An integrative ICT platform for eHealth

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Abstract: Both eHealth and mHealth have much potential for efficient and effective health service delivery. However, fragmentation of applications and the lack of interoperability have been identified as major challenges for the effective deployment of eHealth and mHealth solutions. This paper presents the design of an integrative ICT platform for eHealth that enables (1) the integration of heterogeneous health related information, (2) the orchestration of eHealth and mHealth services and (3) easy deployment of mobile services independent of mobile device, operating system or network. The aim of the platform is to accelerate the adoption of mHealth solutions in support of the reengineered primary health care model and to facilitate the integration of existing eHealth and mHealth solutions on a service and information level. The platform is designed for the context of the South African primary healthcare system, but is relevant to any eHealth environment where integration, orchestration and mobile communication is required.

Keywords: eHealth, mHealth, ICT platform, data integration, mobile communication.

1 Introduction

eHealth is defined by the World Health Organisation as "the use of information and communication technologies (ICTs) for health. Examples include treating patients, conducting research, educating health workforce, tracking diseases and monitoring public health" [1]. mHealth refers to a subset of eHealth, specifically related to the application of mobile technologies for the purposes of healthcare. eHealth and mHealth have been widely adopted internationally with much success [2, 3]. However, a number of challenges regarding the implementation of eHealth and mHealth solutions in the South African public health systems have been listed in the eHealth Strategy South Africa (2012 – 2016) [4]. The challenges articulated in the strategy regarding the lack of interoperability between disparate health systems, the silos of information and lack of broadband connectivity to everyone are particular relevant. Numerous eHealth and mHealth solutions have been deployed in the field, but the solutions are operating in isolation and the possibility of service orchestration is very limited. In addition, each solution maintains its own database or data store which makes is extremely difficult to have an integrated view over the different aspects of healthcare supported by the different solutions.

Due to the limited access to broadband infrastructure in rural areas of South Africa, alternative modalities of service delivery and information access should be considered. Given the penetration and reach of mobile phones, and their ever increasing power and functionality, the use of mobile technologies for improving healthcare delivery – mHealth – is internationally viewed as a central component of a well-functioning health system. In South Africa, the reengineered primary healthcare model with an increased focus on preventative healthcare and taking healthcare to the home provides an opportune environment for mHealth. However, the proliferation of mobile health services has created a number of challenges for the Department of Health at national and provincial levels including: (a)

further fragmentation of health information systems and the emergence of silo solutions managed by individual companies; (2) access by the Department of Health to individual data sources 'owned' by private sector companies is often on a paid-for basis; (3) the challenge to properly manage confidential health data; (4) equity of service delivery – in a sector that is already plagued by great inequity (50% of the country's total health spend is spent on providing care to only 16% of the population); and; (5) the ability to provide mHealth services to the entire population despite the 'power' of their handsets (in fact, it is perhaps more important to prioritise services to people with older, non-smart handsets).

This paper presents a proposed integrative ICT platform for eHealth to accelerate the adoption of mHealth solutions at provincial and district levels in support of the reengineered primary health care model and to facilitate the integration of existing eHealth and mHealth solutions on a service and information level.

The paper is arranged as follows: Section 2 describes the research methodology followed by a description of the relevance of the work in Section 3 and a literature overview in Section 4. The proposed ICT platform is described in Section 5 and the business benefits of the proposed platform is discussed in Section 6. Section 7 concludes the paper.

2 Methodology

Design science research is an appropriate methodology as it facilitates the creation of artefacts usually for a practical purpose. March and Smith [5] differentiate among four different types of artefacts: concepts, models, methods and instantiations. Two important characteristics of design science artefacts are relevance and novelty [6]. Firstly, an artefact must solve an important problem: i.e., being relevant. Secondly, to differentiate design science research from routine design, Hevner, March [7], suggest that design science research should address either an unsolved problem in a unique and innovative way or a solved problem in a more effective or efficient way. The research articulated in this paper falls into Gregor and Hevner [8] exaptation quadrant. The outcome of which is to extend known solutions to new problems as a research opportunity and knowledge contribution.

Design science research contribution requires the following processes: 1) Preliminary study/analysis of practical problems and needs, 2) development of solutions/prototype phase, 3) evaluation and testing and 4) assessment or reflection [9-11].

Hevner, March [7] were the first authors to provide an Information Systems (IS) framework to show where design science research fits. This framework was later improved by Pirenen [12] as well as Wang and Wang [11]. Both Hevner, March [7] and Pirenen [12] stressed the relevance and rigor of design science research in IS that will underpin the conceptualisation of an integrative ICT platform for eHealth to support the integration of existing mHealth and eHealth systems; and; enabling the delivery of health services and information through a channel agnostic mobile communication channel.

The IS research framework suggested in Hevner, March [7] argues a focus on three inherent research cycles: *relevance, rigor and design* with creativity and how each of these contributes to the knowledge base of foundations and methodologies. In the framework people, organization and technology are three components of the environment of design research. Business needs are the driving force for design research so that design research can be relevant. Design research must add knowledge to the knowledge base so that it can be rigorous. Hevner, March [7] also proposed seven guidelines for design research: design as an artefact, problem relevance, design evaluation, research contributions, research rigor, design as a search process and communication of research [11].

Design science research is therefore inherently a problem solving process Hevner [13], which involves the representation and presentation of a design related problem or issue and the

subsequent generation and evaluation of a design-based solution (the artefacts produced in the design science research process) [10]).

Each of the cycles outlined by Hevner [13] and Pirenen [12] are related to the conceptualisation of the ICT platform for eHealth as described below.

1. *Relevance cycle:* The application domain initiates the Design Research through research requirements and criteria for the conceptualisation of the integrated ICT platform for eHealth. The relevance of this study is described in Section 3.
2. *Rigor cycle:* The research rigor is grounded in relevant research literature. The literature study aimed to, through the investigation of relevant literature, develop a firm understanding to guide the exploration of the design of the ICT platform for eHealth. The relevant literature reviews that pertain to this paper are outlined in the literature overview in Section 4.
3. *Design cycle:* The design cycle will be facilitated through the design, construction and refinement of an integrated ICT platform for eHealth as artefact through peer reviewed domain applications and piloting in 2 areas starting in 2014. This paper does not extend to results from pilot implementation iterations but documents the conceptual design based on the relevance and rigor cycle.

The following section articulates the problem description with regard to the relevance cycle.

3 Relevance

The relevance of the study is articulated through the problem description. This is done through a description of the reengineered primary healthcare model and mobile health.

3.1 NHI and the Reengineered Primary Healthcare Model

A foundational principle on which the National Health Insurance (NHI) and the reengineered primary healthcare system in South Africa is based, is the move away from a purely curative health system towards one that encompasses a prominent preventative healthcare component. Health professionals will no longer be responsible for just treating patients, but for ensuring that the population within their prescribed catchment area is kept healthy. Budgeting for healthcare will also be conducted at the district level based on health requirements of population in a catchment area as opposed to patients that visit health facilities. It is therefore critically important for health authorities at the district and provincial levels to have a clear understanding of the health requirements of the population within their catchment area. Currently, planning is based only on information from patients that visit health facilities, and not on household-level information. The last household-level health survey was conducted by the Human Sciences Research Council (HSRC) as far back as 2003.

Within the reengineered primary healthcare model, given the prioritisation of preventative healthcare, primary healthcare (PHC) outreach teams comprising a professional nurse, an environmental health specialist and community health workers (CHWs) are being deployed in different wards across the country. The focus of the PHC outreach teams is on health promotion, disease prevention, and referral for curative care. The National Planning Commission's Vision 2030 document proposes the deployment of between 700,000 and 1.3 million CHWs, a substantial increase from the current estimated figure of 70,000.

A key element of the role of the PHC outreach team is the collection of household-level epidemiological and demographic data to be used for health resource planning. In particular, PHC outreach teams in KwaZulu-Natal (referred to as community caregivers), are an integral

part of the province's plans to conduct household profiling to establish needs at the household level within the "War on Poverty" Flagship Initiative.

3.2 Mobile Health

The proliferation of mobile technologies in health (mHealth) offers significant opportunities for improved primary healthcare delivery from the perspectives of treatment compliance, data collection, disease surveillance, health information systems, point-of-care support, health promotion, disease prevention and emergency medical response. While there are good examples of successful mHealth applications supporting community healthcare workers in South Africa, innovation in the mHealth space is stifled due to excessive technological and regulatory barriers. Typically a mHealth solution and/or service provider and application developer/entrepreneur would need to accommodate/allow for:

- interoperability with a standard (uniform) information structure – content, form and structure;
- electronic directory of healthcare providers and service providers;
- compliance with a country specific regulatory, policy and standards framework;
- accommodate single sign-on (care providers access data/information across organizational and geographical boundaries);
- common secure data transfer standards on national level;
- centralised and locatable design;
- cooperation between solution developers and service providers (interoperability);
- a shared common architecture (ICT system components and internal disposition and the principles that govern their construction and development);
- accommodate complex adaptive nature of health care (accommodate infinite scenarios and workflow permutations); and
- allow the third party service provider community to continuously integrate new services, features and extend existing functionality and accommodate legacy systems on defined rules governing technical and semantic interoperability.

Currently there are no nationally adopted reference models for above outlined functions and support/enabling services. A further consequence of the absence of a set of reference frameworks for mHealth application development is the proliferation of fragmented mHealth applications that cannot interoperate or aggregate data - therefore limiting the use of these systems for health planning and decision support.

4 Literature overview

Health information systems are critical for well-functioning health systems [14] and important for improving health outcomes [15, 16]. Developing countries are undergoing rapid technological transformation in part due to the increased availability of mobile devices and network connectivity. This is accelerating the adoption of eHealth [17]. However, the still limited availability of infrastructure, specialised technical skills and financial resources impact development of systems [18, 19].

eHealth systems in the developing world are fragmented and deployed by multiple organisations without sufficient coordination [15, 20]. They are custom built to satisfy very specific needs, using different architectures and technologies, with interoperability low on the list of priorities [21]. The lack of standards and inability to integrate systems are two of the biggest challenges identified [20].

A need for an open architectural framework to facilitate the efficient and effective deployment of national health information systems in Africa have been identified [22] [23]. In addition, mobile technology has much potential to improve health service delivery [24, 25], but is dependent on the availability of information regardless of from where it was sourced and the ability to integrate the various applications [26].

5 Technology Description

The proposed integrated ICT platform for eHealth is depicted in Figure 1.

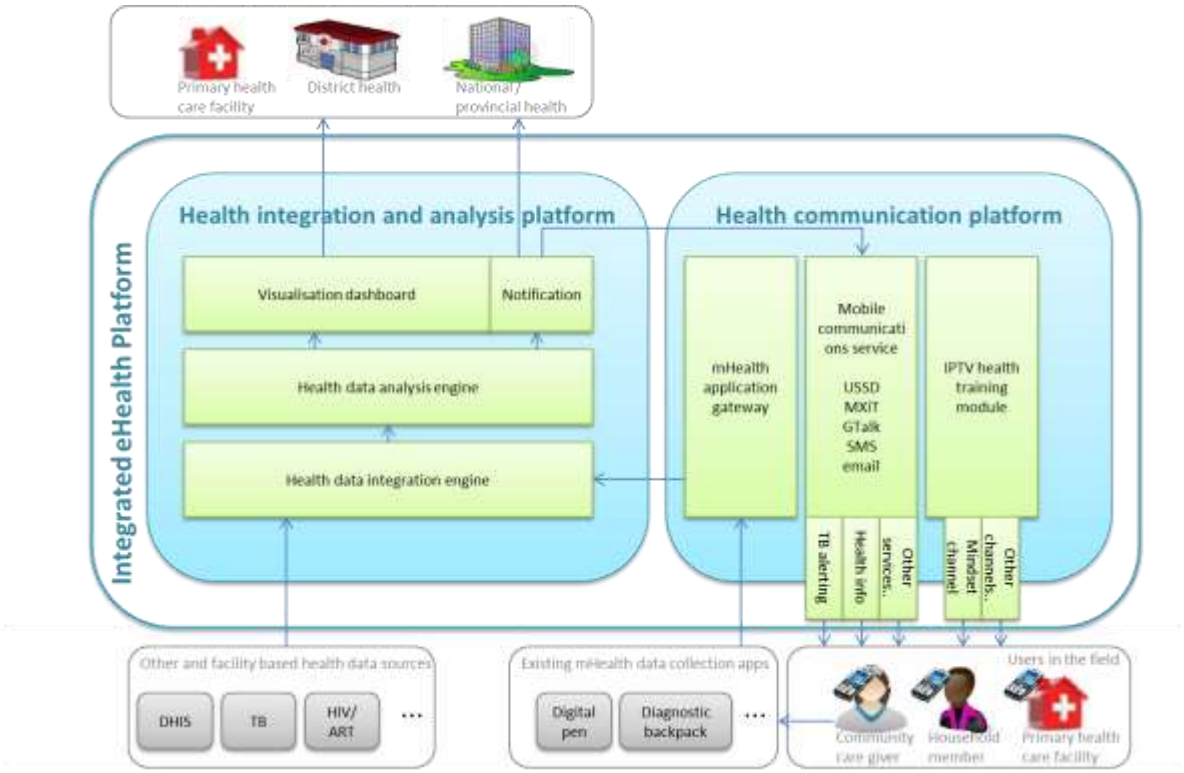

Figure1: The integrated ICT platform for eHealth

As depicted in Figure 1, the Integrated eHealth Platform consists of two sub-platforms: (1) the Health integration and analysis platform, and (2) the Health communications platform. Each of the sub-platforms will be briefly described in the following sections.

5.1 Health integration and analysis platform

The aim of the health integration and analysis platform is to address the problem of fragmentation of services and data from existing eHealth and mHealth systems. The integration of information will be accomplished by creating a facility to accept health related data from heterogeneous data sources, integrate it based on accepted eHealth standards, apply analysis techniques to the integrated data sets and disseminate the analysis results through a visualisation dashboard and through a notification service. The health data analysis platform is designed to be extendible to accept additional data sources as they are identified through a standards-based data integration engine. In addition, the health data analysis platform also provides a standards-based integration architecture able to integrate and mediate services from existing eHealth and mHealth applications.

This platform provides a standards-based architecture to integrate and/or orchestrate services from existing eHealth and mHealth applications and to integrate data from different data sources. The platform is able to apply appropriate analysis techniques to compare and combine different data sources and to disseminate the results through visualisation, reporting and notification services. This platform will enable end users to interrogate and analyse integrated health related information from

sources such as household data collected through existing mHealth applications, facility based health information as well as other information that have an impact on health service delivery (e.g. social-economic data and environmental data). The disseminated information will be used on clinic, district and national level for the purposes of resource planning, cause and effect analysis and to initiate timeous interventions based on alerts sent out based on certain predefined conditions in the data.

The platform includes the following technical components:

- A standards based health integration engine that enable the integration of existing mHealth and eHealth applications
- A health data integration engine that transforms and integrates data based on accepted standards and prepares the data for analysis;
- A health data analysis engine that applies appropriate analysis techniques on the data and prepares it for visualisation;
- A health data visualisation dashboard that disseminates the analysis results visually to authenticated users based on their assigned access privileges; and
- A health data notification service that sends notifications to registered users when certain predefined, rule based events are detected in the analysed data such as when a specific threshold have been exceeded.

The heath integration and analysis platform enables standards based integration of heterogeneous health related data sources providing the facility to perform analysis, visualisation and notification services over the integrated data sets. The data sources can include existing facility based databases and/or, data collected from existing mHealth applications such as household level data collected via a Digital Pen, a portable health monitoring backpack as well as other point of care diagnostic systems.

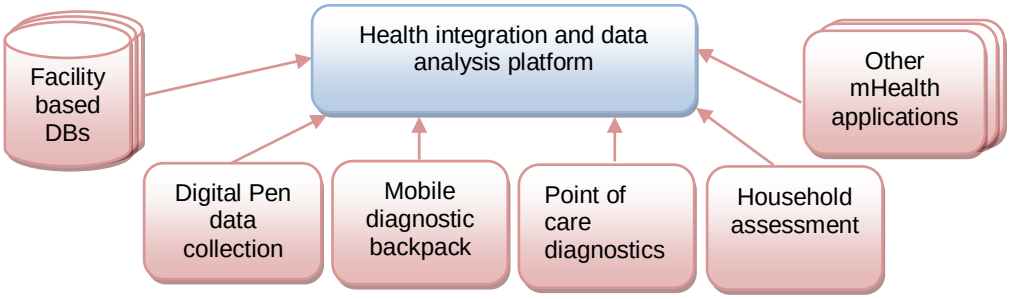

Figure 2: Integrated health data analysis platform with various data sources

5.2 Health communication platform

The aim of the health communication platform is to enable information dissemination and communication via mobile devices irrespective of the device, operating system or networks being used by the end user. This platform supports the implementation of mobile based information and communication services without additional development required.

The health communication platform includes the following components:

- A *mobile messaging module* that supports the sending and receiving of messages and the dissemination of information through mobile technologies in the format of USSD, SMS, email and various social media such as Google chat, MXiT etc.
- A *mobile applications gateway* that enables existing mHealth applications to connect to the integrated ICT platform for integration purposes

As illustrated in Figure 3, the Health communications platform provides a service agnostic plug-in environment enabling the definition and implementation of health related information and communication services.

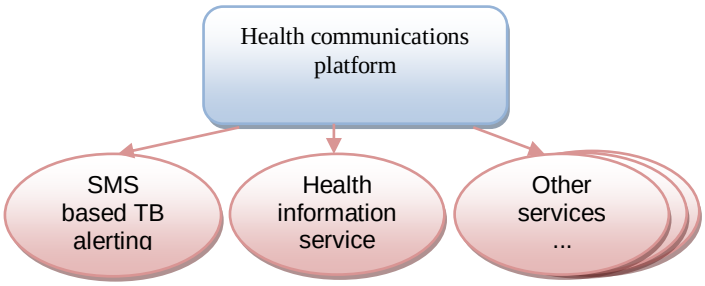

Figure 3: The health communications platform and services

Examples of health specific services to be implemented on the platform includes a SMS based alerting system reminding TB patients to take their medication and a channel agnostic health information service that enables users to find health-related information through USSD, MXiT and GTalk. The power of the health communication platform is the ability to add additional services easily based on the requirement of stakeholders.

6 Business Benefits

The envisaged benefits of implementing the proposed integrated ICT platform for eHealth include, but are not limited to:

- Increased access to integrated information in the health sector, specifically on district and provincial level;
- Increased effectiveness of health related planning based on actual data integrated over data collected on household level by CHWs, facility based data and other health related data;
- A decreased number of patients defaulting on treatment of priority illnesses such as Tuberculosis;
- Increased access to and awareness of health related information such as service providers in the area and preventative health care measures by citizens;
- Increased effectiveness of coordination and communication to community health workers (CHWs) by clinics and community health worker teams; and
- Increased effectiveness of health services and interventions provided by CHWs in the communities

The ultimate outcomes will be (1) improved primary health care resource planning, (2) improved preventative healthcare and (3) reduction in fragmentation of mobile health services.

7 Conclusions

This paper presented an integrated ICT platform for eHealth that addresses the issues of integration of services and information of existing eHealth and mHealth solutions while accelerating the adoption of mHealth solutions at provincial and district levels in support of the reengineered primary health care model by providing a mobile communication facility for service and information delivery over mobile devices.

The paper conveyed the rationale behind the design of the proposed platform and potential benefits of its implementation. The conceptual design of the platform described in this paper will serve as input into pilot implementation iterations as part of the design cycle of the design science research methodology.

Future work will involve further research, development and refinement of the platform and related services as well as close monitoring and evaluation of the effectiveness and impact of the platform and associated services in the field.

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