mHealth: A Developing Country Perspective

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Summary

The health care environment is currently changing, and the health sector is being transformed to meet new challenges and to benefit from new opportunities. Priorities for the 21st century ought to be set based on emerging dominant trends in health care, including the shift towards shared or integrated care, in which an individual's health care is the responsibility of a team of professionals across all levels of the health care system hierarchy. In addition to the requirement for efficient and secure access to the integrated electronic health record (iEHR) of a citizen, this necessitates the development and deployment of regional health information networks (RHINs), synchronous and asynchronous collaboration services, and novel eHealth and mobile health (mHealth) services, facilitated by intelligent sensors, monitoring devices, hand-held or wearable technologies, the Internet and wireless broadband communications. These further require the adoption of an open reference architecture and the creation of a scalable health information infrastructure (HII).[1]

According to the ITU, the total number of mobile users worldwide as of late 2006 was about 2.7 billion and the number of Internet users was just above 1.1 billion. This means that there is at least 23.6% of world population (and at least 22.2% of developing countries' population) that already has mobile phones but is not yet using the Internet. Mobile services are quickly emerging as the new frontier in transforming government and making it even more accessible and citizen-centric by extending the benefits of remote delivery of government services and information to those who are unable or unwilling to access public services through the Internet or who simply prefer to use mobile devices. In theory, many government services can be now made available on a 24 hours a day, seven days a week, 365 days a year basis at any place in the world covered by mobile networks, which today means almost everywhere. Approximately 50%–60% of government services including primary health management can be delivered via mobile channel.[2]

mHealth is one of the major challenges being faced by both medical practice and health care policies. The impact of mHealth is likely to be more far-reaching than other developments such as nanomedicine and genetic therapy, as it will create an urgent need to review the way health care is financed and blur the boundaries between professional medical help and so-called "do-it-yourself" medicine (i.e. minor treatment or self-medication without consulting a physician, but based on previous medical treatment experience, popular medical literature, or a pharmacist's advice). On current trends, mHealth systems will be more widely offered by mobile phone providers, and simple, yet important functions may even be offered as built-in features of mobile phones. This, in turn, will imply that technology providers account for a larger than ever share of the total value of medical services. Consequently, systems for the provision of medical care may have to accommodate new expenses incurred by services from outside of the traditional health care system.[3]

Background

Mobile technologies are increasingly growing in developing countries. There have been several new researches and developments in this space. Nowadays, mobile phones are becoming an important ICT tool not only in urban regions, but also in remote and rural areas. The rapid advancement in the technologies, ease of use and the falling prices of devices, make the mobile an appropriate and adaptable tool to bridge the digital divide. For example, mobile phone ownership in developing country like India is growing rapidly; six million new mobile subscriptions are added each month and one in five Indian's will own a mobile phone by the end of 2007. By the end of 2008, three quarters of India's population will be covered by a mobile network. Many of these new "mobile citizens" live in poorer and more rural areas with scarce infrastructure and facilities, high illiteracy levels, low PC and Internet penetration. The availability of low-cost mobile phones and the already broad coverage of GSM networks in India is a huge opportunity to provide services that would trigger development and improve people's lives.

M-technology is increasingly being used in the health care field. Government officials use mHealth to collect health-related data on the general population. The use of mHealth is becoming a cost-effective method of identifying and monitoring health issues, as well as guiding the formulation of health policies. Programs to support the professional development of people in the health field, using mHealth technology, are becoming readily available. mHealth also provides health professionals with access to patient data as well as access to various information sources, both of which provide valuable assistance in the diagnosis and formulation of treatment. Individuals can use mHealth to access resource materials on health issues. Patients can self-monitor and transmit information to their health care provider; e.g. blood pressure, glycemic data for diabetes control or a photograph of a wound. Using mHealth could be particularly important to people living in remote areas or those who are physically impaired.[4]

Characteristics classification of mHealth

Based on the definitions given above, mHealth systems can be classified according to the characteristics of the source and destination of the medical information flow:

- Patient to (medical) supervisor
- Patient to physician
- Physician to physician
- Physician to expert system
- Patient to medical CRM system (management of patients and medical interventions)

Depending on the target group, mHealth systems can be classified as follows:

- mHealth for hospital patients (i.e. moving within prescribed strict spatial limits)
- mHealth for healthy people (preventive mHealth)
- mHealth for the chronically ill or vulnerable individuals

Another classification, which derives from the technology used in mHealth systems, is given in Table 1.

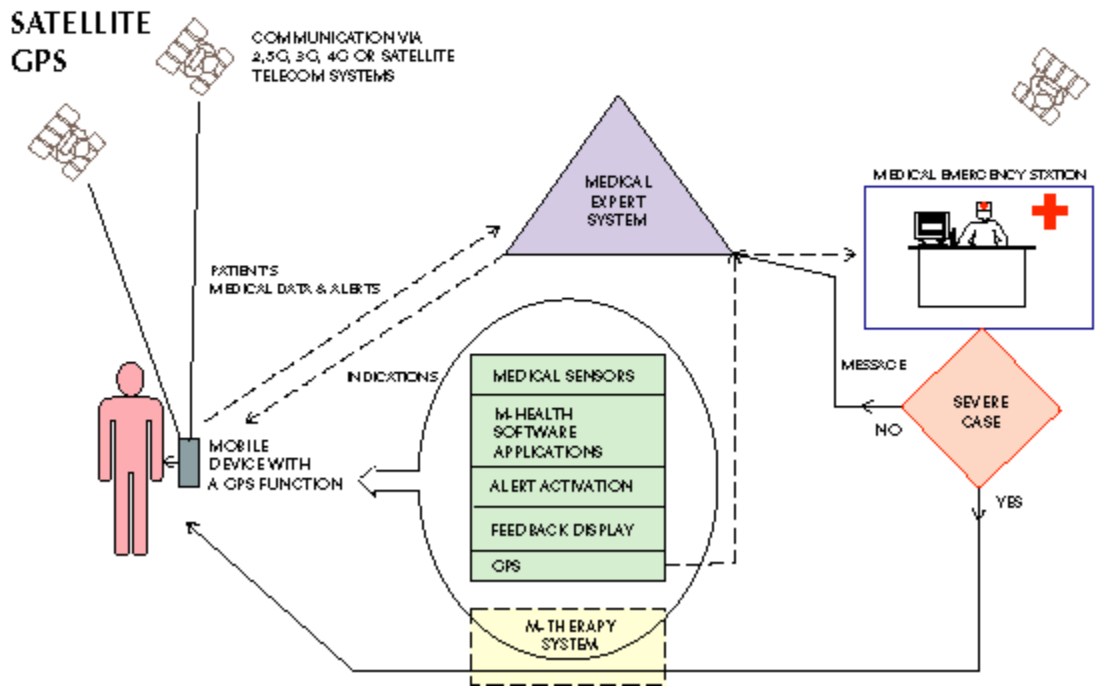
Table 1. Classification of technologies currently used for mHealth

Mobile-technology	**Transmission rate per mobile application**			
No of applications served by m-device	local: Bluetooth	local to medium range: wLAN 802.11a/b	long range: GSM/GPRS, CDMA	long range: UMTS
Single application	< 1 Mbaud	2 to 54 Mbaud	10 to 115 kbaud	0.144 to 2 Mbaud
Multiple applications	< 1 Mbaud	1 to 27 Mbaud	< 10 kbaud (of guaranteed transmission capacity)	< 1 Mbaud

Emergent Technology in mHealth

Current mHealth devices are able to continuously monitor an individual's pulse and blood pressure, detect breathing abnormalities associated with bronchial asthma and other chronic respiratory system diseases. Sleep disorders also seem to be one of the main areas in which there is considerable experimentation with mHealth techniques. Home observations with mobile equipment are often the only practical approach that is convenient and acceptable for a large number (up to 40% of the European population suffer from some form of sleep and/or breathing disorder) of potential patients. Continuous monitoring of heart and brain functions (m-ECG and m-EEG) is possible from the technical point of view, yet difficult, due to the presence of so-called artifacts, i.e. various perturbing signals and noise. Therefore, the appropriate signals are usually measured and transmitted at regular intervals instead. Similarly, monitoring blood content is both inconvenient and unnecessary, since it does not change rapidly under normal circumstances. For mHealth applications, e.g. those already widespread in diabetes, there are mobile devices allowing incidental blood analyses to be made and transmitting the results to the medical supervisor (a physician, a database, or an automated diagnosis system). Continuous blood content monitoring, as well as real-time medical imaging, may be useful in a hospital environment, especially when monitoring the impact of pharmacotherapy, pre- or post-operative patients and recovery processes without affecting the mobility of patients inside the hospital.

Figure 1. Patient-oriented mHealth system



The rapid progress of telemedical systems and mHealth is a phenomenon of the last decade and it has no doubt not yet reached its culmination. Results achieved so far include the definition of a medical information transmission protocol (DICOM - Digital Image Communication), the emergence of numerous professional telemedicine applications and the first large-scale public mobile systems offered by mobile telephony providers. The huge market for medical services, so far monopolized by incumbent health care organizations, will soon be invaded by low-price mobile medical services providers, using medical personnel only for operational and incidental tasks. Technological details are shown in figure 1.[3]

mHealth Potential [5]

The next few years will witness a rapid deployment in both wireless technologies and mobile Internet based mHealth systems with pervasive computing technologies. The increasing data traffic and demands from different medical applications and roaming application will be compatible with the data rates of 3G systems in specific mobility conditions. The implementation and penetration of 4G systems is expected to help close the gap in medical care. Specifically, in a society penetrated by 4G systems, home medical care and remote diagnosis will become common, check-up by specialists and prescription of drugs will be enabled at home and in under populated areas based on high resolution image transmission technologies and remote surgery, and virtual hospital with no resident doctors will be realized. Preventive medical care will also be emphasized: for individual health management, data will constantly be transmitted to the hospital through a built-in sensor in the individual's watch, accessories, or other items worn daily, and diagnosis results will be fed back to the individual.[6]

A 4th Generation mHealth solution builds upon the mobile information portal of a 3G solution by adding the multiple devices rendering capability of the 2G solutions. Now an end user has the ability to access any application with any device. 4G solutions embrace the distributed and loosely coupled HIS applications throughout a health unit. A 4G solution can allow for acquisition of data from various sources and allow the mobile end user to view, analyze, manipulate, graph and merge data according to his or her needs right on the mobile device.[7] In the home of the future, some devices will contribute physiological information about the patient (e.g., heart rate, blood pressure), while other devices in and around the home will contribute information about the patient's environment (e.g., humidity, temperature, carbon monoxide level). In some cases, groups of devices will have enough collective awareness to function autonomously based on sensor data. The challenge for the health care providers and health authorities lies on the comprehension of the end users needs for the effective integration of new technological capabilities to existing settings in order to leverage their capacities and quality of services.

Selected Case Studies from Developing Countries

Experience in South Africa (SA) [8]

The Dokoza system is an innovative cost-effective interactive real-time mobile system for fast-tracking and improving critical services to the broader majority. Components of the system have been patented (SA Patent#2002/1242), the system has been developed in SA for use initially in HIV/AIDS (specifically in respect of the roll-out of anti-retroviral therapy) and TB treatment, with the view to including other diseases. The system involves the use of SMS and cell phone technology for information management, transactional exchange and personal communication. The cell phone makes use of a regular issue SIM card across any existing cell phone network. The system standard is normal SMS text messaging and therefore does not require special additional SIM software or downloading of templates for interacting. The Dokoza back-end system is extensively rules-based for intelligent interaction to build capacity for health workers with little knowledge. Furthermore, the Dokoza back-end system is easily integrated with all existing hospital systems (such as the National Lab) and Dokoza can also be accessed in real-time via PC Web, laptop, PDA, Smart phone, Palmtop and is able to interact with fax and email. Overall, there are various levels of security measures, firewalls and encryption. Dokoza does not display HIV sensitive information on the Web and further security is required to view these in a back-office environment.

Mobile Telemedicine System in Indonesia [9]

This project is being carried out by the biomedical research group at the Institute Teknologi Bandung in Sukabumi in western Java, with a $29,479 endowment from the U.N. Development Programme. This region has an area of 4,248 km^2 and a population of 2,300,000. The elevation ranges from 0 to about 3,000 m above sea level and the geographical features are diverse. In this region, 3 hospitals and 71 community health centers support the medical treatment. Staff members at the community health centers operate the system. Graduates from the biomedical research group at the Institute Teknologi Bandung also participate in the project, and the Health and Medical Bureau of Sukabumi and the district authorities also support the implementation of this project.

The system utilized in the project employs the existing Internet communication equipment, and has been operating with the primary objectives of telediagnosis, remote consultation, and collection and recording of patient information. This system consists of two units: the mobile telemedicine unit on the patient side, and the hospital / doctor unit at the medical service center. The mobile telemedicine unit consists of three blocks: a medical equipment block, a communication block, and a data-processing block. Medical instruments installed in the medical equipment block vary with each installation location, and they are used according to the situation of the locale. Especially, three instruments for blood pressure, electrocardiogram, and Doppler fetal-diagnosis monitor are deemed as the most needed medical instruments. In addition, the patient information record system records the name of the disease and findings of the physician, diagnostic tests to measure the grade of illness, results of diagnostic tests, type of treatment and method of treatment to be given. The system can also record information such as the patient's address, occupation, marital status, age, etc. In the hospital / doctor unit, data sent in various formats can now be processed collectively. Exchange of data between the two units can be performed via packet radio GSM/CDMA cellular phones, fixed-line telephones, etc. Exchange of information can be performed with dedicated software based on the TCP/IP protocol, and communication means can be adopted according to the local infrastructural situation. Although this is an ongoing pilot project, it has allowed those people living in the rural areas or places far away from hospitals to receive periodic medical examinations using cellular phones, and thus the provision of medical services has become possible, without being restricted by geographical conditions. Furthermore, the project has produced such effects that the staff of small-scale hospitals can now receive specialist's advice about diagnosis of patients with advanced diseases.

mHealth in India

1. **United Kingdom (UK)-India Education and Research Initiative (UKIERI).**

UK-based Loughborough University's engineers have entered upon a partnership with experts of India to develop a unique mobile phone health monitoring system. The system, which was first unveiled in 2005, uses a mobile phone to transmit a person's vital signs, including the complex electrocardiogram (ECG) heart signal, to a hospital or clinic anywhere in the world. Professor Bryan Woodward and Dr. Fadlee Rasid from the Department of Electronic and Electrical Engineering at the Loughborough University have developed this mobile phone monitoring system. Presently the system can transfer the signals pertaining to the ECG, blood pressure, oxygen saturation and blood glucose level. Now, the UK-India Education and Research Initiative (UKIERI) has awarded Professor Woodward a grant to further develop this mobile phone monitoring system. They have tied up with the Indian Institute of Technology Delhi (IIT Delhi), the All India Institute of Medical Sciences and Aligarh Muslim University and London's Kingston University to further develop the system.

The research team is aiming to miniaturize the system through designing sensors and mini-processors that are small enough to be carried by patients, and at the same time procure biomedical data. The network of sensors would be linked through a modem to mobile networks and the Internet, and to a hospital computer. Then, doctors can use this device to remotely monitor patients suffering from chronic diseases, like heart disease and diabetes, which plagues millions across the world. The UK government will promote the device to improve the efficiency of health care delivery. In India, the project will link clinics and regional hospitals in remote areas to centers of excellence. The clinical trials of the system will take place in the UK and India in the next three years.[10]

2. **Mobile based Primary Health Care Management System[11]**

CDAC, Electronics City, Bangalore has initiated the development of **"Mobile based Primary Health Care Management System (PHC)"** for deployment in the PHCs for betterment of management of Primary Health Care specifically in the rural and urban slums of India. The system will capture complete information related to an individual patient treated by a PHC. The software components under development are patient database management, interaction between doctor and a patient, capture of medical data acquisition- such as ECG, images of heart and lung, eye etc. and scheduling management. The project involves development of the following:

- A Web based information system for management of primary health care
- SMS interface for integrating SMS messages from the patients using 2nd generation mobile systems (GSM/CDMA) with the information system
- WAP gateway for Web access applications using WML for integrating GPRS/3G/4G mobile devices of doctors and nurses with the Web server
- Development of localization support to national and other Indian languages in mobiles by providing interface for translation.

System Overview

A central repository of primary health center management system with a Web interface is proposed to be developed in an Open source database. An SMS based interface to the Web is planned to be added for integrating with 2G (GSM/CDMA) telephones since Mobiles have penetrated overwhelmingly in rural India. A WAP Web gateway will be developed for integrating with a GPRS/3G mobile devices, which are expected to be used by doctors and health assistants. In case of GPRS/3G systems, the Web request from the phone is first served by the WAP gateway server. The gateway server translates mobile phone requests (WAP) into HTTP requests and sends them to Web server. The Web server processes the request, and sends WML to gateway server, which in turn sends the WML to phone in the binary compressed WML format.

Sub Systems

The sub-systems under development are

- A **central information repository** with database of the patient information and other resources/services.

- **Web server © SMS interface** for receiving/sending SMS to 2G Mobile systems, which receives the SMS, converts the SMS into a query and executes the query. The results are then sent as an SMS reply.
- **WAP Gateway** for linkage with a GPRS/3G mobile. The gateway server translates mobile phone requests (WAP) into HTTP requests and sends them to Web server. The Web server processes the request, and sends WML to gateway server, which in turn sends the WML to phone in the binary compressed WML format.
- **Localization module** for providing interface for translation.

Highlights

A health information system in which each family has an up-to-date family folder is a valuable tool for maintaining, analyzing and interpreting the enormous data . The **mobile based primary health care management system** will seek to achieve:

- Increased quality of primary health care (PHC) services
- Increased efficiency of service care with an adequate referral and remote Consultation system
- Improved epidemiological surveillance and control
- Better pregnancy case registration and management
- Reduction of maternal and perinatal mortality and morbidity

3. Ericsson and Apollo Hospitals Initiative[12]

Ericsson and Apollo Telemedicine Networking Foundation (ATNF), a part of the Apollo Hospitals Group, have taken a major step towards helping bridge the digital divide in rural India by laying the foundation for the introduction of mobile health services. Telemedicine delivered using HSPA technology will enable the provision of affordable and accessible health care to millions of people in remote areas.

More than a million people, predominantly women and children, die each year in India because of a lack of health care. A further 700 million people have no access to specialist health care, as 80 percent of specialists live in cities. At the same time, the teledensity of India is increasing at a phenomenal rate. Telemedicine harnesses telecommunication technology to deliver health care and education to patients in remote regions. It enables easier access to health care for rural populations, helping to provide critical health information, save time and money, and reduce the need for travel.

A memorandum of understanding (MoU) between Ericsson and ATNF will enable them to work together to educate people and to publicize, promote and implement the use of telemedicine deployed as an application over broadband-enabled mobile networks.

ATNF will provide expertise in telemedicine, in the form of applications that provide instant medical advice remotely over the network. This will increase access to quality health care once the HSPA network is in place, and sets the stage for the creation of a stable ecosystem, based on WCDMA/HSPA technology, to support a range of innovative services.

The initiative builds on Ericsson and Apollo's previous collaboration in 2007 for the Gramjyoti project, which showcased the benefits of mobile broadband applications across 18 villages and 15 towns in rural areas.

This agreement is part of Ericsson's support for the United Nations (UN) millennium development goals, which aim to halve extreme poverty and hunger by 2015, while improving education, health and gender equality. Ericsson has been working on several initiatives to demonstrate the use of telecoms in health care provision.

Challenges in mHealth[13]

Regardless of the means or the delivery channels employed for health care provision, the established standard of care needs to be attained at all times: patients have the right to quality health care, whether this is delivered face-to-face or by means of modern ICT technologies. In the context of mHealth, three critical sources of risk in clinical praxis are identified, namely the medical expertise of health care practitioners, the availability of valid supporting information (clinical data, patient records, best practice information, medical literature etc) and the context within which the medical procedure takes place. When making a diagnosis of illness or deciding on the optimal treatment, clinicians need first to have a good overview of the case (i.e. sufficient information), and then to utilize their professional skills and abilities to make an accurate decision unaffected by the environment where this process takes place.

1. Lacking skills & professional expertise (the "human factor")

Traditionally, being a health care professional entails possessing the skill and the qualification to perform a number of medical tasks. By law, health professionals are required to exercise the care and skill of a reasonable professional and achieve a "standard of care". This standard of care is that not of the best or most experienced specialist, but of a reasonable specialist. Failing to reach that standard is considered negligence. In the case of technology-assisted care provision, in addition to possessing the standard medical qualifications, professionals will also be expected to have a certain degree of extra knowledge and skill that will enable them to use technology safely and effectively (e.g. the skill to operate portable medical devices, to use communication devices etc). Nonetheless, setting qualifications standards for ICT-knowledgeable health care professionals remains a challenge. Yet, it is commonly agreed that all health care workers need to be trained in the use of modern health care technologies and be aware of the technical limitations that such systems place upon their work. Whenever health care professionals make a clinical judgment by means of such systems, they must be satisfied that they have sufficient information to form such a judgment and that the information itself is of appropriate quality and reliability.

2. Supporting information & expert knowledge

The management of information emerges as an important challenge. Key to the successful implementation of mHealth is to make available the right information at the right place, at the right time and in the correct form with medical practitioners and patients free to roam and to utilize different access devices (in terms of both display and processing capabilities and of communication characteristics), new problems arise regarding the delivery of information, from a variety of sources and in a multitude of formats (ranging from plain messages to multimedia content) in a secure and reliable way. Critical to the successful handling of supporting information are monitoring devices, health care databases, communication networks and access devices.

a) Communication networks

The variety and complexity of mHealth application scenarios calls for the combined use of wireless technologies (both short- and wide-range), wired communication backbones and the Internet in a seamless, secure and reliable way. The employed wireless technologies include Bluetooth, wLAN, WiFi, GSM/GPRS, UMTS and satellite communications (VSAT, DVB-RCS). The difficulty of achieving operational compatibility between the telecommunication services, terminals and devices continues to be a challenge for mHealth applications.

Although high-speed digital communication infrastructures are gradually gaining ground, it is often the case that the regions that would benefit the most from electronically delivered health care are mostly underserved in terms telecommunication capabilities. High speed communication networks are still far from being a reality in many remote rural areas in developing countries. This limits the options for telemedicine and the involved medical staff, as many services can only function well under specific conditions, in terms of communication capabilities. Many telehealth applications rely on high-speed broadband IP networks to deliver a high quality, timely and converged voice, video, and data.

b) Access devices

mHealth employs a multitude of both wired and wireless access devices, e.g. portable PCs, cellular phones personal digital assistants (PDAs) etc. Each one of these appliances has its own limitations in terms of screen size, processor power, memory, and bandwidth, battery life etc Depending on these characteristics the service capabilities of the device are conditioned.

Clinicians should be particularly aware of the limitations of the access devices employed, what amount of information they can provide and how well they can display it. One important aspect to this, is the limitations of screen sizes and digital imaging technologies in some highly visual telemedicine applications, such as teleradiology, teledermatology and telepathology. The technologies currently available provide excellent pixel density and resolution with a high rate of diagnostic agreement demonstrated in the scientific literature between digital and real images.

There is clinical risk of a wrong or missed diagnosis being made on the basis of a digital image which is of insufficient detail or contains too little clinical information, or because of the alteration or corruption of an image due to technical reasons (e.g. the limitations of the store-and-forward approach adopted). Clinicians called to make a diagnosis, should be aware of this underlying risk.

To the benefit of telemedicine and mHealth is the definition of a medical information transmission protocol (DICOM - Digital Image Communication) and its growing adoption by medical equipment manufacturers.

c) Monitoring devices

Nowadays, a lot of effort is being placed on the development of portable and networked devices for the measurement and monitoring of patient vital-signs. With the help of pervasive and wearable technologies, critical health statistics of the patient can be measured, stored and transmitted to a database during daily routines, emergencies, hospital stays or the treatment of chronic illnesses. Wireless body area networks (WBAN) represent an important step in the evolution of monitoring devices. They consist of lightweight and small size sensor platforms that allow for the continuous monitoring of multiple parameters in ambulatory settings.

d) Unification of information sources

Ideally, the entire medical profile of a patient (medical history, results of laboratory testing, etc.) should be retrievable at the point-of-care at the touch of a button. Yet, the decentralized multi-actor nature of health care and the wide distribution of relevant data sources has produced a patchwork of diverse and heterogeneous, in terms of content, database implementations, that makes access to and retrieval of data from repositories a challenging area. Consequently, one of the major challenges for mobile health applications is the integration and exploitation of heterogeneous scientific information databases in a seamless way, so as to enable the storage, updating, search and retrieval of useful information.

The effective employment and exploitation of structured information requires a cross mapping and standardization of the different coding schemes and medical terminologies used in the health care sector. Semantic representations can help the process of converting data into different formats, thus helping to understand and effectively analyses this information.

Furthermore, in many cases the access to medical information or the exchange of data among health care providers is hindered due to the non-interoperability of the different information systems in place, calling for the adoption of common standards or the development of communication interfaces.

Conclusion

The overall development of mHealth will be driven by the consumer demand, value added service by the mobile phone industry and health care policy makers in the near future. Technological advances in the wireless broad band sector combined with development of rural wireless telephony will be acting as a boost. Depending on the policy approach taken, mHealth could either be used to bolster the overall quality of health care by providing an immediate and reliable source of medical help, it could be used as a cheap surrogate for medical services, or it could be marketed as a value-added service paid for by mobile phone subscribers together with their monthly charges. Clearly, the approach taken will determine whether mHealth reduces inequalities of access to health care services by making services available remotely and free or at low cost, or whether it widens inequalities by being marketed as a luxury for people willing and able to pay for a potentially high-cost additional service.

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