (15.3)
Education	
None	35 (23.3)
Elementary school	68 (45.3)
High school	46 (30.7)
University	2 (1.3)
Contraception duration, years	
<1	106 (70.7)
1	31 (20.7)
>1	14 (9.3)
Willing to receive reproduction counseling	
No	82 (54.7)
Yes	68 (45.3)
Have you ever heard about CC screening?	
No	132 (88.0)
Yes	18 (12.0)

CC, cervical cancer; SD, standard deviation.

Table 2. Data Collected by the Cervical Cancer Prevention System application

SCREENING INFORMATION	ADMINISTRATIVE INFORMATION	OBSTETRIC HISTORY	MEDICAL HISTORY	CERVIX CANCER HISTORY	SCREENING
Time of the screening	Name	Gestity	Smoking	Knowledge of cervical cancer	GeneXpert result
Place of the screening	Consent	Parity	Alcohol	Familial history of cervical cancer	Native colposcopy photo
	Photo (if patient agrees)	Date of last periods	Drugs	Screening of cervix cancer made	Native colposcopy result
	Age	Ongoing pregnancy	HIV status		Photo with VIA
	Address	Age of the first sexual encounter	HIV screening performed: yes/no		VIA result
	Marital status	Number of partners	Willing advice about HIV		Photo with VILI
	Telephone number	Contraception	Willing HIV screening:		VILI result
	Employment status	Contraception duration			Localization of the biopsies
	Education	Willing of advice about reproductive health			Margin of the lesion
					Colposcopy results
					Treatment made: yes/no
					Biopsy results
					Cytology results
					Next appointment date

VIA, visual inspection with acetic acid; VILI, visual inspection with Lugol's iodine.

present, or randomly on the cervix at 6 o'clock when no lesion was visible, for quality control as well.

DATA COLLECTION

Medical consultations were performed with a Samsung Galaxy S5 (Samsung, Seoul, South Korea), using the CCPS application. The m-Health CCPS application is an icon-based mobile application which contains essential patient data, such as personal information, obstetric history, HPV test results, gynecological examination results, and digital pictures of the cervix. Data collected by the application was automatically sent in real-time to a central database called Medical Unit. For security and privacy, data transfer to central database was done using an encryption method. Thus, if needed, the patient's file, including digital cervical photography, could be consulted at any time and any place.

Authentication was required to access the patients' file, and only caregivers who had received a personal identifier and password could log in the smartphone application or the Medical Unit. Access to patient data was made possible by scanning a unique bar code for each patient or by entering the patient's full name, thus ensuring patients' data protection.

STATISTICAL ANALYSES

Data were analyzed using a statistical software package (STATA Release 14; StataCorp, College Station, TX). The number of missing data was divided by the total number of recorded data (number of patients enrolled in the study × number of items recorded for each patient) and was used as the indicator for system performance assessment.

Results

PARTICIPANTS' CHARACTERISTICS

A total of 151 women were recruited in Saint Damien Health Center or in the surrounding rural dispensaries during the study period. The mean ± standard deviation age of the study participants was 41.8 ± 9.1 years. Most women were married, and 60% of them were farmers. The sociodemographic characteristics of the study population are summarized in *Table 1*.

DATA COLLECTION

The CCPS application collected a total of 44 items, including information about the women's identity, medical, and obstetrical history. The types of data collected by the application are thoroughly listed in *Table 2*. Only two patients

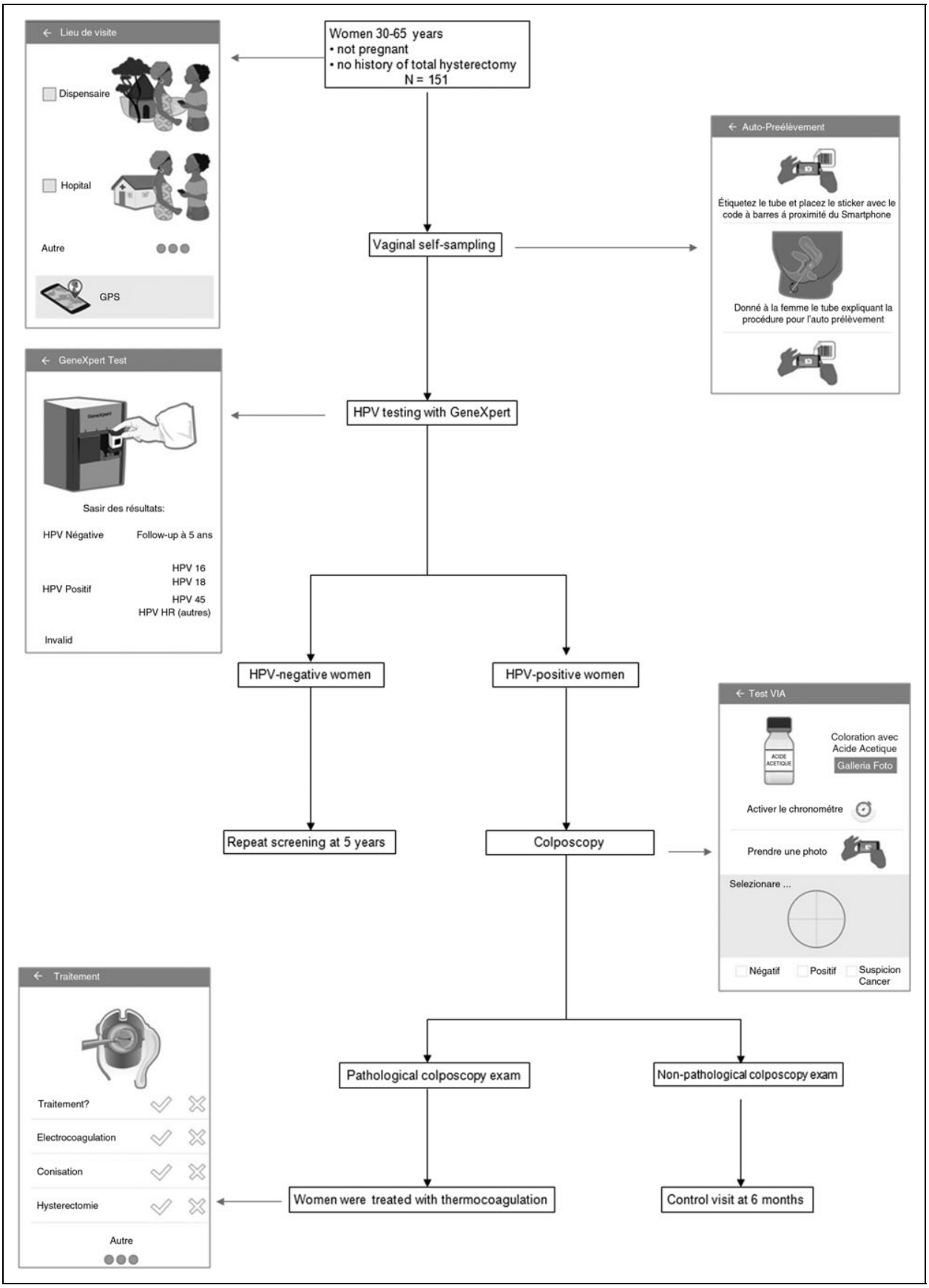

Fig. 1. Flowchart. HPV, human papillomavirus.

Table 3. Technical Errors Reported by the Cervical Cancer Prevention System System

TYPE OF ERROR	NO. OF MISSING DATA	RESOLUTION
Reversible errors		
Transmissions of the photos	All the data	Resolution on the update*
Transmissions of the GeneXpert results	All the data	Resolution on the update*
Transmissions of the pelvic examination data	All the data	Resolution on the update*
Irreversible errors		
History data not send to the Medical Unit	1/6,644 (151 patients)	Not resolved

*Data transmission was dependent on WiFi connection, and could be very slow. Update of the application allowed the use of the application without any network. Data were transmitted afterwards, within a few seconds, once a WiFi or phone connection was established.

previously knew their HIV status; the rest of the participants wished to find out their HIV status in addition to undergoing cervical cancer screening.

A small proportion of women (12%) had knowledge about cervical cancer and none of them reported a family history of cervical cancer (*Table 1*). Some women reported that they had already been screened (17.3%), but they did not know their results. Among the participants, because of invalid or lost results, only 147 self-HPV results were available. The flowchart of the study is represented in *Figure 1*.

APPLICATION'S FEASIBILITY

The use of the application was well accepted by the medical team on site; they quickly learned how to use it and were overall satisfied with it. The clinical visits' duration using CCPS was similar to that of the visits performed using handwritten files, taking ~20 min. This particular aspect, however, was not formally evaluated. Authentication into the application and software using the use of bar code proved to be practical.

TECHNICAL ASPECTS

The turning on and running of the application, as well as data transmission from the smartphone to the Medical Unit on the computer, generally took place in real-time, but could take up to 5 min depending on the WiFi connection. Data were transmitted onto the Medical Unit afterward having finished the clinical visit, within a few seconds, once a WiFi or phone connection was established. Technical problems were identified at the beginning of the study because of intermittent WiFi connection, but a rapid update subsequently allowed the use of the application without any WiFi network. In addition, HPV test results and cervical pictures, which were initially only visible on the smartphone, were also available on the Medical Unit after the application update.

DATA TRANSFER

Only one datum concerning the employment status of one patient was not transferred onto the Medical Unit and was therefore lost, probably due to a transient crash of the application. This represents a data loss of less than 0.02% of all recorded data (1/6,644 recorded data: 44 data for each patient × 151 patients). All the technical problems encountered during first utilization of the application and how upgrade resolved them are summarized in *Table 3*.

Discussion

This study supports the feasibility and reliability of CCPS m-Health system to complete cervical cancer screening database, therefore supporting the role of EMR systems in the scale-up of cervical cancer screening campaigns in LMIC. CCPS proved to be effective in collecting the women's data, which were available to both on-site medical workers who could view data directly on the smartphone and to off-site experts who could consult data via the Medical Unit installed on a computer. Moreover, the women's files could also be consulted by the investigator's staff at the University Hospital of Geneva.

Stephan et al.[11] encourages the development of m-Health applications in LMIC as it is a low-cost and easy-to-use strategy that appears to be appreciated by patients and caregivers, and which could potentially improve the quality of healthcare. The first advantage of this m-Health application compared to a handwritten paper medical record is the exhaustive patients' clinical history, as it is mandatory to answer each item before proceeding to the next one. Secondly, the application allows the quick distinction between women requiring immediate follow-up and those who can be reassured and addressed for a screening visit at 5 years. The system also allows the transfer of women's data from one system to another and may facilitate the registration of data at a national level.

An important barrier to efficient cervical cancer screening in LMIC is the lack of rigorous and systematic registration of the participants' data. Some patients had previously participated in a screening campaign but did not know their results, nor was it possible to find them in the paper archives, thus requiring us to start screening again. We examined the completeness of the data in the EMR CCPS database and only one coming from one patient among the 151 was missing on the Medical Unit, which led to very few missing data (0.02%).The system allows the data

storage on the Medical Unit, thus making it easy to retrieve it at the time of the follow-up visit. Patients' continuous follow-up, as well as HPV clearance, or new acquisition, will be possible and provide important epidemiologic information for the allocation of resources in Madagascar.

Cervical images taken at baseline screening may be consulted before the follow-up visits, helping healthcare providers to understand the possible cervical changes and to decide the best management option for the woman. If a woman decides to be followed up in another health center, her file could be shared with other healthcare professionals, thus increasing use in the context to scale-up of cervical prevention. Moreover, this database of cervical pictures can be used to allow continuous clinical education and empower frontline healthcare workers to become more effective through virtual and dynamic training.

One problem faced by the on-site caregivers was the language barrier when trying to explain the study inclusion criteria, but once patients accepted to attend screening, the use of the application instead of written paper records was no longer a limitation to the screening visit. Education programs should probably be strengthened and promoted during these visits in order to overcome negative perceptions and knowledge deficiencies about the benefice of cervical cancer screening.[12] Indeed, only 12% of the participants had some knowledge about cervical cancer. Overall, the medical team appreciated the friendly interface with the easy navigation system to fill in all the items concerning the patients.

The strength of this study was the robustness of the system using mobile phone for data collection.

The limitations were the small sample size and the fact that data have been completed by a limited number of healthcare providers, thus limiting the generalization of our findings.

In conclusion, our study supports the feasibility and reliability of a smartphone m-Health application data collection system for a cervical cancer screening campaign in a LMIC. The creation of a computer-based patient record that is accessible to on- and off-site caregivers can improve the quality of care in cervical cancer screening. Further studies are required to assess the long-term sustainability of this type of system.

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Author Disclosure Statement

No competing financial interests exist.

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