Exploring Rural Community Practices in HIV Management for the Design of Technology for Hypertensive Patients Living with HIV

Erick Oduor[1], Carolyn Pang[2], Charles Wachira[1], Rachel K. E. Bellamy[3], Timothy Nyota[1], Sekou L. Remy[1], Aisha Walcott-Bryant[1], Wycliffe Omwanda[4], and Julius Mbeya[4]
[1]IBM Research Africa, Nairobi, Kenya
[2] School of Information Studies, McGill University, Montreal, QC, Canada
[3] IBM Research, Yorktown Heights, NY, USA
[4]Lwala Community Alliance, Rongo, Kenya
[ericko, sekou, awalcott]@ke.ibm.com; [timothy.nyota, charles.wachira1]@ibm.com; rachel@us.ibm.com; carolyn.pang@mcgill.ca; julius, wycliffe@lwalacommunityalliance.org

ABSTRACT
Information communication technologies for development (ICTD) can support people with chronic illnesses living in rural communities. In Kenya, ICTD use in areas where undetected cases of hypertension and high HIV infection rates exist is underexplored. Partnering with a health facility in Migori, Kenya, we report on the uses of technology in managing HIV. We see the use of technology to manage HIV was influenced by the roles and routines of patients and clinicians, trust between practitioners and patients, and sources of data that clinicians use for patient examination. We use these results to inform the design of technologies that can support patients living with comorbid HIV and hypertension, as well as their care providers, to manage their care in similar settings. We also reiterate the important mediatory role that community health volunteers (CHVs) can play in the adoption of technology as patients manage their condition(s) once out of hospital.

Author Keywords
HCI4D; ICTD; cardiovascular diseases; HIV; rural Kenya; healthcare; mobile devices

CSS Concepts
• Human-centered computing~Computer supported cooperative work • Human-centered computing~Field studies

INTRODUCTION
Cardiovascular diseases are associated with 17.9 million deaths worldwide and are the leading cause of non-communicable disease deaths. The burden of these diseases is rising disproportionally in lower income countries and populations [43]. Chronic diseases, like hypertension, are aggravated by resource constraints and a lack of patient history, leading to poor patient care and management [1][26]. In Africa, a high prevalence of unrecognized and untreated hypertension cases account for an increasing number of deaths, highlighting the need for efforts that can strengthen health services for the prevention, early detection, and treatment of hypertension [1][19]. The situation is being exacerbated by advances in the management of HIV that has led to patients living longer and starting to deal with conditions such as hypertension and diabetes that generally "show up" later in life [15]. For example, those living with HIV already find it difficult to manage and adhere to daily medication schedules [32]; for these patients, the burden of medication management will only increase with additional diseases.

While intervention planning can address some of the challenges leading to poor patient care and management of hypertension, missing patient data remains a key requirement for information systems to support medical practitioners in making informed decisions related to patients [5]. Recent advances in healthcare technology offer great promise for the provision of healthcare within rural communities in developing countries. For example, electronic health records, electronic medical inventory administration, and telemedicine for in-home patient care are continuously being piloted [9]. Unfortunately, health institutions in rural Kenya are reluctant to pilot new healthcare technologies given their comfort with already established methods and perceived difficulty of use and efficacy of pilot projects [16][32]. We thus set to explore how medical practitioners and patients in rural Kenya used technology to manage HIV with the overall goal of informing the design of technology to support hypertension management in rural Kenya.

Our qualitative study described in this paper explores the technology routines and practices of medical practitioners and HIV patients who are living with co-morbid HIV and

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hypertension. The understanding of such routines and practices offers insights to guide the design of a technology solution that can support medical practitioners in managing these complex clinical cases. To do this, we collaborated with a rural health facility, Lwala Community Alliance, to conduct an exploratory study to understand the existing tools used to manage HIV, along with any social factors that affected technology use. Results reveal that practitioners in different roles interacted with patients both within the health facility and in the patients' homes to monitor their treatment progress.

The paper is outlined as follows. We begin with a review of literature exploring chronic diseases management in African countries, the investigation of doctor-patient interactions, and the study of inpatient and outpatient experiences. We then describe our study methodology and the study setting. Then we present a summary of results, and a discussion of how our results support the design of technology for the management of co-morbid HIV and hypertension conditions.

RELATED WORK

Chronic Disease Management

Mobile health (mHealth) applications have been developed for use in African countries in the areas of medication adherence, health worker communication, health education, and emergency and disaster response during epidemics [39]. Such mobile technologies have been used to improve the communication between clinicians and patients in South Africa and Uganda, including video and text for tuberculosis (TB) management, and SMS for HIV cases in Kenya [12][16]. Various communities have supported ICTD projects that focus on rural telemedicine setups, assistive technologies, and education and monitoring of infectious disease epidemics [14]. Projects such as 99DOTS focus on addressing patient adherence via real time monitoring, efficiency of care providers, and differentiated patient care [38][40].

Along the lines of using technology as mentioned, we also see studies conducted to understand the factors that affect and inhibit the use of ICTs in e-health [32]. Inadequate computer and Internet availability, along with technology illiteracy in healthcare staff have been seen to hinder the adoption and usage of ICTs in telemedicine centres [32]. Multimodal text messages used in HIV/AIDS management in rural parts of western Kenya are at times misinterpreted. While a promising avenue for exploration, the use of text messages to disseminate health information in rural populations is still at its infancy [13][16][19].

Cases of hypertension and HIV are also going unnoticed for those who cannot access proper medical care in Kenya [1][20][30]. A recent national study in Kenya showed that only 16% of HIV-infected adults knew that they were infected [5][38]. With patients living with HIV and suffering from hypertension unaware of their conditions, it becomes important to generate patient awareness and enable early treatment and management of these chronic diseases. mHealth and telemedicine can help to disseminate information that encourages rural populations to undergo voluntary testing.

Prior work has also shown the need for a set of standard criteria that can be used across different institutional frameworks to determine effectiveness of hypertension management initiated programs. Such criteria can provide the basis for comparing different health institutions, enabling various monitoring purposes [9]. For instance, a set of data could be gathered on abstract concepts (such as classification of hypertension level, last five encounters with patients, and last blood pressure measurements) to provide stakeholders with a report of the findings generated for easy reference [31]. Incorporating standardized measurements and recording into the design of electronic health systems that reach larger proportions of rural marginalized populations could improve the utility of information shared in a health context. Additionally, empowering staff in the medical field with intermediate computer skills could enable the smooth implementation of future telemedicine programs. While mHealth applications can support the management of HIV, and its potential to help address hypertension in African countries is clear, we do not yet see work that investigates how these applications impact the lives of patients living with both HIV and hypertension. Moreover, we see a critical need for such work in rural communities.

Trust and Doctor-Patient Interactions

Kenya only has 40 cardiologists serving a population of 48 million people [22]. The high ratio of patients per cardiologist in Kenya highlights a major problem of accessibility to, and availability of their specialized services. Given the infrequency in which patients can meet with specialists, it becomes impossible to develop a relationship that leads to trust in the sharing of meaningful information between practitioners and their patients [21]. Cultural factors also influence disclosure and concealment of information that could be pertinent in health-related discussions between medical practitioners and patients. For instance, a study revealed that HIV-infected women were reluctant to voluntary disclose their HIV status to their spouses in India [26].

The nature of the information shared during the communication between medical practitioners and patients calls for trust. In this regard, community health volunteers (CHVs) serve as intermediaries and visit rural communities to frequently liaise with patients. Doing so enables them to build trust and relationships where patients are able to discuss issues related to their health conditions openly [21]. The issue of trust and accurate communication highlights the necessity of empowering patients in managing their health conditions [26][31]. The problem of bridging a trusted relationship offers interesting opportunities for systems that support managing chronic conditions remotely, coupled with CHVs who can play a major support-role in empowering

patients self-management. CHV work has also been reported in the management of infectious and chronic diseases [28]. Overall, the CHVs interacted with acted as intermediaries between the facility and patients. As a result, they participated in our interview as participants, where they described how technology was being used in their routine work activities. In addition, they guided us around the village and introduced us to patients where they acted as translators during our interviews and provided clarification both for our team and the patients when called upon.

Inpatient and Outpatient Experiences

Within the context of rural communities, the adoption of digital technologies by both patients and medical practitioners relies on factors such as English literacy and access to technology [36]. A significant proportion of intended users are not technology literate or able to embrace new technology without understanding its necessity [2][3][11]. Studies have investigated how information shared by medical practitioners during consultation is eventually interpreted by patients once back at home. For example, an exploration of clinician information and the varying associated translations that people from low income communities made to manage their hypertension was conducted in Michigan. Results showed the need to bind health information to local context, while ensuring correct translation of health information to patients [14].

Another example of health technology intervention is an SMS system that engages pregnant women in Kenya and supports the automation of bulk-sending of personalized messages to patients. This system also allows practitioners to read patients' replies and provides them with the opportunity to respond appropriately [26]. These studies illustrate the need to consider the role health facilities play in facilitating accurate local information translations of clinician information for patients. Properly conveying information related to hypertension even after patients leave health facilities limits any misinterpretations that might arise when the patients get back to their communities [19]. With less comprehensive hypertension studies reported in Kenya, an increased and sustained awareness of the burden of hypertension can assist in the detection, treatment and control of hypertension and associated risk factors. It is against this backdrop that we investigate how technology is currently being used by practitioners to manage health conditions of patients suffering from hypertension and HIV in rural parts of Kenya.

Existing Technologies Available

Several technologies have been deployed in developing settings to support patients and practitioners via web and audio interaction [41]. For example, mobile apps can monitor activities and provide health information and guidance to patients [13][21][26][41]. Lester et al. explored the potential for video and pervasive phones to support mHealth, in addition to how text messages support improved adherence to HIV medication, and how effective use of SMS would increase efficacy of HIV program interventions [13][41]. The ability of CommCare to support frontline health systems has also been explored in the past [6].

However, none of the technology initiatives listed have approached the management of health conditions of rural communities via a holistic approach that calls for both practitioners and local communities to work collaboratively beyond treatment of the identified health conditions. As a start, Kumar et al. explored the use of shared video messages as an illustration of how ICTs could support stakeholders in the health industry to create a sense of community in rural India; they highlight how this initiative was critical for driving community ownership [16]. To the best of our knowledge, there is no prior exploratory work on the use of technology by health practitioners and patients for managing of HIV that aims to inform the design of technology that will support clinicians, CHVs and patients in the management of hypertensive patients living with HIV.

STUDY METHODOLOGY

We conducted semi-structured interviews with 36 individuals to understand how and why medical practitioners and patients used technologies, if any, to manage their hypertension and/or HIV conditions. These interviews occurred over a three-month period and took place at a health facility in Migori, a rural county in Kenya located near the border of Tanzania. We will describe our study site, participants and recruitment process. We also describe the type of technologies that were used by medical practitioners to manage patient conditions. Lastly, we describe the facility personnel and patient interactions that looked to promote remote monitoring activities once the patients left the facility.

Study Site

The local health facility (Figure 1) involved in our study was in a rural community located in Migori County, Kenya (found in the Nyanza province). This county was reported to have the highest HIV prevalence of 15.1%, in comparison to counties in other parts of the country such as the North Eastern province, which had a recorded HIV prevalence of 2.1% in 2012 [18]. In Migori County, most villagers live on less than $1 US a day and rely on subsistence farming [23]. The health facility employs 85 staff and 83 CHVs, who are Kenyans, with an additional three interns from the USA. The health facility's focus is improving health and sanitation and reducing infant mortality rate to zero. The facility also runs programs in education, economic development, and public health outreach. They work in partnership with the county government to initiate economic programs built off market-based models that are run independently by villagers after initial investment support.

Mission of the Rural Health Facility

With dedicated funding for maternal healthcare, HIV eradication and water and sanitation hygiene (WASH) programs, the health facility had also factored in resources in to be used for research in non-communicable diseases

(NCDs) management. Our research interest in exploring how hypertension was managed in rural communities paired well with the research agenda of the health facility; together, we were interested in creating awareness of hypertension using lessons learnt from the facility's existing work around the management of HIV. With extensive experience in running programs on malaria intervention, management of HIV, and reducing both teen pregnancy and infant mortality rates, the facility was interested in exploring technology solutions for hypertension management and leveraging such technology for their existing workflows.

Overall, the rural health facility attends to an average of 3,500 patients per month. Clinicians capture patients' socio-economic information while collecting patient treatment history. Such socioeconomic information is important to the facility so it can best support patients in the community based on their respective financial capabilities. The facility mainly stocks generic drugs as this is what the local population can afford. The health facility adopts a holistic approach when treating patients. As an example, the health facility empowers patients to generate income so they can raise money and purchase meals and ensure that they maintain a balanced diet while taking HIV medication. This is done through training CHVs who in turn pass the knowledge on to patients. To ensure that the CHVs keep up to date with information in the medical field in the area of HIV and water health and sanitation (WASH) in rural communities, the county government provides training manuals expressly for the CHVs. The rural facility also develops their own curriculum in conjunction with the Ministry of Health (MoH). The curriculum covers training CHVs in how to conduct case management for prevalent diseases such as malaria, HIV, hypertension and tracking teenage pregnancies.

Participants

Our 36 participants (22 males and 14 females of which 27 are medical practitioners, and 9 patients) ranged in age from 21 to 50. All our participants reported to have used some form of technology for communication, texting, chatting, and mobile banking (e.g., MPESA). We conducted meetings with the managing director, operations director, community programs director, and the head clinician to determine who could best provide relevant information during our study. Other meetings were conducted with IT staff, nurses, pharmacy technicians, laboratory staff, adherence office staff, CHVs and members of the Monitoring and Evaluation team (Table 1). Participants (health facility staff and patients) were provided with a consent form that described our research interest and stressed that participation was voluntary. There was no monetary reward in this study since the health facility had initiated various long term and sustainable empowerment programs. We also ensured that the CHVs, or the health facility staff were present during our interviews with the patients. All participant identities were anonymized prior to data analysis.

Facility Department	M	F	#
Administration, Lab & Records	6	2	8
Clinical Health	2		2
Community Health Volunteers (CHV)	3	4	7
Information Technology (IT)	2		2
Monitoring and Evaluation (M&E)	4	2	6
Pharmacy	2		2
Subtotal			**27**
Patients (with HIV)	3	6	9
Total			**36**

Table 1: Breakdown of participants, including per facility department.

Recruitment and Research Team

The principal researcher, a native to the local community, contacted the health facility with a research proposal. The health facility was already interested in increasing awareness and investigating ways of managing cases of diabetes, hypertension, and cancers in this western region of Kenya. We worked with the management of the health facility to select the medical practitioners who would provide the most accurate information to inform this study. At the senior management level, we interviewed the managing director of the medical facility, the hospital and operations director. The focus on the senior administration provided us with the health facility position regarding collaboration in this study. We found that their yearly strategy involved a push to conduct research in identification and management of hypertension in the local community. This paved the way for a collaboration that satisfied mutual interest of two organisations.

The clinicians, pharmacists and a set number of CHVs were selected by the hospital administration based on the regions they represented. The CHVs identified six patients who were visited in their homes, while three patients were interviewed at the facility. Our research team consisted of six males and one female. Five of the researchers were Kenyans, one was Caribbean and one was African-American. The principal researcher also explores technology use in the areas of water and financial inclusion in rural settings of Kenya. The principal researcher's ties to this community, along with the interests of the facility's director in this research focus area ensured timely coordination of site visits, enabling the research team to conduct the interviews. We would keep the facility management team informed about our work to ensure the success of our collaboration.

Semi-structured Interviews and Site Visits

Semi-structured interviews offer an open framework that allows focused, conversational, two-way communication [4][36][37]. Our interview questions aimed to capture the role of the participant, whether or not and how they used technology to support them in accomplishing tasks as a part of their role. For example, pharmacists were asked to provide

information about their qualifications and describe the services they currently offered. This provided clarity on the professional qualifications of the practitioners and also helped us think about how our findings might generalize to a similar demographic across the country. Among other questions, we also asked how they ensured that medication being dispensed was safe and asked them to describe how they followed up with patients once they had dispensed medication. This set of questions highlighted the challenges around time delays that resulted from reviewing several information sources manually and applying the information acquired to a problem that required historical health records that did not exist for most new patients attending the clinic in critical health. In addition to the described questions, CHVs were asked to describe a scenario where they followed up with a patient after leaving the health facility. These types of questions provided insights into the interaction points between CHVs and patients, and opportunities to enhance interaction with patients with the aim of improving adherence for co-morbid HIV and hypertension.

Three members of our research team conducted semi-structured contextual interviews with both the staff at the health facility and the patients and recorded notes. Observations and focus groups were also conducted and attended by all our team members who were present during meetings with the medical practitioners at the health facility. We also had one dedicated note-taker during this entire process. In the focus groups, discussions explored awareness of NCDs, such as hypertension, and their current practices as well as current ways in which the facility was using technology in identifying and managing HIV cases. Here, we were interested in their views of how technology could help them in their work. We also asked about service delivery where we wanted to know how the institution was already working to address some of the challenges related to managing cases of hypertension, among other questions. CHVs were represented by the members from the monitoring and evaluation team.

The semi-structured interviews and observations lasted 40 to 60 minutes. In the first visit, we conducted interviews with the facility staff and 2 patients. The participants included the administration and staff from the monitoring and evaluation (M&E), IT, and Lab and Records departments to understand how they did their work and whether technology was involved. In the second visit, conducted two months later, we interviewed 7 CHVs, 7 patients and performed observations with 1clinician, 1 pharmacist and 6 staff from the monitoring and evaluation team. The CHVs acted as intermediaries in the process of interviewing the patients. This was not the case with the rest of our participants. Clinicians, pharmacists and some CHVs were interviewed in English while the CHVs interacted with the patients in the local Luo language as we observed and took notes. A third interview, conducted with all our study participants, focused on confirming whether we had collected and recorded accurate information from our previous visits. Overall, our participant selection gave insights into the practices of medical practitioners and a rural community around management of hypertension and HIV. To reciprocate, we kept in touch with the health facility via weekly phone conversations, videoconference calls. And frequently invited the facility's employees who visited the city to our offices.

Data Analysis

Our findings are based on 108 transcribed interviews, 130 photographs, and 56 pages of field notes. We recorded each interview and transcribed the audio files to better code the information collected. Thematic analysis of the notes was conducted and a coding process on the entire interview data was performed by multiple researchers [4][37]. This analysis involved categorizing participant responses using open and axial coding, and then selectively drawing out main themes once they reviewed the generated codes [37]. High-level coding categories related to how current technology was used to coordinate information sharing around the management of NCDs, how this information was shared between patients and medical practitioners, the ways people tried to mitigate challenges arising from this form of technology use, and the ways in which people felt technology could support them better in managing chronic illnesses. We discuss these topics in our results section next.

RESULTS

The interviews with our participants and our observations at the health facility revealed general practices of how and why medical practitioners and patients suffering from HIV used technology to manage their health condition.

Relationships between Practitioners and Patients

Clinicians

The interaction between the clinician and patient was generally geared towards understanding a patient's medical history mainly from the patient's perspective, and then determining the best course of action to address the situation. From this perspective, the clinician would inquire about family history, records of TB, hypertension, and diabetes. For most patient cases at the facility, this information would be missing, more so for patients visiting the facility for the first time. In the case of chronic conditions such as hypertension, the discussions would focus on determining the patient's current medication regimen and medication history. Often, patients did not recall the names of their medication, so the clinician would display samples of medication to see if the patient could recognize these. Medication history was necessary to avoid cases of adverse drug reactions. Once a clinician could document a patient's medical history through a question and answer session, he would then explain to the patient the condition being treated while providing instructions on how the prescribed drug should be taken.

Since many patients in this community were living with HIV, the issue of strict adherence to the HIV treatment regimen

was discussed by the clinician. The clinician recorded the history of adverse drug reactions for any past conditions because every health institution in the country was required to share such records (for the case of HIV) with the government on a designated form. The information gathered would eventually be used to update health guidelines provided by the Ministry of Health. In a single clinic visit, the interaction with the patient ended once a prescription was provided. Before leaving, the patient was provided with a return date for the review of their condition. In addition to HIV management, clinicians faced challenges in the management of NCDs. Here, the clinicians hoped that patients would provide the correct information as per their knowledge. This assumption was made on the premise that HIV awareness was already high in this community and people embraced living more openly about the condition through empowerment programs initiated by the facility. These included forming self-help groups among patients living with HIV and engaging in income generating activities that included subsistence farming, soap making and selling groceries.

Pharmacy Technicians (Pharmacists)

The pharmacy work area was divided into a storage section and a dispensing section. Patients were called through a window and then seated in the dispensing room next to a desk where one of the pharmacists attended to them. Once the patient entered the room, the door would be closed for patients who were worried about stigma and privacy. There was an assistant in the room who helped with packaging medication in the storage room, following the pharmacist's instructions. The pharmacist's role was to confirm the accuracy of the prescription for the condition it was intended to treat. Pharmacists also discussed the drug regarding the condition being treated with the patient prior to dispensing the medication and conducting post-pharmacy counselling. The pharmacists informed us that there were various reasons that could lead to HIV patients discontinuing medication. For example, reasons included side effects of a medication leading to non-adherence, patients forgetting when to take the medication, and difficulty managing the complex medication regimen.

Community Health Volunteers (CHVs)

CHVs covered ten geographical areas that were structured around schools. CHVs visit patient households and provide patient surveillance in the home and dispense medication when provided with patient refills. In addition to monitoring whether patients were taking medication as recommended, CHVs also engaged patients in discussions of economic empowerment. Income generation provides the patients with the opportunity to have resources that can enable them to afford the appropriate food for their dietary requirements. All patients who had tested HIV positive at the clinic were encouraged to join local self-help groups as part of the facility's holistic treatment and care plan for the patients. Within the groups, patients were supposed to share ideas around maintaining good health in addition to economic activities. It was the CHV's duty to follow up on the progress of such initiatives. In one such interaction, a patient provided an update of activities that they had been engaging in since the CHV's last visit to their home:

> "I make it a point to take medication on time and also make sure that I go to the hospital any time I am asked to do so. I also advocate for people to take their medication and adhere to it during our self-help group meetings." – P14, Patient

CHVs would record meetings with patients on a paper form that listed all patient names. The patients also kept with them an attendance card that would be used during hospital visits and also to record CHV visits. Data stored in paper form presented several challenges to data collection: it was difficult to easily share patient files with others, inefficient to find and retrieve patient information, and potential loss of confidential medical history in the event the paper form was misplaced. Furthermore, at home patient surveillance information was not connected to the clinic's patient records.

Public Health Team

The Public Health team's main focus was on the following areas: community prevention of diseases, nutrition and sexual reproductive health, quality improvement, partners and government engagement, maternal child health and HIV and water, sanitation and hygiene (WASH). The team engaged, supported and encouraged patients, via the CHVs, to participate in income generating activities that were initiated by the facility in addition to treatment. CHVs, working within the Public Health team, were tasked with monitoring the progress of the facility initiatives and sharing the gathered feedback with the whole Public Health team. During another visit to a patient's home, we observed the patient being asked to provide updates of economic activities that they were currently engaging in with their self-help group. The patient enthusiastically described activities they undertook on planting various vegetables as a topic of interest for most members. The patient also mentioned that they had discussed the idea of manufacturing soap using locally available ingredients and sell these to members of the community as an income generating activity.

Technologies Used Within the Facility and Community

Overall, various departments at the facility reported the use of some form of technology while performing their work. The clinical team used a point of care computer system in the consultation rooms to store patient records and generate required reports. The Public Health team used Salesforce and Dropbox to store M&E data and to perform data analysis while the KenyaEMR was used in the management of HIV cases [42]. Clinicians reported the use of various sources of information as they looked up drug information, guidelines, and other medical content required to support patients. For example, a clinician described the tools he used to learn more about new drugs when asked about his source of information regarding recommended drugs:

> "My information sources are many. For example, I can read about new drugs from government circulars or from MEDS (Mission for Essential Drugs and Supplies) who are also ISO certified and have a laboratory where they conduct rigorous tests on their drugs. MEDS is accessible online [via desktop computers or mobile phones]." – P2, Clinician

Clinicians also relied on various information sources to make decisions on which drugs to prescribe. These included the official government drug index booklet (Drug-Index.IT), the MEDSCAPE website, the OMNIO medical resources website and MoH guidelines [9]. In addition, the Pharmacy and Poison Board would also communicate changes in the current drug list to health institutions.

The clinicians strongly felt that technology could better support the clinic in the storage of patient records, by facilitating easy access to the records, and by providing the opportunity to share such information with neighboring government facilities. Here is a clinician's quote regarding the opportunities offered by technology while describing how the automation of tasks could improve work performance:

> "Using a computer application makes it easy to conduct analysis. One can just use an icon to sort all patients who missed their hospital visit dates." – P1, Clinician

The pharmacists used the KenyaEMR to track patients by region after receiving referrals upon testing positive for HIV. The pharmacists also worked closely with CHVs. Pharmacists trained clinicians on administering medication at the facility and periodically generated a list that was shared with the Public Health team and CHVs using the CommCare website [6]. Due to the broad nature of activities they engaged in for their roles, the CHVs felt that a system that automated their inventory of drugs, and their reporting needs for both CommCare and Salesforce would better support them in their work.

Mobile phones were used for communication between the medical unit in charge of adherence and the CHVs in case an intervention was required for patients who had stopped coming to the clinic for medication refills and consultation. Once it was clear that a patient was not adhering to their medication regimen, the adherence monitoring office at the facility would send a message to such patients via the CHVs or neighbors. In the event the neighbors could not be reached, the CHVs would try to locate these patients in their homes and explain to them the importance of adherence in the presence of other family members so that everyone would be responsible for ensuring the patient adhered to the medication schedule. Note that 50% of the patients we interviewed reported owning a mobile touchphone with no experience of ever using a computer.

Challenges Around the Use of Technology

Like prior studies [7][25][32][35], in the rural region we studied, the risk of HIV and hypertension was impacted by poverty and illiteracy, which, moreover, presented challenges for the design of appropriate technology. In addition, our study highlights various social constructs, described next, that affected the management of HIV and potentially other chronic conditions, and thus the potential use of technology. The social constructs were observed as user roles as participants performed their work, user routines in the daily lives of participants and challenges associated with poverty such as access to technology (contrary to [21][32]). We also saw such challenges in situations where clinicians had to use patient data as provided by the patients themselves rather than via official medical records.

User Roles

In terms of how technology supported practitioners in their routines, participants informed us that various technologies did not support smooth service delivery. The clinicians used various technologies to support them in addressing patient needs but none of these could provide the comprehensive information required in an easier to consume manner. Asked about how they used such technology while attending to a hypertensive patient living with HIV, this is what a clinician said:

> "The KenyaEMR system is rigid in that it offers only room for selecting a regimen for a patient and an automated button that leads one to the next step selection. As a clinician, I am not able to make notes or additional comments for the pharmacist to consider in case prescribed medication is out of stock." – P1, Clinician

In addition, the information regarding a patient's hypertension condition was stored in a notebook or card, while that associated with HIV was stored in the KenyaEMR. Over time, the notebooks or cards were likely to be lost as opposed to the digital records on KenyaEMR. As a result, only partial medical records would be available leading to the lack of a clear picture of such a patient's treatment history. Remotely availing such information for clinicians could greatly speed up attention to patients in case they attended other facilities. Below, a clinician recalls a recent case when asked about the challenges associated with attending to patients suffering from chronic illnesses but have missing health records.

> "Deaths can occur due to inability to trace patient history in a timely manner. There is a recent case where a non-adhering patient was brought here in a near stroke condition and it took us a while to actually figure out the problem." – P2, Clinician

The facility director also reiterated the fact that more integrated technology could lead to saving valuable time, something that was not the case currently, in case critically-ill patients brought to the rural facility required immediate attention. This was shared during a focus group discussion with the health facility staff as captured below:

> "Having patient data from the triage saved in a database that consistently provides synchronized data access. Can

> mean that information gathered at the nurse station would already be updated by the time the clinician opens the patient's profile and save time." – P4, Facility Director

User Routines

The need for the pharmacist to gather insights from the patient meant that trust with the patients was necessary to achieve the required outcomes during the dispensing of drugs. Therefore, the pharmacist conducted discussions with the patient on the importance of having a proper and balanced diet, taking all medication as prescribed, and encouraging patients to liaise with CHVs in case of any questions. All this would be done in addition to the pharmacist's primary role, which was to dispense medication. However, taking medication at the recommended times was found to be a challenge for the patients. Patients attributed this to forgetfulness due to other work engagements even though they assured the CHVs that they eventually made up for the misses before the end of the day. Other reasons, such as the distance to the facility, also affected some patients who lived further away in case they needed to refill medication yet they felt weak due to an opportunistic illness. Despite these challenges, the patients used various means to ensure that they adhered to taking medication as required. Here, a patient responds when asked about how they ensured adherence to medication:

> "Sometimes I get reminded to take medication by my eldest child. I take medication at 8pm daily and check the time via watch, radio and phone which is always on the table." – P20, Patient.

Patients who had been identified as living with HIV or hypertension required monitoring either by returning for their appointments at the facility, or via CHVs visiting their homes. In cases where such patients were not reachable the adherence team would take up their cases. Here, a patient explains how they could be reached:

> "I do not have a mobile phone but in case you are looking for me, you will need reach Nyan'gao area. Once there, you will just ask and people guide you to my home." – P19, Patient

Monitoring patient progress with treatment once the patient had left the clinic was done via CHV visits to patient homes where they collected feedback and periodically shared the feedback with the facility. The whole data collection and recording was done on paper. Collection on paper meant that clinicians were not able to automatically interact directly with CHVs in case there was an immediate need to change a patient's drug prescription remotely as a result of drug related complications. A participant responding to a question on adverse reactions to a prescription described their experience:

> "I had whizzing sound in my head and felt nauseated. I asked the CHV for a different medication which was given to me after two days. Currently, I have no issues regarding any problems while taking the new type of medication that I was re-issued." – P25, Patient

Duplication of Activities and Poverty

Other results that have been reported before but are necessary to reiterate as they affect the use of technology within rural community include duplication of activities using technology and effects of poverty on implementing technology supported solutions in rural communities [7][10][23]. For example, the technology used by the Public Health team to monitor WASH activities and used by clinicians to conduct KenyaEMR enrollments duplicated data collection, hence consuming time that could have been dedicated to improving patient care.

Poverty, an issue already raised in prior studies, can lead to problems such as exclusion of the underprivileged in accessing technology or, can even impact effective implementation of programs initiated to alleviate diseases such as Malaria [7][33]. Poverty has also been extensively reported as a social challenge in prior ICTD literature when family members in rural villages attempt to communicate with their distributed relatives [23][32][35]. In our study, we found that half of our patient participants often did not have a mobile number to follow-up with the facility after visiting the clinic. The significance of this challenge, closely tied to poverty is summed up below:

> "In case you really are looking for me, it would only be possible when you get to my home. Currently, my husband's number isn't working meaning that using mobile phone communication is an off limit way of communicating with me for now. I am not able to afford a phone." – P7, Patient

Traditional norms such as those associated with wife inheritance seriously jeopardized efforts focused on the issue of non-adherence in the treatment of HIV [23][28]. Wife inheritance is a cultural and social practice whereby a widow marries a male relative of her late husband. Healthy community members reportedly inherited widows who could be HIV positive but for the allure of keeping to traditional beliefs such as wife inheritance overshadowed the need to even do HIV testing before marrying surviving brother-in-laws.

Cases where infected discordant partners would stop taking medication due to frustration and stigma were frequently reported by the CHV. The pharmacist was thus strongly encouraged to ensure that post pharmacy counselling touched on all issues that were relevant to each and every patient based on feedback from the CHV. Currently, they would rely on paper reports to understand the issues facing patients. In cases where there were many patients to attend to, it was not possible to go over these reports. The pharmacist would be faced with no option other than gathering information from the patient with the hope that it would be accurate, and then provide post pharmacy counselling as appropriate.

Knowledge Transfer between Facility and Community

The health facility reportedly trained 83 CHVs to work in the local and surrounding communities. The facility worked in close contact with the MoH via the county office to empower not only its CHVs but also to engage the county government's CHVs. The facility's CHVs could also refer patients to neighboring government dispensaries in addition to the rural health facility.

The interaction process between the CHVs and patients was cordial and seemed to have been built on mutual trust since the patients looked comfortable chatting in our presence. The conversations with the patients were conducted in Luo dialect. Once we entered a home, we would be invited into the house with meetings opening with a word of prayer. The CHV would then ask the patients to take them through the health-related activities they had been doing since their last visit. The CHV reiterated the importance of adherence to the patient and gave the patient an opportunity to ask any questions before the meeting closed. In cases where the patient complained of feeling unwell, a referral letter for a facility visit would be provided immediately.

Note that the CHVs spent some time describing to the patients that we (the study observers) were only going to observe their interaction and would not take part in any discussions with them directly. All the patients we visited agreed with this arrangement and informed the CHVs that they were partly alive because of the initiatives of the institution hence had no problems participating in the research. The CHVs were also interested in the place where the patients stored their HIV medication since this could provide insight whether drug storage in the home affected a patient's adherence. Generally, the patients we interviewed in their homes shared this information willingly as captured and translated during an interaction with a CHV.

> "When I get home from the clinic, I keep medication somewhere safe in the bedroom but I am not comfortable to mention the exact location with you. But, know that I keep them in a safe place. The place is obviously the place is definitely above the ground and could even be the walls." – P27, Patient

The CHVs visited the patients at least once a month either to provide lifestyle advice, provide information about medication, or to refer a patient suffering from a persistent infection. Other times, the CHV would just pass by a patient's home while on personal duties around the village.

DISCUSSION

Our research goal was to understand the existing tools used by practitioners to manage hypertension and HIV along with any social factors that affected the use of such healthcare technologies. We begin this section by emphasizing that our research goal of exploring technology design for use in the management of hypertension aligned with the facility's plans to understand challenges around this condition.

The opportunity to have a shared research interest with the health facility in an understudied area provided us with a pathway to study the experiences from within a rural health institution that worked closely with the surrounding community. The facility's interest in approaching the management of hypertension and HIV holistically [11]also enabled us to explore factors that inform the design of technology [14], and empower patients to manage their conditions once they leave the health facility [26]. Our interest in technology design for the management of a chronic illness based on past experiences of a local community working closely with a rural health facility, is highly exploratory, from an HCI perspective, paving the way for further research in this space as we move into the future.

Supporting the Role of CHVs in Managing Hypertension for Patients living with HIV

The CHVs strategically sit between clinicians, pharmacists and patients. Here, they play an important role in ensuring that a holistic treatment approach is implemented in the community. The current ways of operation can be borrowed while thinking about how the facility will engage with the community while managing hypertension for patients living with HIV moving forward. Along these lines, the facility's intent to focus heavily on training the CHVs in how to identify and manage hypertension using MoH guidelines [9] sets the stage. However, low literacy levels among CHVs mean that they will always face challenges when using technology in such a bridging/support role between patients and practitioners [14].

In addition, our results highlight a constant need for health practitioners and patients to increase their knowledge base. For instance, clinicians and pharmacists continuously need to update their knowledge of new drugs, CHVs continuously require training to keep up with current practices in the managing of diseases, while the patients require engagement to understand the importance of adherence to medications and keep to prescribed dosages. The CHVs could also be equipped with the necessary skills to support clinicians in diagnosing hypertension in patients living with HIV. This could require conducting simple procedures that do not require special expertise but can reduce the preliminary activities that a clinician would be required to perform in case of emergency (similar, but different than the use of intermediaries or helpers in [23][34][35]).

Designers should explore avenues through which the CHVs can have quick conversations with clinicians and pharmacists while reviewing a patient's progress remotely. The CHVs could be equipped with the necessary skills to support clinicians in diagnosing hypertension in patients living with HIV, and conducting simple procedures that do not require special expertise but reduce the preliminary activities that a clinician would be required to perform in case of emergency. The CHVs could also be intermediaries should any patient face challenges with interpreting health related information that is delivered to their mobile phones.

On the patient's end, a chat module accessible via text or audio could provide them with information regarding the management of their health condition remotely. The same platform could also be used to provide contextualized lifestyle advice, medication information, or even to share discussions in a manner similar to those used by farmers in rural India [25].

Accessing Patient Data

The challenge of accessing patient data has been reported widely as a major problem in Africa [3]. Our results revealed that clinicians, pharmacists and CHVs interacted with patients to either understand, gather, or monitor their medical history. Clinicians required this information to treat and provide appropriate prescriptions, pharmacists used this information to ensure that the correct prescription was handed out, and the CHVs monitored the patients to ensure that they were taking medications directed by the pharmacist. We also saw the clinicians and pharmacists used various technologies to access health guidelines that guided prescription of medication [9]. The clinicians and pharmacists reported stressing the importance of adherence to medication during consultation and post pharmacy counselling. In addition, the CHVs monitored the patients in their home to ensure that they engaged in all the activities that covered the holistic approaches fronted by the facility in managing patients [31].

These results provide an opportunity to think about the design of systems that can integrate guidelines for identified health conditions, a patient's medical history and triage information. Based on such aggregated data, the system could analyze a patient's adverse drug reactions (ADR). Based on a rules engine, it could then suggest informed medication prescription options to the clinician, who could then select the best possible combination of drugs based on every patient's unique situation (different than [31]).

Appropriating Technology

Our results highlight various technologies that practitioners and patients used while in and out of the hospital. Extensive research has been performed to study telemedicine use in Africa to extend the reach of limited healthcare workers [2][16][18]. We go a step further to understand how clinicians use certain tools in their roles to diagnose diseases, to access information about health guidelines and to access the latest information regarding prescription drugs. The practitioners generally reported that the various technologies used did not provide end-to-end functionality that smoothly accomplished their tasks [9][21]. For instance, KenyaEMR did not provide clinicians and pharmacists with the opportunity to edit regimens already assigned to patients, or even make extra comments for each other in case they needed to revise a prescription [20]. For a hypertensive patient living with HIV, KenyaEMR would be used in the treatment of HIV, while paper cards were used to record the hypertension related medical details. CHVs also used paper cards to record their observation while visiting patients [3][7]. The use of paper records in addition to digital technology for patient records highlights a potential situation where it becomes complicated to monitor adherence especially when patients suffer from multiple health conditions and need several medications over long periods.

Designers should think about addressing an ever-present problem in polypharmacy with systems that minimize the pill burden of patients. Such systems could suggest the most tolerable combination of medications and recommend periods when medication could be most conveniently taken based on a patient's schedule. Such recommendations could be guided by patients' preferred meal times, usual time of work and ideal sleep times. The recommendations could be delivered to patients' mobile phones with a notification and also forwarded to their designated CHV.

Study Limitations

We recognize that while valuable, our study results do come with their limitations. We focused on a country that is highly multicultural with many different ethnicities and village types. We also interviewed a small sample size, especially the number of patients (nine). The findings based on the small number of patients in our studies suggests the need for additional investigations focussing more on how patients in rural communities use technology to manage chronic conditions.

CONCLUSION

We have reported on an investigation conducted with a rural health facility in Kenya that applied a holistic approach to treating patients living with HIV. Our study explored the use of technology by medical practitioners and patients in managing these conditions. Our results reveal several factors that impacted commitment to adhering to treatment. These included: trust during patient and care provider interaction, strong support networks among patients and with CHVs, and economic activities initiated as part of the health facility's mission in the community. However, we also found that cultural norms, and the lack of uniform access to technology affected the effectiveness of the institutional health objectives. We expect that our study implications will open discussions and opportunities for designers of healthcare technologies for rural communities with similar settings.

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