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mHealth to Revolutionize Information Retrieval in Low and Middle Income Countries: Introduction and Proposed Solutions Using Botswana as Reference Point

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Abstract

Information retrieval (IR) practice is invaluable in health care, where the growth of medical knowledge has long surpassed human memory capabilities, and health care workers often have unmet information needs. While the information and communications technology (ICT) revolution is improving, IR in the Western world, the global digital divide has never been wider. Low and Middle Income Countries (LMICs) have the least advanced ICT infrastructure and service provision, and are also burdened with the majority of the world's health issues and severe shortages of health care workers. Initiatives utilizing mobile technology in healthcare and public health (mHealth) have shown potential at addressing these inequalities and challenges. Using Botswana as a reference point, this paper aims to broadly describe the healthcare and ICT challenges facing LMICs, the promise of mHealth as a field in health informatics, and then propose health informatics solutions that specifically address IR content and needs. One solution proposes utilizing Unstructured Supplementary Service Data (USSD) for accessing treatment guidelines, and the other solution outlines applications of smart devices for IR.

***Keywords**:*

mHealth, Information Retrieval, Low Resource Settings, Low and Middle Income Countries, Botswana, Treatment Guidelines, Mobile Technology, Smart Devices, Digital Divide.

Introduction

Over the past two decades, the world has experienced a proliferation of information and communications technology (ICT) systems that has fundamentally changed the way human knowledge is recorded, stored, and retrieved by all members of society. Arguably, the most visible transformation in everyday life has occurred in the practice of information retrieval (IR). Before ICTs, accurate IR required significant time in a library and physical access to hard copy materials that contained information related to one's topic of interest. Recently, this conventional IR requirement has been replaced by digital search bars that instantly search inconceivably vast amounts of data, and can be accessed on any computer or mobile device, anywhere in the world with an Internet connection (and in some situations without Internet).

This has changed the way all information-reliant industries operate, and healthcare is no exception. Sound IR practice is invaluable in the field of medicine, where the growth of medical knowledge has long surpassed human memory capabilities, and clinicians often have unmet information needs. Additionally, medical researchers and clinicians must constantly update their knowledge on certain topics and new areas quickly, in order to remain competitive in research, and keep up to date with the latest treatment modalities. Undoubtedly, the influx of digital IR resources and informatics tools helps medical professionals avoid medical errors and provide care in a more effective, efficient manner.

While the Western world and Western medical healthcare professionals experience the fruits of this informatics revolution, the global digital divide has never been wider. Not only are Low and Middle Income Countries (LMICs) the least advanced in terms of ICT infrastructure and service provision, but they are also burdened with the majority of the world's health issues and severe shortages of healthcare workers. Such circumstances present many challenges to IR that are unique to LMICs. Initiatives utilizing mobile technology applications in healthcare and public health (mHealth) have shown great potential at addressing these inequalities and their associated challenges in the medical realm.

Using Botswana as a reference point, this paper aims to broadly describe the healthcare and ICT challenges facing LMICs, the initial promise of mHealth as a field in health informatics, and then propose two health informatics solutions that specifically address IR content and needs using mobile technology.

Health and IT Landscape in Botswana

Human Development Index (HDI) places Botswana in the "medium" human development category [1]. It has a national public health system made up of health posts, clinics, district hospitals, and three referral hospitals. There are approximately 40 physicians per 100,000 people in the country, and physician access remains a challenge outside the major city centers [2]. Also, the majority of clinicians practicing in Botswana are trained in other countries, which results in inconsistent healthcare delivery and quality. While hard copy national treatment guidelines exist, they are rarely utilized, and there are concerns about their accessibility and utilization. The health system is burdened by the second highest prevalence of HIV in the world, estimated as 32.5% of pregnant women [3]. Botswana has TB notification rates in excess of 500 per 100,000 people (fourth highest in the world). TB accounts for approximately 40% of deaths in HIV patients and is a driver of morbidity and mortality in the entire population [4]. The complexity of diseases and related ongoing research studies, combined with the variability in standards care, has created an enormous need for IR in LMICs such as Botswana.

Unfortunately, the ICT landscape in LMICs presents multiple barriers to digital IR in the health care setting. Traditional ICT relies on expensive, fixed-line infrastructure that is susceptible to power outages and widespread computer viruses. While Internet access in Botswana is available in populated areas, it remains costly (11.5% of per capita gross national income) and unreliable. Additionally, Internet access in public health care facilities is generally observed to be below the national average in terms of bandwidth strength and reliability, and it is not uncommon for the computers to be virus-ridden and unusable. This ICT environment, which is not uncommon in most LMICs, presents many challenges to digital IR for healthcare professionals.

Early Promise of mHealth

Mobile technology has been identified as a “leap frog” technology that has the potential to circumvent many of the existing ICT challenges in LMICs, including those in the health informatics realm. The growth of the mHealth field in LMICs is a direct result of the growth of mobile technology worldwide. The percentage of the world’s population covered by a mobile cellular signal increased from 61% in 2003 to 90% in 2009 [5]. In 2010, 143 countries offered 3G services commercially, compared to 95 in 2007, which demonstrates the improved signal strength and expansion of general packet radio service (GPRS) [6]. As coverage expands beyond urban centers, the price of mobile devices continues to decrease. In 2000, citizens of developing countries owned 25% of the world’s 700 million mobile devices. By 2009, their share had grown to 75% of the 4 billion total mobile devices in the world and by 2011, their share was 76% of 6 billion [7]. Botswana ranks second in Africa for number of mobile devices per capita at 140.41 per 100 [8]. These mobile technology growth trends in LMICs are expected to continue in coming years.

It is important to clarify that the term “mobile technology” actually encompasses multiple types of technology that can be utilized on mobile devices, including: voice calls, short messaging service (SMS), GPRS, Unstructured Supplementary Service Data (USSD), Bluetooth, Wi-Fi, central processing unit (CPU), data storage, and operating systems for running apps that leverage the previously mentioned technologies in different ways. The availability of this portfolio of technical functionality on portable devices has brought a new wave of innovation into the healthcare environment, especially in LMICs where such innovations make a bigger impact. mHealth has been utilized within health care systems for treatment compliance, data collection and disease surveillance, health information systems and point-of-care support, health promotion and disease prevention, and emergency medical response [9]. As of 2011, over 80% of countries around the globe have reported hosting at least one mHealth initiative [10].

There have been a few overlapping mHealth and mLearning (mHealth equivalent in the education sector) initiatives that have touched upon aspects of IR in healthcare to varying degrees. Some papers look at potential technical models behind mobile IR [11] and others focus on availability of published referential content [12]. Pilot projects in Botswana have studied the efficacy of specific types of IR, such as using SMS to search PubMed [13] and smart phone technology to provide point-of-care support for resident physicians in remote areas [14].

Overall, existing mHealth IR initiatives represent only the tip of the iceberg. The following proposed health informatics solutions offer IR solutions for healthcare providers in LMICs that utilize mobile technology. The first solution is a service that can be utilized by all types of mobile phones, and the second is an outline of the IR functions of smart phones and tablets (i.e., “smart devices”) that are applicable to the health care setting.

Informatics Solution #1: USSD for Treatment Guidelines

Secondary knowledge-based scientific research in the form of treatment guidelines are an integral type of IR for clinicians, both as a resource for providing care, and as a method of standardizing care and measuring quality in a health care system. In Botswana, pneumonia is the second-leading cause of death in HIV patients behind tuberculosis [15]. Since most clinicians in Botswana are trained in different countries, there are often variations in the treatment for pneumonia cases. Therefore, the Ministry of Health and other partners, in an effort to standardize care in the country, have developed pneumonia guidelines.

National treatment guidelines for conditions other than pneumonia have been developed and implemented in the past. However, there are concerns about the efficacy and sustainability of these implementations, since they are limited to one-time lectures and provisions of hard copies of the guidelines, which make it difficult to evaluate efficacy and adherence. It has also been observed that the hard copy versions of the guidelines are kept locked in rooms in health facilities and rarely referenced by clinicians, for a variety of reasons.

A potential health informatics solution to this issue would be making pneumonia treatment guidelines available via an interactive USSD system. USSD is a protocol used by all cellular telephones to communicate with databases, usually through a mobile provider (e.g. dialing *155* to query one’s available prepaid account balance). USSD messages are up to 182 alphanumeric characters in length; and unlike SMS messages, USSD messages are free for the individual initiating the session. It also creates a real-time connection with a database that remains open, allowing a two-way exchange of a sequence of data. This allows USSD services to be more responsive than similar services that utilize SMS to transfer short text data. For this reason, it is common practice for mHealth initiatives to pilot using SMS, then transition the system to USSD before scaling up operations.

A USSD guideline support system in Botswana would allow health care providers to dial a code such as *154* from their mobile phones in order to access the pneumonia treatment guidelines. The clinicians would receive messages outlining recommendations for treatment, be walked through a treatment algorithm (e.g. “Press 1 if the patient is older than 65 years old, press 2 if patient is younger than 65 yrs old”) and also be able to query the database for appropriate treatment based on the resources in their setting (e.g., if a clinician types “no amoxicillin-clavulanate”, then they will receive a modified recommendation for treatment).

Such a USSD system is ideal for secondary knowledge-based scientific research such as treatment guidelines, but would not work for primary knowledge based scientific research, since that type of IR requires more data filtration, consumption and time to find satisfactory results. In a study conducted in Botswana in 2010, a service called "Txt2Medline" was introduced to healthcare professionals, which allowed them to search PubMed using SMS. The formulas for searching the system, and the abbreviated, limited search results proved to be far too complicated and constricting for users [16]. When an average PubMed search on a computer by an American clinician takes about 30 minutes, this type of response to an SMS system is understandable.

USSD and SMS IR solutions are attractive to those pursuing mHealth in LMICs because all types of mobile devices can access the services. However, these services have a threshold of content and user-friendliness of which mHealth researchers and implementers must be wary. USSD for IR of relatively straightforward treatment guidelines may be the most effective implementation that such technology can deliver. Other types of IR require more multimedia and interactive technology in order to be effective.

Informatics Solution #2 - Smart devices for all types of IR Content

The introduction of smart device technology has brought all of the functionality of a desktop computer with an Internet connection to consumers', and healthcare workers', pockets. Smart phones loaded with medical apps and resources have proven to be a useful IR tool for clinicians in remote areas in Botswana [17]. This solution aims to share the promise of smart phone and tablet technology in LMICs and outline how devices can specifically address various types of IR content.

Customized mobile applications and mobile websites add even more IR functionality and versatility to mobile devices, compared to computers. Recognizing this, the National Library of Medicine has published an online gallery of its resources for mobile devices [18]. Countless more medical information publishers have also made the transition to mobile apps and sites. Table 1 below outlines select examples of mobile resources for each type of IR content classification, and specific applications and features of mobile devices that can be leveraged to provide easy access to the content in LMICs.

New resources for healthcare providers, and updates to the resources in Table 1, are constantly changing, establishing a need for up-to-date reviews of mHealth resources provided by publications such as iMedicalApps [19]. Also, as the wealth of medical knowledge available on mobile devices increases, so does the integral importance of search literacy capacity, which will be an essential skill to build within communities implementing mHealth and IR initiatives.

Initially there were two major barriers to widespread deployment of smart device hardware in healthcare in LMICs: screen size and costs. The influx of 5", 7", and 10" mobile devices for global consumers has addressed the issue of screen size, and early observations suggest that 7" tablets are the ideal

IR Content	Resource	Example Apps / Mobile Sites	Feature Notes	URLs
Bibliographic	Medline	PubMed for handhelds mobile	All mobile sites can be saved as bookmarks and placed on device home screens for easy access. Only available with Internet connection.	http://www.ncbi.nlm.nih.gov/m/pubmed/
Bibliographic	RSS Feeds from local medical communities, online medical lectures, etc.	Podcast apps that aggregate RSS feeds from any website or other source.	Podcast apps introduce a wealth of features that can maximize the use of RSS feeds in LMICs. RSS feeds can be customized for certain groups of clinicians (e.g. surgical training videos for surgeons), and podcast apps can be set to download RSS feed content overnight when the device is charging and/or has Internet access, which would make the content available when no Internet is available.	
Full−text	Textbooks, Handbooks	eBook Readers, Handbook Apps (e.g. 5-Minute Clinical Consult, Epocrates)	Many handbook publishers have developed their own mobile apps. eBook readers on tablets can be used to read medical textbooks. eBooks and Handbook app content can be saved locally on the mobile device, providing users access to the content independent of Internet access.	http://5minuteconsult.com/ http://www.epocrates.com/
Full-text	Wikipedia	Wikipedia mobile site and app	Health information quality on Wikipedia has been deemed "reasonably good" [20] and is constantly improving. Orange is now providing free access to Wikipedia through all of it's SIM cards in the Middle East and sub-Saharan Africa.	http://en.m.wikipedia.org/
Annotated	Image collections, Clinical Overviews	VisualDx, Up to Date, Dynamed	Clinical overview resources such as Up To Date and Dynamed have created their own mobile apps that download content onto devices, and then regularly update that information when an internet connection is available. Image databases, such as VisualDx for dermatology, are easier to use on tablets than phones.	http://www.visualdx.com/ http://www.uptodate.com/home https://dynamed.ebscohost.com/
Aggregations	Merck Medicus	Merck Medicus App and mobile site	Similar to other medical mobile resources, the app versions of aggregate IR content allow information to be downloaded to the device so clinician can access it independent of Internet connection.	http://www.merckmedicus.com/

Table 1 - Mobile resources for each type of IR content classification, example applications and features that can be leveraged to provide access to the content in LMICs

size for clinicians in Botswana to read information and conduct primary research. Additionally, trends show that the cost barrier of smart devices in LMICs will crumble in coming years due to the open source Android operating system that many low-cost mobile device manufacturers have embraced. Several sub-US$100 Android phones have been introduced to the sub-Saharan African market since 2010, and India introduced a 7” Android tablet in 2011 that costs US$35 (a subsidized rate offered by the government for Indian students). Combining the existing low-cost device availability with Moore’s Law (processing speed, memory capacity, sensors, etc. will continue to improve at exponential rates) presents a promising forecast for the availability of high-power, low-cost mobile devices in LMICs in the coming years.

While the forecasted growth of smart device users in LMICs will occur initially in urban settings and with educated, literate users, the most rural and remote communities still stand to benefit in the short-term from community health worker programs that will embrace low-cost smart devices responsibly and effectively. Dimagi, an mHealth software group based in Boston that develops ICT solutions for LMICs, found that adding locally-developed audio recordings and diagrams to its java-based phone application CommCare increased community patient engagement and community health worker credibility within their community [21]. The larger screen sizes, increased connectivity, and superior computing and storage space in smart devices will empower such initiatives to develop even more detailed, functional, and interactive multimedia to improve health systems and educate rural communities.

Smart phones and tablets provide access to the entire realm of IR content and multimedia, but they also offer a connection to arguably the most valuable and overlooked IR resource: peers. Observations in Botswana show that doctors prefer to consult their peers with a clinical question before searching any other resource. The options that mobile devices provide clinicians to communicate with peers are endless: voice, SMS, email, facebook, Google+, twitter, etc. Messaging platforms that offer the function of uploading images add an entirely new dimension to clinical communications. When utilized for case consultation among peers, this type of communication overlaps with the field of telemedicine. Store-and-forward telemedicine using smart phones has already proven to be effective in the fields of dermatology, oral medicine, radiology, and women’s health in Botswana [22]. As more powerful, inexpensive mobile devices get into clinicians’ hands in LMICs, connecting them easily to valuable IR resources - including each other - has the potential to result in a true “leap frog” of the digital divide in healthcare IR.

Conclusion

As previously mentioned, existing projects and the two solutions proposed in this paper represent just the tip of the iceberg when it comes to the mHealth and IR in LMICs. Botswana serves as a broad example of ICT and health care environments in LMICs. Key principles, specific open source tools, and lessons learned from mHealth projects in Botswana can be applied to launch similar initiatives in other LMICs, but ultimately mHealth solutions must be tailored for local settings and driven by local stakeholders in order to be sustainable. While it is easy to get caught up in the vast potential of mHealth, a multitude of factors ranging from societal to technical to behavioral must be thoroughly addressed before it is possible to translate the potential into effective programmatic practice in individual LMICs, and these factors require time and resources to address.

Such is the case when it comes to any new health informatics solution, reflecting the timeless informatics principle that the information - not technology - is at the heart of successful health informatics solutions. ICT changes rapidly, so technical solutions must evolve to meet the needs of health care workers, and blend with technology that is appropriate for their environments in order to have the largest, most sustainable impact.

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