Large-Scale Innovations and Approaches for Community Healthcare Support in Developing Nations

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Abstract Over the past two decades, many large-scale innovations have been designed for the individuals' information support in improving public healthcare. Studies show rapidly growing interests on cloud computing and telecommunication-based technologies such as mobile-based innovations that are mainly evident in form of improving the social healthcare support systems for community, organisations and individuals. Approaches for various innovations to healthcare support delivery enable people to build on their strengths and to improve the independence and overall wellbeing in the community. The objective of such innovations for community healthcare has been well-established in developed nations, but still emergent to achieve various goals for many developing nations. A lot of application aspects are therefore under-researched to achieve the outcomes such as for encouraging healthy lifestyle choices [4, 8], for individual's wellness monitoring [31], and in providing general-healthcare information and advice for self-management [21]. This chapter describes issues of the innovative large-scale technological developments for the community healthcare and well-being in context of developing nations, from an angle of service receivers' perspective. The discussion in the chapter will also capture on various useful large-scale technologies and their effective provisions. In relation to the software-as-service and other forms of cloud technologies as well as the mobile health infrastructure are discussed as they would be useful for the benefit of healthcare service receivers, and through them how individuals can be able to achieve services in the community for enhanced self-management-oriented healthcare.

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S.U. Khan et al. (eds.), *Handbook of Large-Scale Distributed Computing in Smart Healthcare*, Scalable Computing and Communications,
DOI 10.1007/978-3-319-58280-1_13

1 Introduction

Large-scale computing technologies become essential in improving healthcare systems, especially both to improve processes for efficient care facility and to address organisational and managerial changes in industries. Approaches for various innovations to healthcare support delivery enable people to build on their strengths and to improve the independence and overall wellbeing in the community. Implications of large-scale computing provisions, such as cloud computing and relevant telecommunication service options such as e-health and m-health (mobile health) for improving healthcare delivery, demonstrate potential to significantly improve the accessibility and quality of public or community health and their well-being. The service related to public health includes advisory, emergency and any form of consultation support, treatment and enhanced patient diagnosis through the provisions of m-health and cloud computing are well-established in developed nations [11, 27] but still emergent to fully adopt the applications in many developing nations.

The limitations of medical resources and skilled healthcare professionals are common in rural areas of developing nations. Specifically, resources and healthcare expertise on various support care are inadequate in most of the district towns of developing countries. Network of transportation are also not robust in rural and remote areas; however, wireless and cable based infrastructure and Internet facilities are quite rapidly growing (3G mobility), in rural areas of developing countries [32]. It is due to new research on sustainable and demand-driven technological provisions development. There are scopes to develop sustainable large-scale technological solutions for healthcare industry to maintain and improve information dissemination in relation to various supports such as diagnosis, clinical consultations and for business operations in rural areas.

Cloud computing can be seen as large-scale computing resources as the technological provisions are demand-driven, end-user enabled, resource pooling based and easy to access and manage [3]. For instance, [3] propose a cloud computing based solution for diagnosing neurological diseases in developing countries. The solution uses patient's voice sample for diagnosing the diseases via mobile application. The system uses an artificial neural network classifier for the diagnosis. Rural patients can communicate to healthcare professionals if they use Internet to access the cloud-based solution through their mobile or other form of computing tool. The cloud-based solution also ensures large-scale infrastructure as a service, large-scale platform as a service (PaaS), and user demand oriented large-scale software as a service [3]. Such huge hierarchical view can exemplify the development and use of sustainable public healthcare in order to meet its diverse demands across the huge population.

A large-scale technology in from of telecommunication infrastructure base, m-health provides health service through mobile communication on medical issues and diagnosis of both—well-known and complex diseases, by electronically connected to healthcare professionals who are geographically dispersed. The growth of

m-health adaptations in forms of telemedicine, mobile applications, telehealth, and telematics are widely accepted provisions for their service delivery capability and they successfully address issues to bridge social and economic gaps between rural and urban communities [24]. Such m-health infrastructure improves access and provides options for various health services to enhance wellbeing and quality of life of underserved people who are living in the rural, regional and remote locations. For the huge population, m-health innovations have been gained numerous attentions to both—researchers and service industries, because of its basis is on telecommunication infrastructure. Since telemedicine has become a prosperous evidence to be an useful approach for information exchange and transferring, mobile phone convert as an ubiquitous electronic tool for rather than communication and shopping [16].

Having mentioned about the provisions of the large-scale computing technologies for improving rural healthcare, it is imperative task for exploring aspects that are under-researched but hold promises to achieve potential improvements for the rural communities, such as, for encouraging healthy lifestyle choices [4, 8], for individual's wellness monitoring [31], and in providing healthcare information and advice for self-management [21]. The aim of the chapter is to describe issues of the innovative large-scale technological developments for the rural community healthcare and well-being in the developing nations. The discussion in the chapter will also capture on various useful large-scale technological innovations and their effective provisions for improving public healthcare delivery.

The chapter is organised through five sections as follows. The Sect. 2 presents background of relevant large-scale technologies for various healthcare service innovations. The section after that provides two vital but common general solution frameworks for enabling healthcare services to rural community. The next section presents the issues of the service provisions followed by a discussion and further research directions drawn from the study.

2 Large Scale Innovations

The innovations around the large-scale technologies have demonstrated its positive impacts on the structural transformation in organisations, specially for achieving various business, economic and social objectives. Tegenu [26] described that

> Large scale technologies are the means for the reallocation of resources between and across sectors, particularly in a country such as Ethiopia where there is high population growth and pressure. I am of the opinion that incremental approach to technological change in a model designed for small scale production does not help us to cope up with the demand and speed of growing population of the country (pp. 1).

In healthcare sector, digital healthcare became a rapidly-growing discipline that deals with various ICT based innovations for addressing health service problems

and challenges encountered by healthcare professionals, patients and relevant administrative managements. The healthcare is a multi-disciplinary platform in which different sectors are interconnected to serve the healthcare operations and functions, therefore complex and large computing technologies for improving the functions and operations are essential for providing benefits to relevant people and management in organisations [30].

In an editorial note titled *"What is e-Health: the death of telemedicine"*, Mea [15] described telemedicine, as a type of healthcare systems, that is related to medical professionals, while e-health is driven by non-professionals, namely patients (or, in the e-health jargon, consumers) that hold potentials to drive innovative services of healthcare delivery, typically for general parients' empowerment through their freedom of access to relevant information and knowledge. Although the central focuses of the large-scale innovations are considered as drivers of three main aspects in organisations: for large-scale change management, for large-scale integration in service management and for large-scale process maximisations, latest innovations lead the development and innovation for improving public focused process and practices, through which empowerment of users is vital for designing technological solutions.

The ultra large scale technologies are not new aspect in healthcare domain for meeting various stakeholders' service demands. The large-scale technologies are mainly used for addressing integration issues and often with conflicting purposes where interchangeable needs are necessary. The concept was first introduced by Northrop et al. [19] as a problem concept for solving issues in the United States Department of Defence. The technology represents complex IT systems that involved many stakeholders from multiple organizations, in heterogeneous forms that signify complex dependencies and growing properties. Northrop et al. [19] also reported on key characteristics of the ultra large scale technologies that can be viewed as aspects for innovations. The aspects of innovations development are given below:

- Technological provisions for managing decentralized data and their operational control.
- Technological features for continuously addressing conflicts and incomprehensible requirements.
- Technological improvement for evolving operational capabilities.
- Technological improvement for continuously meeting user's demand for encountering failure and exception.
- Technological features that are required for acquisition of new knowledge, policy and control methods for re-adjustments.

The country wide national healthcare system can have lots of benefits from the concept of an ultra large scale system. National healthcare builds on projects that demands not just from the cutting-edge innovative technological development, but involved latest software, system engineering and operations managements of information processing systems. Although Sullivan [25] explained the ultra large

scale system as a "Cyber-Social Systems Approach" for meeting the demand of cyber-infrastructure requirements for healthcare system, all most none of the studies previously, so far, discussed the ultra large scale digital technologies for the advancement of the public access, their empowerment and appropriate service delivery options for their self-management.

3 Common General Framework of Large Scale Innovations

Various public-focused healthcare innovations have been introduced over the past few years for the developing nations. Such large-scale innovations are mainly for the purpose of countrywide healthcare service delivery. Two vital technologies are used as the basis: cloud computing and telecommunication based such as mobile-based service allows options both—healthcare professionals for maintaining and monitoring heath records, collaborate with healthcare professionals, analyse patient health record (PHR) as well as for patients for their freedom of information access.

3.1 Cloud Based Innovations

Relatively new information technologies based research movement such as cloud computing provides a strong infrastructure and offer a true enabler for e-health services over the Internet. Cloud computing is a large-scale ICT service model where computing services (both hardware and software) are delivered on-demand to customers over a network in a self-service fashion, independent of device and location [14]. Cloud computing adopts a service oriented architecture that enables functionalities in form of an integrated e-health system in order to offer various inter-operable software services [12]. Such services exchange and share healthcare data among patients, healthcare workers/professionals, facilitators, nurses, and doctors in order to improve the overall quality of healthcare diagnosis and consultation offered to people. The adoption of cloud computing for e-health introduces many opportunities to innovate healthcare service delivery in various ways, especially for developing nations. However, existing e-health solutions utilized in developing nations has been incomplete, under quality remarks, inefficient and in most of the cases, requires extensive internal and external resources and considerations to be operationalised [6, 9].

As mentioned earlier the end user or internal system can be a part of cloud based platform that services can be as Infrastructure as a Service, Software as a Service, and Platform as a Service in order to ensure appropriate and effective storage, processing, and controlling services for supporting applications without physical computing hardware or devices. This clearly represents an option with none or

minimal technological intervention needing at user-end and enable less chances of service interruption or access restrictions, as long as the Internet connection is provided. Two vital examples of cloud computing based innovations for the benefits of public healthcare are given in the section below, for better understanding on the growing demand of the field.

Framework 1

Hossain and Muhammad [11] reported an innovative country-wide approach of cloud-based system in which a platform for collaborative services were offered among service or care-givers and healthcare professionals. In the large-scale system, cloud computing provisions mainly facilitated an environment for effective collaboration by considering a voice pathology assessment scenario, in which all stakeholders such as healthcare professionals, care-givers and patients in the communities can collaborate to assess voice pathology, using an *extensible messaging and presence protocol* and the sensing capability of the smart phones's audio components [11]. This collaboration was mainly aimed for delivering quality patient care.

Figure 1 illustrates the overall framework which is developed based on the model of Hossain and Muhammad [11]. In the framework, a patient can give his or her voice through a smartphone, which is used as a media sensor then the media content server (a component of the cloud-based framework) receives and transmits it to the other node, cloud manager. The could manager then sends the voice data to a collaborative service manager for uploading the information to the website for the use of a family doctor. The collaborative service manager are key part of the framework dedicated to the extraction of features from the patient's voice, to modelling pathological samples or/and to classifying the samples.

After analysing the doctor prepares a report or feedback for sending it to collaborative service manager. If the family doctor needs to check the report by an external doctor, the report can be accessed by the doctor and they can analyse the report prior to process in the collaborative service manager for storage. The patient can get the feedback from the doctor from the CM. One of the main problems of this collaboration between the patients and the doctors is to maintain the quality of the voice during transmission, because pathological voice is already noisy [11]. Central focuses are to empower patient community by giving them option to actively collaborate and participate for their own potential health monitoring, quality care, and decision.

Framework 2

Miah et al. [16] introduced a consultancy system utilizing cloud computing that enabled healthcare professionals and field workers to identify and treat non-communicable diseases in rural and remote communities. The framework is called as ''On-Cloud Healthcare Clinic". Figure 2 illustrates below an overall architecture of the solution.

According to Miah et al. [16], the idea of designing the cloud-computing tool is mainly the intermediary tier through which patients were introduced and linked up

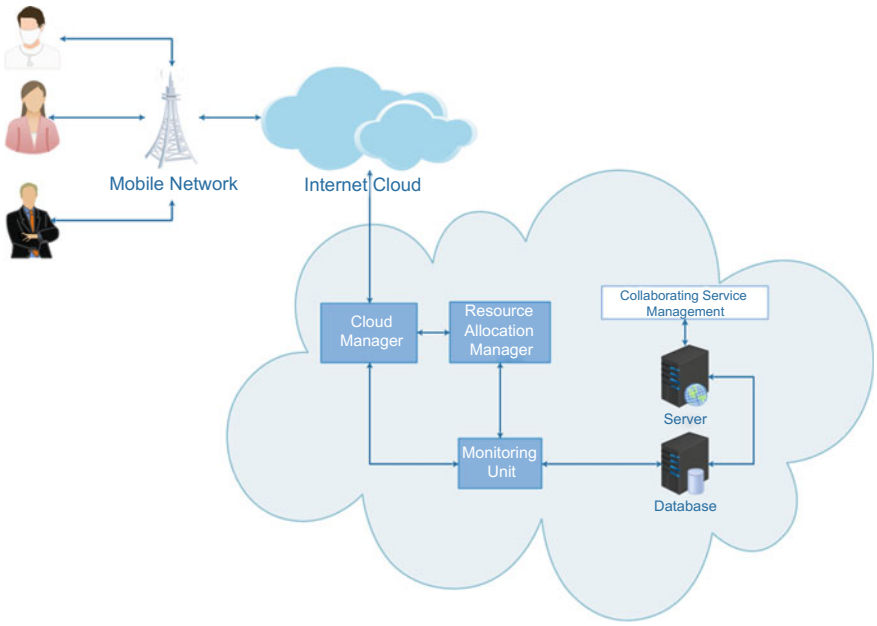

Fig. 1 Solution framework of the cloud based collaborative environment for patients

Fig. 2 Solution framework of On-Cloud Healthcare Clinic

with the doctors. Such cloud-based approach could be local hospitals or in a form of healthcare centres. Access to the cloud based service was managed through local or assisted IT services. The solution structure allowed front-end applications at end users' level that can be seen as an extension to this, addressing the problem on intermediary assistance, and shifting the burden of data inputs to the patient. This option also enables monitoring and assessment role at intermediate level. For various diseases management, such solution can work with body sensors, wearable monitors and other specialised devices potentially to generate accurate data as required in real time, and without necessitating physical travel.

The cloud computing solution provides storage support for patient initials records, patient medical history, and diseases conditions with treatments details for mobile healthcare professionals. Access controls via login forms, and registration processes for new patients have been designed for web access using technologies such as MySQL and PHP in the server side. Appointments are managed through the features of the system that were populated from the database of existing medical records, input—verified by healthcare workers. Using open or cloud-based software means, the solution is not locked into proprietary data forms or devices and liable to commercial pricing concepts.

In the cloud-based system, healthcare professionals also are to be registered with their expertise and availability details. Load balancing allocations can be naturally handled in the cloud, so the system was entirely scalable, and because it is located on cloud, appears unified to the people in the community for their information aids. Person specific details and medical conditions are formulated in terms of medical ‘‘rules of thumb” that begin to specify diagnosis and other information control and delivery to specific actions [16].

The cloud-based approach allows storage of detailed record of workflow, tests or medicines required, time spent and the like, making both individual and collective pricing and informing future resourcing and provisioning decisions. There is no overhead for such record keeping, as it is all mediated within the flow of the system. Healthcare professionals can do evaluation through patient details and concerns, perform an initial diagnosis, so that they can convey additional advice through the system, in case any further diagnostic tests are required or emergency is considered. That does mean that healthcare professionals and patient can meet up online as required through an intermediary platform [16].

Medicine prescriptions or lifestyle adjustment guidance can be provided and followed up on over time, especially in the case of diabetes treatment, as a case. In the same way, details of healthcare professionals and healthcare workers can be populated for the coverage of areas. They are also in terms of providing necessary support during and after healthcare professionals’ specific patient consultation process. Comprehensive reporting for the patients the system provides options for healthcare professionals but any complete online-based healthcare system would need to be monitored for patient data security and privacy details [16].

3.2 M-health Innovations

M-health aims to provide health professionals, patients, clinicians and other relevant users with information support services to manage, disseminate, collect, administer, control and monitor healthcare information and improve health service delivery and quality of care support. The service eliminates geographical and temporal constraints while enhancing the coverage, quality, cost savings and other user provisions of healthcare [7, 18, 28]. Moreover, the m-health innovations allow

acquisition, monitoring, forecasting, sharing and control of various health conditions. Such provision is designed for healthcare personnel and patients with various needs to make decisions regarding treatments and care support, and administration requirements for developing anytime-anywhere service support. Illustrative examples include: m-health systems for remote patient monitoring [5], disease prevention and wellbeing [29], knowledge exchange [22] and medication management [13].

Many current m-health innovations are, however, designed that encompass steps or iterations for identifying and analysing requirements, designing or implementing a system solution and testing the system within the problem domain. For instance, Radzuweit and Lechner [23] utilised prototyping for designing a consultation service that supported effective interaction between individuals and health professionals. Oluwafemi and Olanrewaju [20] proposed a patient communication solution through messaging but, although the study used phases such as design, development and evaluation, the authors did not evaluate the solution with the target user patient group. In the following sections two vital frameworks are introduced for better understanding on the growing demand of the field. Milošević et al. [17] used a basic software engineering methodology for designing an m-health application for community well-being by monitoring individuals' health conditions such as physical activity, weight and heart activity. The methodology consisted of common phases such as problem definition, (mobile) architecture design and implementation. Many of the m-health innovations designs, however, did not develop the large-scale capacity and evaluate the solution capacity directly or indirectly with the target user groups.

Framework 1

Wayne and Ritvo [31] designed a health coach intervention for patients with diabetes in the community that promoted adoption and maintenance of health behaviours. The solution framework was so-called "Connected Health and Wellness Platform Health Coach app" offers advisory support for helping people to attain personal goals through their intrinsic health-oriented motivations. The smartphone-based application framework supported multi-channel communications between stakeholders such as patients in the community and health (professionals) coaches and supportive family members. The solution framework in a form of prototype version established positive gains in terms of medication adherence and improved psychological functioning, as the people's positive illness-coping strategies [31].

According to Wayne and Ritvo [31], the solution framework was collaboratively developed by application designers and researchers to support participants in electronically tracking health behavioural matters. These matters are mainly exercise, diet, stress reduction practices and self-monitoring health data such as—blood glucose, blood pressure, mood, pain, and level of energy. In the solution framework, security provisions were vital for the service provider-patients interactions

through the two-way communication channel in which certificate-based authentication and individual's password were encrypted with entered data recalled by the patients and healthcare professionals or service providers. Figure 3 illustrates an example of mobile healthcare support system for rural communities.

Framework 2

Thomas and Wing [27] introduced an innovative m-health approach so-called "Health-E-Call" and the main objectives of the innovative smartphone application was to determine whether key components of behavioural weight loss treatments such as self-monitoring, feedback, and skills training could be accomplished and potentially enhanced. The idea was to reducing the need for intensive care for person specific treatment. Main aim of the solution is to enhance patient's self-monitoring, given the importance of this skill for successful weight loss. Use of an electronic handheld device already popularised not only for self-monitoring improved adherence to the self-monitoring procedures, but also to improve accuracy of self-monitoring. Figure 4 illustrates an example GUI of this type of mobile-based applications. The vital outcome measures in the system were weight loss and devotion to the self-monitoring procedure and transparent reporting for self-satisfaction by patients [27].

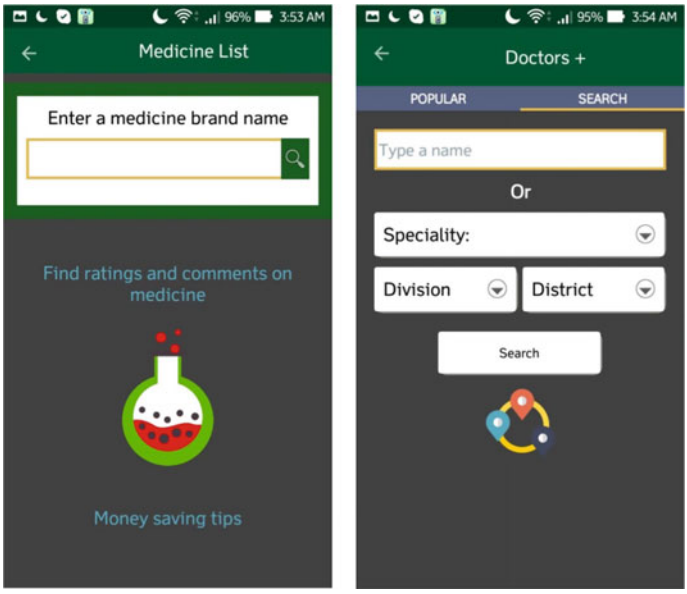

Fig. 3 Example solution framework of a mobile healthcare support system for rural communities

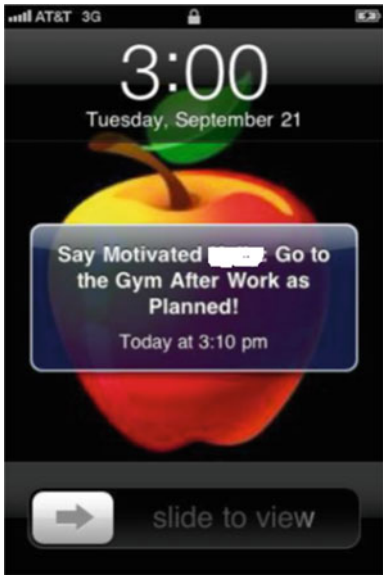

Fig. 4 Example GUI of a mobile-based approach (adopted from [27])

4 Potential Aspects of General Large-Scale Framework

In this section potential aspects in which various applications are designed are described. For both technological innovations top ten aspects are only given as case demonstration. The findings are collected through a literature review study to investigate relevant literature in both fields. Following Figs. 5 and 6 represent various aspects of existing application design through the innovations of cloud computing and m-health technologies.

The importance of utilizing cloud computing for providing health analysis, diagnosis and consultancy made strong argument for it to be adopted for rural and remote communities where a trained professionals or nurses would be able to record and enabled the entry of data on cloud based e-health systems using preferably mobile computing devices. With the extensive usage of mobile computing and telecommunication infrastructure, such a system solution would be feasible to quick design and implement for meeting any healthcare information service demands. The mobile platform allowed for direct healthcare professional patient discussion for effective medical diagnosis, monitoring, consultations and follow-up.

Fig. 5 Various aspects of cloud computing based application innovations

5 Discussion

In this book chapter, large-scale innovations and approaches for community healthcare support have been discussed. The aim was to focus the emergent technological perspectives in healthcare for developing countries. We focused on two divergent of large-scale technologies related innovations with their applications. These are cloud computing and telecommunication infrastructure for m-health that were described with its provisions and benefits for improving healthcare support and service delivery for citizen/patients in developing countries. The discussion also highlighted existing aspects of both cloud and telecommunication based interventions that could be of paramount for underdeveloped nations particularly when they aim to adapt large-scale computing resources through the implementation of cloud computing and m-health systems/services. Based on the theoretical

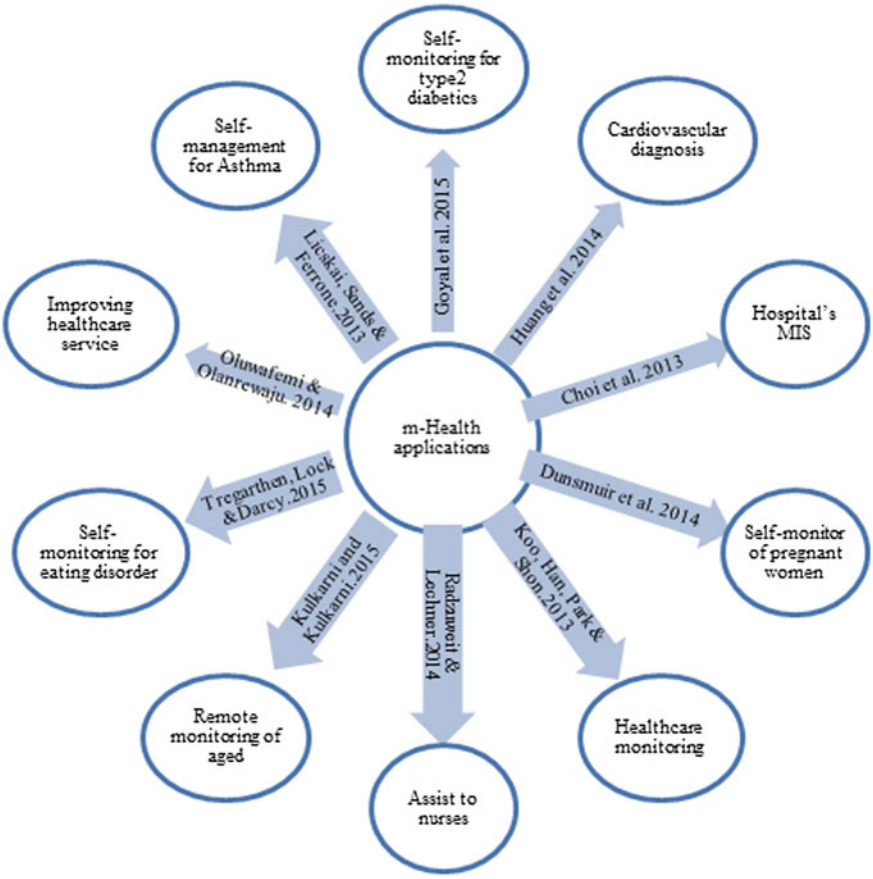

Fig. 6 Various aspects of m-health based application innovations

Fig. 7 Conceptual framework of a large-scale healthcare service

analysis, a conceptual framework was proposed that combines both cloud and mobile computing provisions as a platform of large-scale healthcare service. Figure 7 illustrates the diagram of the combined solution platform.

In developing countries, the public healthcare situation is considerably overlooked over the past years. The situation has changed a lot in the current era. Government, NGOs and private organisations are concerned to put forward their effort and financial budgets to improve the situations. Relevant researchers are keen to investigate the practical issue for meeting the complex healthcare demand of rural communities. South-Asian developing countries have large remote populations, but lack of balanced medical and healthcare expertise. For example, Bangladesh has only one healthcare professional for every 1700 patients, against a Millennium Development Goal of at least 2.5 healthcare professionals per 1000 people [32]. The healthcare sectors in Bangladesh are undeveloped due to inappropriate use of ICT for the need of the remote communities [16]. The majority of the population in Bangladesh live in remote areas without access to modern healthcare facilities and specialized hospitals [2, 10, 16].

The government authorities in developing countries have been considered the public healthcare a priority agenda due to the growing interests of the international donner and aids agencies such as United Nations and World Bank. Without large-scale technologies it would be nearly impossible to deliver a satisfactory and effective level of health care for the public demand of medical support. One of the reasons of that is, the healthcare and its underlying issues are include from large and widely spread population. Most of the nations at their developing stage or still lack of medical infrastructure due to many issues such as organisational heritages and bureaucracy in civil services, and limited financing for improving healthcare sector [1]. In some cases, there is a recognised shortage of well-trained healthcare professionals and nurses but they do not have required skills and motivation to work on a large-scale technological platform for providing support services to rural and regional people. In some other cases, telecommunication infrastructures and support services are quite advanced, with extensive and rapidly growing coverage. They just need to commence new projects on large-scale systems development. Developing large-scale system solutions utilizing these infrastructures such as cloud computing therefore suggests functional methods to deliver healthcare services to meet the demand of individuals in rural areas.

6 Conclusion and Future Aspects for Research

The chapter discussed both the issues and potential solutions for more sustainable healthcare service delivery. In this chapter, we reinforced on the requirements of developing large-scale technologies for the communities in developing nations. We reinforced the requirement of a comprehensive approach using cloud-based and telecommunication based technologies for various aspects such as community care, treatment support, patient self-management support, medical consultation support etc. we also discussed various examples in Sect. 4 for both technological divergence. We focused on the public care aspect, but professionals at specific problem domain may have their own opinions about a variety of different system that may be

used involving different management concerns that were not covered in the chapter. We may only covered the technological aspects on limited organizations that may not have appropriate reflections in terms of resource allocations and infrastructure required associated to particular service management. Although the cloud-based solution can support flexibility and easier access to real-time data and mobile infrastructure can support every-where any-where access and presence, both technological provisions involve common issues of security and privacy of information and integrity of data or information resources including access control policy and other legislative and management concerns.

Although individual or end user computing techniques have grown to a sophisticated level, the large-scale technologies and their relevant services through the use of cloud-based and mobile computing are still in the emergent stage. Many relevant tools and technologies are still being developed. The topic area introduced in the chapter on public healthcare aspects of developing nations is just based on existing studies and concepts. There is a need for considerable research on developing new knowledge and technological innovations in this field to address the complex practical demand in public healthcare. The author attempts to bring an overview of the relevant technological developments and introduce the application area of large-scale techniques to enhance readers' knowledge in the field.

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