Leveraging Digital Health for Global Chronic Diseases

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Management of chronic diseases requires effective modalities for screening, prevention, and treatment of these conditions. At the core of chronic disease management is the need to effectively use health information for decision-making. In general, when the right information is availed to the right person at the right time, the right decisions will likely be made. Digital technologies offer the potential to significantly transform delivery of chronic disease care by putting the power of information in the hands of patients, providers, and decision makers. Beyond the use of computers, mobile technologies, and the internet, digital health also encompasses wearable devices, sensors, Web 2.0 technologies, and genomic data, among others [1].

The global application of digital technologies is increasing, but utilization has not been optimized. Oftentimes, stakeholders who would benefit from these technologies are unaware of their potential to transform care. Further, many potential users get paralyzed by the complexities of implementing digital health systems within already complex health care environments. In this paper, we provide: 1) a high-level overview of some common applications of digital health for chronic disease care that are relevant in the global setting; 2) some guiding principles for adoption of digital health care; and 3) demonstration of a use case of these principles within a resource-limited setting in Western Kenya.

A DIGITAL HEALTH FRAMEWORK APPLIED TO GLOBAL CHRONIC DISEASES

Digital health solutions can be perceived simply as tools that can be leveraged in a multitude of ways for managing chronic diseases. Some of these solutions have a direct effect on the quality of patient care, whereas others are used to strengthen health systems and to improve governance and equity. Simply focusing on the direct clinical effect of digital systems often ignores these other useful effects of digital health solutions.

Figure 1 demonstrates a range of digital health systems that can be applied in global chronic disease management [2]. This framework is based on a generic digital health framework whose key intervention categories include providers, patients, and the health system. Increasingly, digital health systems for public and population health are also being implemented in the global setting, ranging from Integrated Disease Surveillance & Response systems to electronic registries. The current framework excludes some categories of digital health, such as bioinformatics-based systems, as their adoption remains very low in global health settings.

It should be noted that digital health systems serving similar functions can often be implemented using different technologies. As an example, one can achieve computerized decision support by generating computer-based reminders that are disseminated as alerts within standalone or web-based electronic record systems, displayed during a computerized order entry session, transmitted to a smartphone app, or delivered as text messages through a short message service. In fact, robust digital health solutions often incorporate a number of these technologies within the same product. Caution is thus required when describing digital interventions (like mobile health solutions) as if they exist in isolation, as this often misses the multicomponent and integrated nature of the solutions. It should be noted that success of digital health goes beyond the technological product, and is also influenced significantly by how the system is implemented. It is therefore not uncommon for the same system to have highly variable effects on the basis of the implementation context.

POINTS TO CONSIDER

Given the potential complexities in implementing digital health systems for global chronic disease care, we present some guidance on how to navigate through decision-making processes around digital health systems. These points should be used to help reach sound judgment on whether and how to adopt particular digital solutions in managing global chronic diseases.

Clearly define the problem before settling on a digital health solution

Oftentimes, digital health advocates push for a solution before an in-depth analysis of the problem has been done—akin to a hammer looking for a nail. An approach that objectively looks for the best solution for that problem, regardless of whether or not it involves a digital health solution, is the best approach. A digital health solution should only be used when it is clear that integrating the solution makes the most sense given the problem at hand.

Digital solutions should not exist in silos

Digital solutions should easily be able to exchange data and communicate with one another. As an example, patient-level data are often stored within electronic health record

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Intervention Category	Systems in Category	Digital Health Technologies for Categories	Intermediate Outcomes	Outcomes
Health System Adequacy	Electronic Health Records Inventory Management Logistics Management Monitoring & Evaluation Systems Supervisory monitoring Financial Management Systems Scheduling	Tracking systems Geo-location systems eFinance Systems In-built M&E functionality Data Analytics systems Supervisory / performance systems	Data Quality Resource utilization (Human, material & financial) Supply chain management (e.g. stock-outs) Remuneration/Fraud rates reduction	Health Outcomes Cost-benefit
Provider Performance	Decision Support Continuous Medical Education Point of Care Diagnostics (PoC) Performance Metric Self-monitoring Telemedicine/Teleconsultation Enhanced Counseling Digital Assistance tools	Data collection systems Computerized Decision Support eLearning Systems Point of Care systems Tele-Consultation Systems Counseling Systems Order-Entry Systems ePrescribing	Provider behavior change Care quality by providers Provider efficiency Provider satisfaction Provider retention rates Provider competency	Health Outcomes Cost-effectiveness
Patient Knowledge and Efficacy	Patient Self-Management Support Adherence / Reminders Patient Education Social Networking	Patient Decision Support Systems Personal Finance Systems Patient monitoring systems/ wearable devices Interactive Voice Response Systems TeleMed & Consultation Systems Pt-focused social media applications	Patient Behavior change Adherence to Care Patient knowledge & self-efficacy Patient empowerment Satisfaction with care	Health Outcomes DALYs
Public Health	Disease Surveillance Signal Detection Monitoring & Evaluation Systems Outbreak management	Data collection systems Data analytics Decision Support systems	Case-finding rates Time to disease detection Epidemic modeling adequacy Preventative care rates	Elimination of diseases (e.g. polio) Disease outbreak rates Outbreak severity
Population Health	Mass education Mechanisms Wellness Programs Disparity / Equity Monitoring Health Information	Wellness Apps Education Apps Access & Resource Distribution	Population health knowledge	Population Health Indicators Population disease burden

FIGURE 1. Logic frame for digital health applied to global chronic diseases. Informed partially from work by the mHealth Alliance Evidence Working Group (2014) and the Mitchell-Labrique mHealth logic model [2]. DALY, disability-adjusted life-year; M&E, monitoring and evaluation; PoC, point of care; Pt, patient.

systems, and other digital solutions collecting patient-level data should be able to communicate and share data with the electronic health record systems. This is best achieved by having systems that use standard application programming interfaces, leverage accepted clinical messaging standards like HL7 [3], and use standard terminologies, such as the International Classification of Diseases, Tenth Edition, and the Systematized Nomenclature of Medicine—Clinical Terms, to allow semantic interoperability [4]. It is also essential that individuals should be able to be uniquely identified.

Infrastructure considerations

In many resource-limited settings, significant infrastructure challenges exist, ranging from unreliable electrical supply to poor Internet connectivity. Recognizing the infrastructure needs of proposed digital health solutions is essential for successful implementation. As an example, mobile applications in many cases need to have the capability to work in both online and offline modes.

Security

Security is important to consider in digital applications deployed in the global setting. Beyond providing requisite physical security, application-level security can include user authentication, data encryption on devices, audit trails, and secure data transmission mechanisms, among others. Systems should offer device-level security, with the ability to remotely lock and wipe data off devices.

Cost-effectiveness

One of the bigger challenges in implementing digital health systems is in proving their cost-effectiveness, especially in settings with limited resources. Approaches to evaluate both cost and effectiveness of the systems, the return on investment, or the value proposition are thus essential for decision-making.

Usability

Many digital systems do not use human-centered design approaches, and have little input from end-users during the development process. These systems often prove disruptive to work and are unusable once implemented. To avoid this problem, user-centered design approaches are needed during the development stages of digital systems.

Scale and sustainability

It is common knowledge that many piloted digital systems in the global setting never go to scale. Oftentimes, the systems cannot handle multiple implementations or large transactional volumes. In addition, developers and implementers often fail to engage key players, like the Ministry of Health, who can be crucial to scaling and sustaining the digital solution. Engaging all relevant stakeholders is a crucial part of planning. During the implementations phases, buy-ins from government, the private sectors (insurers, information technology companies, and medical suppliers), medical organizations, and civil society entities are essential.

Implementation issues

It is not uncommon to find that the same digital health solution works very well in one setting, yet fails miserably in another setting. An appreciation of the implementation science around digital health systems goes a long way in ensuring implementation success [5].

Local capacity

Considerations of the local capacity to enhance, implement, and support the system become relevant for successful implementation.

CASE EXAMPLE: DIGITAL TECHNOLOGIES FOR CHRONIC DISEASE MANAGEMENT IN KENYA

It is well recognized that significant gaps exist in finding, linking, treating, and retaining patients with hypertension in low- and middle-income countries [6,7]. The LARK (Program to Optimize Linkage and Retention to Hypertension Care in Western Kenya) study uses community health workers to screen and follow patients with hypertension in the community, while referring them to higher-level facilities as needed [8,9]. The LARK study has equipped community health workers with a smartphone-based Android application, mUzima [10], that allows for data collection, decision support, tele-consultation, and enhanced counseling using pre-recorded media (Figure 2). The program is implemented within the AMPATH (Academic Model Providing Access to Healthcare), which serves a catchment area of over 3 million people [11].

mUzima is customized to interoperate with the OpenMRS electronic record system, where clinical data for the same patients are stored [12]. Unique identifiers for

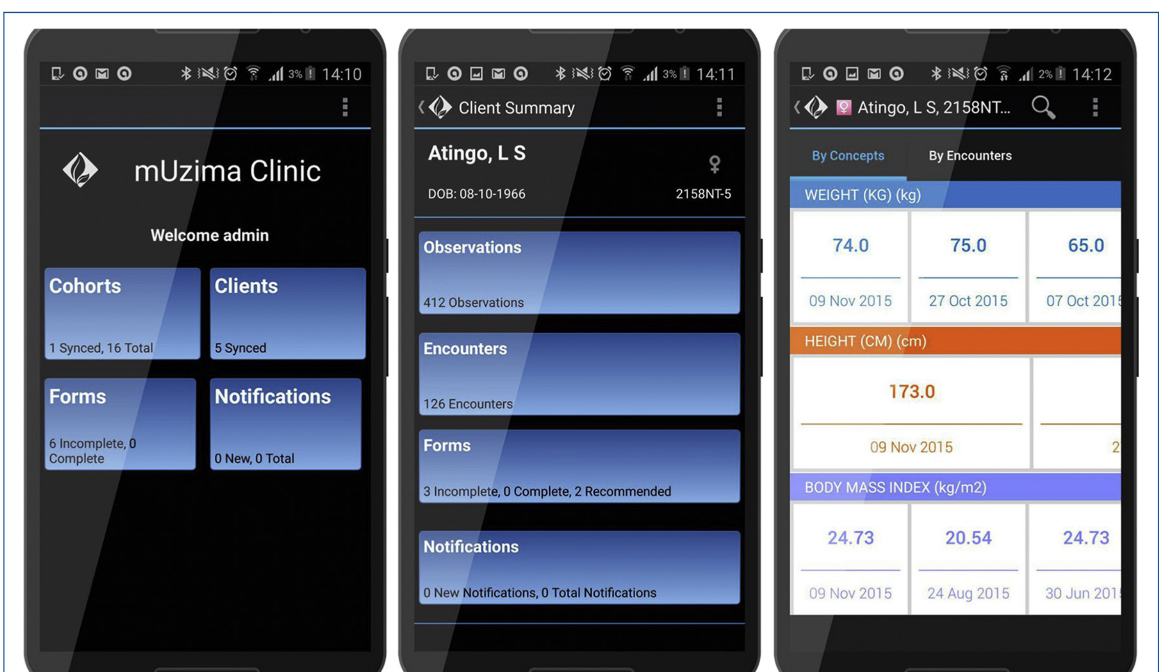

FIGURE 2. Screenshots of the mUzima application used for hypertension management.

patients are shared between the community and health facilities, and the same sets of terminology are used to define data elements to be collected. Taking into account the reality of poor connectivity, mUzima is customized to work efficiently in both offline and online modes. Data security within the application is achieved through encryption of data within the mobile devices and in the electronic record system, with user-based authentication and automatic time-outs after a period of inactivity. An additional layer of security is offered through a Device Management and Security application that can remotely lock the mobile device, detect SIM card changes, and remotely wipe data from the device.

Both mUzima and OpenMRS are open-source applications, and are relatively easy to customize, hence reducing the total cost of implementation. The LARK study involves end-users at all stages in customizing and testing the applications prior to implementation. Data analytics can be done on top of the OpenMRS platform where shared data is stored.

SUMMARY

Great potential exists for using digital health solutions to improve the quality of global chronic disease care. Practitioners and implementers have to be aware of the range of existing solutions, and the contexts within which it would make sense to implement these solutions. A systematic consideration of the multiple issues relevant in selecting a solution, guided by the issues discussed in this paper, will help in reducing the risk of a failed implementation.

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