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## Perceived mHealth barriers and benefits for home-based HIV testing and counseling and other care: Qualitative findings from health officials, community health workers, and persons living with HIV in South Africa

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### Abstract

mHealth has been proposed to address inefficiencies in the current South African healthcare system, including home-based HIV testing and counseling (HTC) programs. Yet wide-scale adoption of mHealth has not occurred. Even as infrastructure barriers decrease, a need to better understand perceived adoption barriers by stakeholders remains.

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We conducted focus group discussions (FGD) in South Africa in 2016 with 10 home-based HTC field staff, 12 community health workers (CHWs) and 10 persons living with HIV (PLH). Key informant (KI) interviews were conducted with five health officials. Perceptions about current home-based HTC practices, future mHealth systems and the use of biometrics for patient identification were discussed, recorded and transcribed for qualitative analysis. Themes were based on a conceptual model for perceived mHealth service quality.

Stakeholders brought up a lack of communication in sharing patient health information between clinics, between clinics and CHWs, and between clinics and patients as major barriers to care that mHealth can address. CHWs need better patient information from clinics in terms of physical location and health status to plan visitation routes and address patient needs. CHWs perceive that communication barriers create distrust towards them by clinic staff. PLH want automated appointment and medication reminders. KI see mHealth as a way to improve health information transfer to government officials to better allocate healthcare resources. Stakeholders are also optimistic about the ability for biometrics to improve patient identification but disagreed as to which biometrics would be acceptable, especially in older patients.

All stakeholders provided useful information towards the development of mHealth systems. Hospitals are adopting patient-centered approaches that solicit feedback from patients and incorporate them into decision-making processes. A similar approach is needed in the development of mHealth systems. Further, such systems are critical to the successful extension of the health system from health facilities into people's homes.

## Keywords

South Africa; mHealth; biometric authentication; HIV; home-based counseling and testing

## 1. Introduction

mHealth, i.e. healthcare systems and services that are supported by mobile devices, is rapidly evolving in low and middle income countries (LMIC) in response to outdated healthcare practices that are outpaced by the growing burden of disease (Mukund & Murray, 2009; Leon, Schriver & Daviaud, 2012; Padma, 2010). In many LMIC, home visitation is an important first step in healthcare delivery through community health worker (CHW) programs and home-based HIV testing and counseling (HTC; Were, Mermin, Bunnell, Ekwaru & Kaharuzat, 2003; WHO, 2008); trained personnel conduct home visitation, administer rapid diagnostic tests for HIV, and refer individuals who test positive, i.e. persons living with HIV (PLH), for clinic care. Driving home-based HTC is its ability to improve HIV testing and diagnosis as the first step in the HIV care continuum; non-clinic attending populations are reached (Ganguli, Bassett, Dong & Walensky, 2009) and common barriers to facility-based care, including lack of transport are reduced (Geng et al., 2010). Success has been demonstrated with home visitation where CHWs and medical personnel are equipped with mobile phones for data collection and supervision (Tomlinson et al., 2009, Wouters, Batjis, Maponya, Martiz, & Mashiri, 2009). Despite the potential, wide-scale adoption of mHealth has not occurred (Krah & de Kruijff, 2016; Leon et al., 2012). Barriers need to be explored across the spectrum of stakeholders from health officials to patients. In this article,

we fill in gaps by presenting findings from qualitative interviews that were conducted with South African health officials, research field staff, CHWs and PLH.

South Africa is the country with the largest total number of people living with HIV. The national prevalence rate is around 12%, with higher rates in regions like KwaZulu-Natal (25%) (Shisana, 2013), where this study took place. Home-based HTC is a key component of home visitation programs in South Africa due to its demonstrated scalability (Naik, Tabana, Doherty, Zembe, & Jackson, 2012) and the great need for HIV services. The value of home-based HTC and CHWs programs is highlighted by the South African government's plan to train between 700,000 and 1.3 million CHWs by 2030 (National Planning Commission, 2012; Singh & Sullivan, 2013).

Despite successes, poor integration between home visitation programs and the healthcare system is a significant barrier for home-based HTC and other CHW initiatives in the current era of paper registers. This includes difficulties in tracking the number of people who receive health services in the home (Tomlinson et al., 2013), ensuring referral and linkage to care, and a lack of adequate communication between CHWs and referral clinics (Macintyre & Littrell, 2008; AMREF, 2012). Monitoring CHW services is also challenged due to the lack of adequate and standardized health information tools and processes, poor integration of information into existing routine health information systems and the absence of dedicated monitoring and evaluation staff (Leon & Schneider, 2012). Integration and monitoring issues will only increase as home-based HTC programs attempt to scale to meet the burden of HIV and other diseases. The increased CHW workload has had the unintended consequence of reducing the quality of data going into the Health Information System. Register data is fragmented, error prone, incomplete and inaccessible (Mate, Bennett, Mphatswe, Barker & Rollins, 2009; Sherman, Jones, Coovadia, Urban, & Bolton, 2004).

A key integration challenge is how best to identify and track enrollees in home visitation programs, including through the HIV care continuum. These data are critical to achieving the UNAIDS 90-90-90 targets. It is well-known in the healthcare community that early HIV testing and engagement with ART reduces morbidity, mortality (Coetzee et al., 2004; Wouters, Meulemans, van Rensburg, Heunis & Mortelmans, 2007) and infectiousness, and therefore, onward transmission of the virus (Cohen et al., 2011; Mills, 2011; SANAC, 2011). Yet the drop-off that occurs at each step from HIV testing to viral suppression results in up to 30% of those tested retained in care (Mugglin et al., 2012; Rosen & Fox, 2011). Moreover, the link from HIV testing to initiation of care is often weak, with large numbers of HIV+ persons delaying or never initiating ART. Studies have estimated that as few as 63% of individuals who test HIV-positive are linked to care (Rosen & Fox, 2011) and subsequent retention is far from optimal. The inability to track PLH also impacts retention estimates themselves as PLH travel and migrate; a patient lost to follow-up in an analysis may be retained in care at another clinic (Geng et al., 2010). Moreover, the inability to share patient records that include ART initiation and staging information impedes ART regimen maintenance (Hickey et al., 2016). mHealth tools have been introduced to streamline CHW programs that rely on paper registries. Technological advances have brought opportunities for improved patient identification through fingerprint scanners and other biometric identification devices that connect to mobile platforms. Across 70 LMIC, there are now over

160 biometric programs covering 1 billion people (Gelb & Clark, 2013). Improved identification and tracking strengthens the ability to share patient information between CHWs and clinics. mHealth tools pick up where current home-based HTC protocols leave off after testing and diagnosis to fill in additional gaps in the HIV care continuum, including retention in care and ART adherence. For example, PLH can receive appointment and medication reminders on their mobile phones (Forrest et al., 2015; Mukund & Murray, 2009; Lester et al., 2010).

Despite the potential of mHealth, wide-scale adoption has yet to occur. In South Africa, there are an estimated 42 mHealth services to address HIV / AIDS (Cargo, 2013). Obvious barriers in the South African information and communication (ICT) infrastructure need to be addressed, including the cost of linking information between different health systems and poor network coverage in some areas (National Department of Health, South Africa, 2015). Yet improvements in infrastructure will not be enough. Bukachi and Pakenham-Walsh (2007) state a need to better understand local conditions, health worker training, and how to select appropriate ICT tools before scaling mHealth programs. Patient confidence in healthcare services is paramount to engagement (Kaplan & Litweka, 2008; Dagger & Sweeney, 2006), especially when considering mHealth (Ahluwalia & Vershney, 2009; Kaplan & Litweka, 2008) and biometric technology (Chandra & Calderon, 2005). Issues relating to user acceptability, trust, and privacy are potentially amplified by mHealth systems.

The current study reports on qualitative data that was collected in South Africa to inform the development of an mHealth platform to support home-based HTC. We examine perceptions towards mHealth, biometric identification and essential features in future mHealth systems. We build on prior qualitative work in South Africa that examined perceptions of Mxit (a social media network) users towards the proposed National Health Insurance plan (Weimann & Stuttaford, 2014), perceptions of young people towards youth-oriented health services (Schriver, Meagley, Norris, Geary & Stein, 2014), CHW roles (Druetz, Kadio, Haddad, Kouanda & Ridde, 2015; Kane et al., 2016; Mlotshwa, Harris, Schneider & Moshabela, 2015), perceptions of program managers and researchers towards mHealth capabilities and CHWs (Leon & Schneider, 2012), and perceptions of bank employees (Poe & Labuschagne, 2011) and the general population (Riley, Buckner, Johnson & Benyon, 2009) towards biometric technology used for identification.

Our work adds to this body of literature through inclusion of stakeholders across the spectrum of users who would engage an mHealth system for home-based HTC. Perhaps most importantly, focus group discussions (FGD) included PLH, which has larger implications for the development of mHealth systems that are acceptable and meet the needs of vulnerable populations. Until now, biometric perceptions have largely been evaluated in the financial sector for banking versus mHealth. We also interviewed three major types of providers in home-based HTC programs, including health officials, research field staff, and CHWs. Nuances between staff and CHW perspectives are especially important to tease out as they operate with differing resources, despite having overlapping roles. For example, research staff can travel farther by car when conducting home-based HTC, in contrast to CHWs who travel on foot and work in their own neighborhoods. One repercussion for

CHWs is that stigma may result if home-based HTC is conducted with neighbors (Ganguli et al., 2009).

Perceptions are examined using a model for the perceived quality of mHealth services (Akter, D'Ambra & Ray, 2013) that has previously been used to examine patient perceptions. The model yields three service quality themes, starting with *system quality*, i.e. the quality of the mHealth platform. System quality is described through three subthemes for the *reliability* (and availability) of the platform to users over time, the *efficiency* of the platform, including ease of use and adaptability to different user needs, and *privacy* in terms of the degree to which health information is protected.

The second theme is *interaction quality* and captures the degree to which the mHealth platform facilitates communication with three subthemes. *Cooperation* describes the “willingness” and “responsiveness” of service providers in helping users. In our study, cooperation entails several layers of users, including CHWs and PLH. *Confidence* represents the degree to which the platform is perceived to be “safe” and fosters “trust” between users. The third subtheme reflects the *care* of the provider in attending to users’ needs.

The third theme is *information quality* and includes two subthemes. *Utilitarian benefits* come from a platform that services its intended purpose with regard to information services. *Hedonic benefits* refer to “positive feelings” that result from the information services.

## 2. Methods

### 2.1 Overview

This study was conducted in KwaZulu-Natal (KZN), South Africa, between April and August 2016, to inform the development of a mobile platform to be integrated into a home-based HTC program to assist CHWs linking PLH to HIV care. We examine perceptions towards mHealth and biometrics, and how they can be used to enhance home-based HTC. Ethical approval for all study procedures was obtained from the Institutional Review Boards of the participating institutes in the United States and South Africa. All participants provided consent to participate.

### 2.2 Participants and procedures

Four samples of home-based HTC stakeholders were purposively selected based on prior engagement in home-based HTC as a CHW or patient and familiarity with mobile technology:

1. *Key informants* (KI) consisting of five South African Department of Health Officials (n = one man, four women). Three KI had direct involvement in mHealth projects, including two KI who were part of the eHealth Directorate (KI 3 and 5). All were familiar with electronic patient tracking systems.
2. *Research field staff* (n = four men, six women), hereafter referred to as “staff,” who were involved in a prior home-based HTC study conducted in KZN, and used mobile phones for data entry (Linkages study; Barnabas et al., 2016).

3. *CHWs* (n = 12 women), i.e. community care givers (CCG), who are deployed through the Department of Health and conduct home visitation to advise and engage in clinic referral for different illnesses, including HIV. Most CHWs were familiar with mHealth programs, including *MomConnect*, an mHealth program for pregnant mothers that provided SMS appointment reminders and advice.
4. *PLH* (n = ten women) were a subset of study participants in the Linkages study who agreed to be contacted for future studies.

Participants were at least 18 years old, based on eligibility requirements for PLH to have participated in the Linkages study (median = 25.5 years old; range = 19–41), or job eligibility for remaining participants, including KI (median = 45; range = 42–58), staff (median = 31.5; range = 26–42), and CHWs (median = 30, range = 19–58).

Separate interviews were conducted with each KI in quiet spaces at the interviewees' places of work in English and lasted approximately half an hour. KI were not paid for their time. Three separate FGD were carried out in our research offices in the Zulu language with staff (n = 10), CHWs (n = 12), and PLH (n = 10). FGD lasted approximately two hours with staff, two and a half hours with CHWs, and one hour with PLH. Participants received 120 Rand (approximately \$9 dollars) for their time.

All participants were told that the study was being conducted to inform the development of an mHealth platform for home-based HTC and in doing so, to elicit opinions and experiences related to home-based HTC and ways that mobile technology can improve the care of individuals who receive these services. FGD started by asking about home-based HTC perceptions, then how participants currently use technology, and ways they think mHealth could improve home-based HTC and CHW programs. Questions concluded by asking participants what type of biometric identifiers should be used in an mHealth system. KI questions followed a similar format with the question on current technology usage replaced by asking if they were involved with projects that incorporated mobile phones into healthcare.

### 2.3 Qualitative analysis

All conversations were audio-taped and transcribed for thematic analysis (Ryan & Bernard, 2003). Codes were developed from conversation content pertaining to current home-based HTC practices and proposed future mHealth practices. Codes were then classified by service quality themes and subthemes presented by Akter et al. (2013). We allowed new themes to develop but found themes from Akter et al. (2013) to adequately anchor our study's classifications. Two researchers (Comulada and Harris) manually analyzed conversation transcripts. If codes were inconsistent, consensus was reached after reanalyzing the transcripts.

## 3. Results

We begin by summarizing participant discussions on how they currently use technology in Section 3.1. Sections 3.2 – 3.4 present results that pertain to perceptions about current home-based HTC practices and improvements that mHealth can bring. Results are presented

within Akter et. al's (2013) framework of perceived quality of mHealth services and grouped by themes and subthemes for interaction quality, platform quality, and outcome quality. Quotations from individual FGD participants and KI are indented and italicized. Participant numbers were recorded and presented along with quotations, e.g. CHW 1 for the first participant in the CHW FGD. Numbers are not presented for staff as they were not recorded. Quotations from different staff are represented to the best of our ability by differentiating staff based on conversation flow.

### 3.1 Technology usage

Everyone reported using mobile phones for basic communication. Staff and CHWs reported using mobile online tools more than PLH. Staff used internet banking to make payments, buy electricity, and transfer money. They also communicated through *WhatsApp* and used *Google* to search for information, including health information. CHWs bought electricity, airtime, and transferring money. One PLH was familiar with *WhatsApp* and reported sending airtime through a mobile phone. We did not ask KI about their technology usage because they were selected based on familiarity with mHealth projects.

### 3.2 Interaction quality

**3.2.1 Cooperation**—KIs, staff, and CHWs discussed a lack of communication in sharing patient health information (e.g., “an X-ray”) between clinics, clinics and CHWs, and clinics and patients, as a main drawback to the current system. Stakeholders saw potential for mHealth to improve interaction quality by streamlining procedures to improve cooperation between healthcare providers and quicken response times with patients. Communication breakdowns start with home visitation by CHWs, at the beginning of the HIV care continuum. CHWs complained of not having clearly defined catchment areas and wasting time to find homes. Efforts are duplicated when CHWs visit homes that were previously visited by other CHWs.

What is missing is that at clinics as we live here in the rural areas, each household has a house number. In clinics they do not record the house number where people live. They just take these details, the name, surname, ID number, where one lives. They do not ask for the house number. That way they make it hard to follow up. That is the problem of the clinic in the community. – CHW 5

The need for tools to plan visitation routes was elaborated upon on by Staff. They expressed interest in mHealth mapping tools and a documentation system that would help prioritize cases along their visitation routes and remind them of follow-up visits.

I would say maybe if it could be designed and have a map that has EA [Enumerator Area], cluster and a VP [Visit Point]. – Staff

Staff and CHWs shared similar frustrations in not knowing if patients follow through upon clinic referrals, i.e. link to care, and not receiving updates on patients' health statuses from clinics to prioritize follow-up.

They [CHWs] test at home but the main problem is that they don't know whether [the] patient has reached the clinic or not, when they were referred. – KI 2



You go to the hospital, there is a patient file, the doctors can then look and see what's there. The Health Workers don't currently have anything like that. – KI 5

I said if that app could have a feature that when the participant is at the clinic, then shows on my side that so and so came on this date to do this, if that could be added, that feature in phones so that when you do follow up you already have the information in your phone that he has gone. If he didn't go on his date you also see that, the phone should tell me. - Staff

When a person says there is a problem we just refer you to the clinic without seeing what we see, we refer you as long as they say there is something that they are feeling [they are not feeling well], because we don't have the information that the clinic has. – CHW 9

Staff and CHWs discussed a need to share health information beyond the initial clinic referral to coordinate patient care. Specific examples were given, including a clinic not utilizing CD4 count information collected by staff to treat a PLH and a clinic not sharing a tuberculosis [TB] diagnosis with a CHW who suspected a PLH had TB because they “kept coughing.” In the second case, the CHW later found out that the PLH did have TB and was unaware of their own TB diagnosis as well. KI 2 gave an example of a mother who miscarried and continued to receive SMS reminders for prenatal visits through *MomConnect*.

When you refer the participant to the clinic and when you come back for the follow up he will say “no nurse said I am fine.” And because you knew and had seen it and you know how much his CD4 count was, you then explain that if your CD4 count is this much, maybe if they are 900 you don't have to start treatment. And maybe at the clinic they just said “you are fine” only to find that they were very busy at the clinic and didn't spend enough time with him. – Staff

PLH wanted reminders sent to their mobile phones to prompt adherence to medication regimens and remind them of upcoming appointments. PLH noted that incorrectly remembering appointment dates meant not being seen. PLH were also frustrated by long waiting times in clinics.

Clinics are full as it happens that if you did not go on your date they postpone and ask you why you did not come on your date and tell you this is other people's date. – PLH 6

The thing of phones that you just mentioned... for me that I forget a lot. They sometimes tell me to come on the 10<sup>th</sup> and I would go on the 11<sup>th</sup>. I get reminded, it would be easy and it is good to have to beep on your phone. – PLH 7

**3.2.2 Confidence**—CHWs touched on another important aspect of interaction quality by highlighting how an mHealth system could instill confidence in its users. CHWs stated that a lack of communication between clinic staff and CHWs creates distrust. KI 4 echoed this sentiment by recalling an instance where fewer clients were referred by CHWs in a particular catchment area than they thought should have been; KI 4 was not sure if there was a lack of clients or “maybe they [CHWs] don't do their work”. CHWs felt that an mHealth

system could improve rapport between them and clinic staff by documenting their work flow to prove they are working.

One day when they have defaulted, when you cannot find a person, where are you going to find them because at the clinic they have this notion that we do not look for them, we do not do our job. – CHW 6

I think it is alright because people deny us at the clinic and say I don't even know the CCG [CHW], it will prove that "but here it is why do you say that you don't know me". – CHW 9

KI and staff emphasized the importance of training for CHWs and patients as a confidence-building step in the role out of future mHealth systems. Staff felt that the "manner" in which the mHealth-based program is presented is more to secure patient buy-in than the patient identification method to be used. They felt that how identification will help patients should be emphasized, e.g., "It won't be the same as standing in a queue and being unknown" and "your thumb [print] will prevent other people from collecting your tablets." Staff were optimistic that patients' trust in mHealth would improve as technology improves and becomes embedded in daily routines. KI 3 and staff also indicated that training would be needed to weed out individuals unable to develop the necessary skills to use the system. In particular, there was concern about older CHWs, who may be more resistant or unable to learn how to use an mHealth system. However, KI 3 shared that older CHW who were trained on an mHealth pilot system using a digital pen "were quite happy with using the pen".

I think if you could tell them as we do this study this will help you when you go to the clinic and find that your file is lost and this will be in the system. - Staff

In looking at the CHWs that work in the communities, most of them are old people that are not familiar with technological things, you would even find that the phone he carries can only receive calls and make calls. So in that case they should be assessed if they can be able to use the material given to him. – Staff

### 3.3 Platform quality

**3.3.1 System reliability and privacy**—CHWs and PLH discussed a lack of affordable transportation to clinics as a barrier to care. This was not discussed in relation to mHealth. However, we include transportation barriers here because they would hinder system reliability as the need for clinic care would remain in future systems.

I took a week, I don't want to lie. I took a week because I was waiting for the mobile to come because I was thinking of money for transport going to the town. I then waited for that mobile to come because it was coming the following week. – PLH 1

KI 3 and 5 noted that in the absence of an mHealth system, mobile phones are already being used by medical personnel to communicate and share pictures in order to convey medical information, e.g. in the field of Dermatology. This can negatively affect system reliability, in terms of the availability of information, as valuable medical information is lost (3 and 5) and the privacy of patient health information is difficult to monitor and enforce (3).

The problem that we found is that a lot of doctors and medical officers they use the personal phones, even Whatsapp for that matter. – KI 3

As we speak now, people are using the cellphone in the clinics and hospitals, nurses are taking pictures, sending it to the colleagues, to the PIs, to the doctors, to the specialists. – KI 5

All stakeholders expressed that patient identification and linkage of patient information between CHWs and clinics was an important issue for mHealth systems to address. This relates to system reliability as identification as a first step in accessing patient health information for the delivery of care. Currently, names and other pieces of information, depending on what is available, such as date of birth, South African (ID) number, and a contact phone number, are collected. There was a consensus that names alone are not enough.

People come to the clinics and use other names that are not theirs. You would look for that person and not find him/her, we know some people by other names and other surnames, where else in their ID's they use other names.” – PLH 1 (This participant is now a CHW.)

System privacy was discussed along with patient identification. Opinions on what types of identifying information should be collected and what patients would be willing to share varied. KI and staff indicated that they understand how mobile technology works in regards to the safe and secure transfer of data. They were not overly concerned with phones being stolen, lost or found with personal information. Staff acknowledged that some patients may be wary of having identifying information collected through mobile phones, especially older patients less familiar with technology. Some PLH expressed concerns with having identifying information collected through a mobile phone. It was interesting that PLH expressed interest in an mHealth system and did not express concerns when asked about reactions to CHWs collecting identifying information, before the discussion of an mHealth system began. In particular, some PLH expressed concern with an ID number being used as an identifier but another PLH explicitly stated that they did not mind having the ID number used.

About IDs, I don't have a problem with it because my ID is everywhere even in town and hospital wards they have my ID. – PLH 1

You see this project of cellphone that you are coming with is alright but I am scared if there will be an ID number. A name and surname and date of birth is alright, I am scared that maybe unfortunately a phone gets lost and someone finds it, this thing has people's information and people's ID's. – PLH 2

IDs and patient photographs were discussed as helpful pieces of information for staff and CHWs. Drawbacks of both were also discussed. Staff indicated that ID numbers are associated with fraud and are sometimes difficult to collect from older people as they cannot always find their ID book during home visitation. KI 5 noted that “not everybody has an ID.” CHWs conceded that some patients would not consent to having their picture taken. KI 5 noted that “multiple ways” of finding patient records are needed and suggested a facility number be recorded along with other information.

Another brother who is famous and a business man just came, he took out his ID book and when we checked we find that he is deceased. – Staff

It must include their name and surname and ID number and where they live, their cell phone number should be here but on the other hand I would have loved for her/his photo to be included. – CHW 6

Three types of biometric information were introduced as options for identification during FGD with staff and CHWs: voice recognition, iris and fingerprint scanning. There was a consensus in favor of collecting biometric information with differing opinions on what types of biometric information would be feasible and acceptable. One staff mentioned that patients would be more willing to provide fingerprint information than an ID due to issues of fraud that are associated with IDs. Staff and CHWs were split in opinions as to whether fingerprints or iris scans provided the most unique identification information. There was a consensus that voice identification would not work, if someone had the “flu” and their “voice is not well”, for example. There were concerns with being able to collect fingerprints amongst older participants, given their association with pensions. Others felt that fingerprints were familiar to patients and would be more acceptable than iris scans.

I think that it is the thing they will be happier of because there is no crime you could do using an eye, but from other things there would be that. -Staff

Maybe I don't know much about an eye, but I think people are comfortable about thumbs because people's thumbs are not the same. I think they would be very happy to use thumbs because they are not the same, but I don't know about eyes. - Staff

**3.3.2 System efficiency**—When prompted about design features they would like to see, Staff and CHWs brought up desired specifications related to system efficiency, in usability and adaptability. Some CHWs preferred a tablet to a mobile phone, feeling it would add credibility during home visits and that the larger screen would be easier to read for older CHWs who may have trouble seeing. Other CHWs and staff expressed concern about being mugged by young men using *whoonga*, a street drug that allegedly contains a mixture of HIV medications and illicit street drugs (Grelotti et al., 2014), in rural areas. Staff mentioned that phones could be tucked away more easily, attracting less attention. Aside from theft, KI 4 expressed concerns that CHWs could sell their assigned cell phones and “say it was stolen.”

Boys that smoke whoonga will catch the community workers because sometimes you will enter where they smoke whoonga and they would take this phone, but if it has a tracker it will be easy, if the phone is taken and lost tracker will find it quickly. - Staff

And a tablet has easy visibility [on the screen] as we are old and cannot see well. We will be able to see where we are pressing and it has a lot of things, there are these old phones with buttons, old phones do not have many features that are available now in phones. – CHW 2

### 3.4 Outcome quality

**3.4.1 Utilitarian benefits**—KI discussed the utilitarian benefit of an mHealth system in its ability to provide them with more timely and accurate patient data that is aggregated by clinics, both from CHWs' reports and services received in clinics. The aggregated data is used by health officials to direct resources and address shortages in clinic supplies, such as medications, that were discussed by CHWs and PLH. Paper records delay aggregating data. KI 2 and 4 indicated that this happens on a monthly basis. KI 4 noted that any discrepancies between CHWs and clinic data are difficult to rectify with paper records. KI 5 indicated a six to eight-month delay before aggregated data is received at the government level for resource allocation. Without better communication, KI 5 noted that there are just “silos” of data.

There is a back log of 6 to 8 months, CCGs [CHWs] begin from the households, it takes about 6 to 8 months for somebody at a District or Provincial level to access this information so that they can direct resources accordingly. – KI 5

**3.4.2 Hedonic benefits**—Positive feelings towards home-based HTC were expressed by all stakeholders. Staff felt they were “empowering people.” Staff and CHWs felt that home visitation was an important first step in linking PLH (and other individuals) to clinics for several reasons. There may be a lack of awareness that treatment at a clinic is needed (e.g., for individuals who would not otherwise know they are HIV positive). Moreover, patients may not know where to go for treatment. Upon home visitation, CHWs provide referral letters for individuals to present at the clinic that indicate illnesses they need to be seen for. Staff, CHWs and PLH all expressed the importance of referral letters to expedite treatment at a clinic.

The importance of the home visit itself was also emphasized by staff, CHWs and PLH. Staff noted that individuals were freer to ask questions in their own home and could have more time with staff than with a clinic provider. This sentiment was also echoed by KIs and PLH who noted that CHWs were patient, took time to answer questions, and followed-up with phone calls.

They [CHW] are on the ground, they are able to get to places that we don't normally get to and I think they are our key. – KI 3

What I like is that if I visited a household maybe there is someone who is sick maybe that has a problem and I tell them of a place of where they will get help then when I go back they tell me I did go to the place where you told me to go to. – CHW 10

I was happy with the project of home testing, they have explained everything. What helped me the most was that I was able to disclose to my mother about what is happening in my life [HIV status] – PLH 4

Another hedonic benefit for home-based HTC was expressed by staff, who noted that home visitation conversations were understood to be more confidential and less stigmatizing relative to clinic visitation, where services for PLH are clearly marked. In contrast, CHWs felt stigma related to home visitation was an issue; this was confirmed by KI 4. KI 1 felt that HIV-stigma is declining.

## 4. Discussion

An underlying theme across stakeholders was enthusiasm to better incorporate mHealth tools into the delivery of healthcare services that meshes with South Africa's developing ICT infrastructure (National Department of Health, South Africa, 2015). Most South Africans have cell phones and network coverage is ubiquitous (Cargo, 2013). Stakeholders in this study were familiar with mobile technologies and using some of its capabilities. Medical personnel exchange health information through public mobile apps such as *Whatsapp*, highlighting an urgent need and opportunity to develop mHealth systems that maintain the functionality and convenience of apps that are already being used while ensuring system privacy and the accuracy of patient information.

Discussions relating to interaction quality largely focused on how mHealth systems could improve cooperation by making patient information more readily available to different users. Barriers to healthcare that are seemingly unrelated to interaction and platform quality may also be addressed by mHealth systems, including lack of transportation and supplies of medications and medical equipment (Eide et al., 2015; Schriver et al., 2014; Weimann & Stuttford, 2014). Smartphones can help leapfrog the distance between clients and clinics to facilitate access to care. For example, PLH were interested in receiving appointment reminders on their own mobile phones to avoid incorrectly remembering dates and the need to reschedule visits. Automated appointment reminders could reduce transportation costs.

CHWs have expressed feeling undervalued and a fault-finding focus when reporting their work in other African countries (Druetz et al., 2015; Kane et al., 2016), so it was not surprising that CHWs in this study described tension with clinic staff. A new finding linked to the confidence subtheme was that CHWs felt an mHealth system could improve trust with other providers. Given the key role that CHWs play in home visitation as expressed by different stakeholders and the World Health Organization's (2008) call to task-shift healthcare responsibilities to CHWs, this finding calls for further study to examine how mHealth tools can motivate CHWs and streamline their workflow to improve performance. To date, financial and non-financial incentives, such as training, have been a mainstay to improve CHW performance (Naimoli, Perry, Townsend, Frymus & McCaffery, 2015). Financial incentives are not always practical in resource-poor settings. Empowerment is also important to CHWs (Kane et al., 2016) and not something that incentives alone can provide. mHealth training is a key component of future systems as participants recognized. Together with better decision-making and workflow-enhancing tools, CHWs may feel more empowered and able to take on additional responsibility.

In the development of our own mHealth platform to help CHWs link PLH to care, FGDs led to protocols for automated text messages. If a patient tests positive for HIV during home-based HTC, the CHW who conducted the test will receive a text message to confirm when the newly-diagnosed individual is enrolled in care at a clinic. Otherwise, follow-up home visitation facilitates linkage. Moreover, CHWs and staff expressed a need for better procedures to plan home visitation routes and prioritize patients. This led us to plan automated mapping tools that will be incorporated into CHWs' phones as part of our planned mHealth platform. Catchment areas will be shown with interactive markers on

homes to indicate visitation. It is important to note that the WHO has guidelines on the organization and supervision of CHWs. In addition to the automated text messages and mapping tools that are discussed here, guidelines should be carefully examined to see how other mHealth applications can be built to support implementation of the guidelines and achieve a higher level of coordination between clinics and CHWs.

The design of the mHealth tool that will be used in the field was another interesting discussion point relating to system efficiency. Some CHWs preferred a tablet to mobile phone because they felt it would add credibility and be easier to read while others expressed concerns about theft due to the tablets' higher visibility. In the development of our own mHealth platform, we feel the issue of theft and potential harm is an overriding factor; mobile phones will be used instead of tablets. It is encouraging to note that improvements in technology will likely make advanced smartphones and tablets more commonplace and less attractive for theft. For example, smartphone penetration in South Africa was recently estimated at 37% (Africa News, 2016) whereas almost no one owned a smartphone in 2007 (Cargo, 2013).

Mobile technology proliferation will also likely address its acceptability by patients and the use of biometrics to identify them. Similar to other studies (Leon & Schneider, 2012; Poee & Labuschagne, 2011; Riley et al., 2009), we found variations in perceived levels of comfort with mobile technology and proposed biometric systems. Age was one factor as there was a feeling that older individuals may be more reluctant to submit to fingerprint scans that are associated with identification to receive a pension. Like mobile technology, biometric technology is becoming more commonplace in everyday life; fingerprint authentication is already being used by certain smartphones to unlock the screen. Further, biometric identification is rolling out in three of South Africa's major airports for security screening (Perala, 2015). It is reasonable to posit that increasing levels of comfort will follow suit, as our stakeholders pointed out. In designing our mHealth platform, we considered both fingerprint and iris scans. Based on the FGD data, fingerprint scanning is most acceptable.

Perceived outcome quality was an important theme that was elaborated upon in ways we had not anticipated. Improvements in communication at the clinic level are certainly important to improve day-to-day care at an individual patient level. KI also noted that there is currently a long delay in the flow of healthcare information from clinics to officials. They felt that mHealth systems could streamline the flow of information so that health officials could better monitor regional health outcomes and direct resources more quickly to alleviate supply shortages and address healthcare needs.

Themes that emerged in our study focused on service quality perceptions of future mHealth systems, which are important for determining initial uptake. Perceptions will likely change with system use. A study with current users of mHealth systems would better evaluate the sustainability of mHealth systems by exploring themes as they relate to intentions to continue using mHealth systems modeled by Akter et al. (2013). For example, privacy concerns with patient identifiers that emerged during FGD may lessen or worsen with actual usage. Participants expressed optimistic views about having more reliable patient information through an mHealth system versus paper records; again, optimism may be

strengthened or weakened with actual system usage. New themes may emerge with system usage. The care subtheme under interaction quality did not emerge in our study, perhaps because it hinges on contact with providers in an mHealth setting that stakeholders had not yet experienced. Unanticipated problems may also arise. We have found mobile phone battery life to impact system reliability in our own mHealth research; yet, participants did not raise battery life as an issue in this study.

There were several study limitations. First, CHWs and PLH in the FGD were all women. The gender composition of CHWs is representative of CHWs' gender in general (Kane et al., 2016; Mlotshwa et al., 2015). The gender composition of PLH does not reflect the gender composition of the HIV epidemic and highlights difficulties in engaging and retaining South African men in care (Geng et al., 2010). This is unfortunate as men are on par with women in using mobile technologies and highlights a missed opportunity to gain insight into ways that mHealth may be used to better engage male PLH in care. Second, PLH represented a narrow age range between 19 and 41. Biometric acceptability was discussed as a possible barrier amongst older individuals, but as hearsay. Including older PLH in FGD would have provided more conclusive information and may have broadened the discussion on mHealth acceptability. A valuable contrast would have been provided by PLH younger than 19 years old who are likely to be more amenable to new technology. Moreover, young PLH often enter care in "adult-oriented" HIV clinics and face challenges in navigating HIV treatment protocols (Evans et al., 2013). They are an important voice to be heard for future studies that design mHealth systems. Third, KI and staff were selected based on familiarity with mHealth tools and PLH were recruited from a prior study that engaged them using mHealth tools. Lastly, participants were told that a purpose of the study was to inform the development of a mHealth platform and interviewed by co-authors involved in the platform development. It is difficult to rule out social desirability bias in giving responses. Given study limitations, care should be taken in generalizing perceptions towards mHealth to the general population of healthcare workers and PLH in South Africa.

What can be generalized is that it is important to elicit perceptions and opinions about mHealth from stakeholders across the spectrum, from decision-makers to CHWs and patients. All provided useful insights into the benefits and challenges of mHealth. In high-income countries, feedback from individuals that are farthest removed from hospital administrators, such as patient satisfaction survey data, has typically been left in the hands of administrators who ultimately make policy decisions. In recent years, some hospitals have found value in inviting patients to be involved in the decision-making process to fully close the loop (Svitil, 2016). We advocate a similar arrangement, as mHealth policies role out in LMIC; CHWs and patients need to be a part of the decision-making process.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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### Research Highlights

- Input from South African stakeholders about future mHealth programs and biometrics
- Officials feel mHealth will improve information exchange and resource allocation
- Community health workers feel mHealth will increase trust with clinic staff
- Persons living with HIV want appointment reminders delivered to their phones
- Fingerprint scans seen as most viable biometric identification solution