Towards the Development of an mHealth Strategy:

A Literature Review

Original Draft prepared by Patricia N. Mechael August 2007

For the World Health Organization

Update by Daniela Sloninsky for the Millennium Villages Project

The Earth Institute at Columbia University

August 2008

Table of Contents

Acknowledgements

There are many colleagues to whom we owe a debt of gratitude. Without their work and guidance the original draft report prepared for WHO would not have been possible. First, I would like to thank Yunkap Kwankam, the Coordinator of the Global Observatory for eHealth at WHO, for his strategic vision in the practical use of mobile technology as a tool to promote health throughout the world. It is the extension of this vision to harness the potential of mobile communication technologies that this report has been commissioned. I also would like to thank Walter Curioso, Bruce Dahlman, Ayedee Domingo, Paul Fontelo, Richard Heeks, Adesina Iluyemi, Robert Istepanian, Warren Kaplan, Jose Lacal, Alvin Marcelo, Lloyd Marshall, Birhanu Mekuria, Lady Murrugarra, Neil Pakenham-Walsh, G.V. Ramaraju, Ulrike Rivette, Francisco Rubio, and Mitul Shah for reviewing drafts and sharing information resources, contacts, and strategic recommendations that have been integrated throughout this document. Much appreciation is owed to the organizers of the Med-e-Tel 2007 conference in Luxembourg for providing a platform for gathering useful recommendations as well as information on the state-of-the-art in mobile eHealth solutions throughout the world. To the many others who have contributed to this process in other ways, many thanks.

In addition, we would like to acknowledge our colleagues at the Earth Institute at Columbia University for the strategic vision to facilitate our update of the original review and apply findings from the literature to the development of an mHealth Strategy. This strategy forms the foundation for the implementation of scalable mHealth solutions in partnership with Ericsson and Sony Ericsson in 10 countries in Africa, ranging from rural-based Emergency Medical Service delivery and mobile telemedicine to the development of decision support and data collection tools. Using this strategy, the Millennium Villages Project provides a critical opportunity to explore how mobile technology can be leveraged to achieve the MDGs for health.

There were a number of challenges that were encountered while developing this review. The first was maintaining a focus on low and middle income countries in a learning environment where much of what is documented in mHealth is focused on applications developed and deployed in high income countries. Where appropriate, lessons from high

income countries have been integrated to illustrate the potential of such applications in low and middle income countries. Another challenge faced in developing this review was in maintaining a balanced approach between identifying health-related information and communication needs and applying technology strategically as a tool versus the more traditional use of technology as a driver of change within the health sector. To address this dichotomous representation within the literature, we have presented both perspectives based on how they have been communicated within the literature. Where possible, the strategic application of technology as a tool within broader health sector objectives has been prioritized. Despite a growing body of knowledge related to mHealth in low and middle income countries, there is a critical learning gap in the availability of evaluation data for strategic planning at a large scale.

The study of mobile and wireless communication technology and health is a moving target, as the availability and accessibility to technology is constantly in flux. As such, this document ought to continue to be viewed as a living review that will be updated regularly based on newly documented initiatives and trends.

List of Acronyms

ART	Antiretroviral Therapy
AIDS	Acquired Immunodeficiency Syndrome
BCC	Behavior Change Communication
CSR	Corporate Social Responsibility
DHS	Demographic and Health Survey
DfID	Department for International Development (United Kingdom)
DOI	Digital Opportunity Initiative
F/OSS	Free and Open Source Software
GIS	Geographical Information System
HMIS	Health Management Information System
HIV	Human Immunodeficiency Virus
ICT	Information and Communication Technology
ITU	International Telecommunications Union
MDG	Millennium Development Goal
MARS	Mobile Anti-retroviral Support
MIT	Massachusetts Institute of Technology
MOH	Ministry of Health
NGO	Non-governmental Organization
NHS	National Health Service
NLM	National Library of Medicine
OHT	Open Health Tools
OMPT	One Media Player per Teacher
PAHO	Pan-American Health Organization
PDA	Personal Digital Assistant
PEPFAR	Presidential Emergency Plan for AIDS Relief
RESCUER	Rural Extended Services and Care for Ultimate Emergency

	Relief
SARI	Sustainable Access in Rural India
SMS	Short Message Service
TALC	Teaching Aids at Low Costs
TATRC	Telemedicine and Advanced Technology Research Center
TBA	Traditional Birth Attendant
TB	Tuberculosis
UNDP	United Nations Development Program
UNPAN	United Nations Public Administration Network
USAID	United States Agency for International Development
VGF	Vodafone Group Foundation
WHO	World Health Organization

Introduction

Health in Low and Middle Income Countries

Background

Over the course of the past 40 years, great efforts have been made to highlight and address critical public health problems throughout the world, particularly in low and middle income countries. The Declaration of Alma Ata in 1978 highlighted health as a "most important world-wide social good" (World Health Organization, 1978). The declaration introduced the concept of Primary Health Care, which has since formed the basis for health service delivery systems throughout the world (World Health Organization, 1978). More recently, the Millennium Development Goals (MDG) were developed to provide macro level targets towards which the broad range of development and health stakeholders can aim interventions. In keeping with the WHO definition for health as "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity," (World Health Organization, 1946) almost all of the MDGs have some association with health. This series of output and outcome targets include those associated with poverty reduction, education, and technology.

The Millennium Development Goals

The **MDG**s that specifically address health as set forth by the United Nations *Millennium Declaration* in 2000 include (United Nations, 2000):

- Reducing child mortality
- Improving maternal health
- Combating HIV and AIDS, malaria, and other diseases
- Increasing access to safe drinking water

A progress report published in 2007 indicates that childhood immunization and deliveries by skilled birth attendants are on the rise, while many regions continue to struggle to achieve reductions in the prevalence of the diseases of poverty including malaria, HIV and AIDS and tuberculosis (TB) (United Nations, 2007).

Health Workforce

Increasing attention has also been drawn to the critical shortages in trained healthcare personnel throughout the world. There are now 57 countries

with critical shortages in health work force density with a global deficit of 2.4 million doctors, nurses, and midwives (World Health Organization, 2006). Investing in the training and ongoing development of the healthcare work force is considered among the most effective means of improving health (World Health Organization, 2006).

mHealth Review Overview

*The **purpose of this report** is to map what is known about a broad range of mobile and wireless technologies and the contributions that they are making towards achieving healthcare objectives in low and middle income countries.*

This report is divided into six sections:

Section 1 provides an overview of **mHealth** as a domain within **eHealth** and key strategic learning that ought to be applied to the formal integration of mobile technologies within the health sector.

Section 2 reviews health-related applications associated with mobile phones, PDAs, remote patient monitoring systems, MP3 players, and other mobile technologies.

Section 3 explores how various technologies are being used to achieve health objectives, including improved access to health services, health service delivery, disease surveillance and control, prevention and well-being, and human resources development. These are presented within the broader framework of WHO's eHealth priority action areas:

1) ICT for health promotion (and prevention)
2) ICT for human resources for health
3) ICT for service delivery

Section 4 documents key leaders and partnerships that have emerged to test and expand mHealth in low and middle income countries. The emergence of creative partnerships between governments, technology companies, telecommunications service providers, international donors, academic institutions, implementing partners, and health service providers is a significant feature of this movement. The need for such collaborative efforts cannot be overemphasized, particularly as efforts intensify to achieve the MDGs for health as well as to reduce the digital divide (Fontelo, 2007).

Section 5 provides critical considerations based on early mHealth initiatives and research. Such considerations include using health information and communication needs of various stakeholders as the starting point for identifying appropriate tools and technologies (Pakenham-Walsh, 2007), the rapidly changing environment of mHealth and the nature of mobile technologies (Istepanian, 2004) and the need to build on existing access to mobile communication technologies within the general population and health sector as well as informal usage patterns (Mechael, 2006).

Section 6 provides key recommendations for next steps in the area of mHealth.

This report draws heavily on the work of many pioneers who have developed innovative approaches to improving health care and making the health service delivery environment more efficient and effective. It is based on an intensive review of peer-reviewed literature, program evaluation and industry reports, and grey literature, as well as communication with a broad range of stakeholders. Drafts of this report have been shared with a committee of advisors whose feedback has been integrated and cited as appropriate.

Section 1.
mHealth: a critical domain within eHealth

eHealth Trends

Alongside endeavors to improve health outcomes are concerted efforts to reduce the digital divide, or differential access to technology of low, middle, and high income countries and of rich and poor within the same country. Regarding the digital divide, the world has witnessed significant increases in the numbers of internet users as well as mobile and fixed-line telephone subscribers in the past five years (Curioso, 2006; United Nations, 2006). It is at the cross section of health and technological domains that eHealth initiatives have evolved, creating an unprecedented opportunity to improve access to services and efficiency within the health sector in low and middle income countries.

eHealth

eHealth (or electronic health) is broadly defined by the World Heath Organization as the "use of information and communication technology for health" (World Health Organization, 2005b). The main objective of eHealth programs is to use Information and Communication Technology (ICT) to improve healthcare service delivery and health outcomes through the strategic use of technologies such as computers, Internet, satellite receivers, mobile phones, and Personal Digital Assistants (PDA). The increasing availability of free and open source software (F/OSS) will more affordably extend the benefits of a broad range of higher quality targeted eHealth solutions to low and middle income countries (Lacal, 2007). In addition the expansion and enhancement of wireless networks throughout low and middle income countries will increase access and capabilities of these technologies to healthcare providers and the general public in more remote geographical locations.

Uses of eHealth

eHealth has great potential to promote healthy lifestyles, improve decisions by health professionals as well as patients, and enhance healthcare quality by improving access to medical and health information and facilitating instantaneous communication in places where this was not previously

possible (Shields, Chetley, & Davis, 2005; World Health Organization, 2005b). The increased use of technology can help reduce health care costs by improving efficiencies in the health care system and promoting prevention through behavior change communication (BCC). It also has the potential to advance clinical care and public health services by facilitating health professional practice and communication and reducing health disparities by applying new approaches to improve the health of isolated populations.

The initial focus of many eHealth initiatives has been the use of the Internet to promote the organization of and access to health-related information. For the health sector the key areas of benefit include the development of Health Information Systems (HIS), Knowledge Management, Electronic Patient Health Records, open access to electronic medical journals, and eLearning and training for health care professionals. As of May 2008, the overall penetration of Internet users within the global population was 21.2%, ranging from 5.3% in Africa to 14.0% in Asia to 23.8% in Latin America and 73.4% in North America[1]. The emergence of internet cafes and kiosks in low and middle income countries extends the benefits of e-mail and the world wide web to a larger audience.

More recently there has been a growing interest within the health sector to capitalize on the rapid uptake of mobile communication technologies and the overall improvements in telecommunications within the general population throughout the world. Characterized as a 'leapfrog technology,' mobile phones have allowed developing countries, even those with relatively poor infrastructure, to bypass fixed-line technology (Economist, 2008).

Data illustrating these trends are increasingly becoming available on ICT usage in Africa. The International Telecommunications Union published Africa ICT Indicators for 2007, detailing usage of fixed-line telephone, mobile, and Internet users by country.[2] The number of mobile users worldwide by the end of 2007 was 3.3 billion with a penetration rate of 49 percent.[3] The report also indicates that between 2005 and 2007, Africa added over 60 million new mobile subscribers, with mobile phones comprising about 90 percent of all telephone subscribers and mobile

[1] http://www.internetworldstats.com/stats.htm
[2] http://www.itu.int/ITU-D/ict/statistics/at_glance/af_ictindicators_2007.html
[3] http://www.cellular-news.com/story/31352.php

penetration is close to 30 percent.[4] According to MIT's Entrepreneurial Programming and Research on Mobiles Unit, Africa's cell phone usage has increased 65% per year for the past five years from approximately 63 million users in 2004 to 152 million in 2006 (Haynes, 2008).

The cost of mobile technology deployment is rapidly decreasing (Domingo, 2007). In addition, increasing functionality of newer phones enables SmartPhone-capability in relatively inexpensive phones (Domingo, 2007). The capabilities of mobile phones in low and middle income countries has not reached the sophistication of those in high income countries, which now enable web browsing, GPS navigation, and e-mail access. In spite of these differentials, the basic SMS text functions and real-time communication capacity of devices available in low and middle income countries offer a broad range of potential benefits to the health sector (Mechael, 2006). Increased availability and efficiency in both voice and data-transfer systems in addition to rapid deployment of wireless infrastructure will likely accelerate the deployment of mobile-enabled health systems and services throughout the world (Istepanian, 2004).

WHO eHealth Priorities

In 2005, at its 58th session, the World Health Assembly adopted a resolution that established an eHealth strategy for the World Health Organization (WHO). To implement its formal program on eHealth, the WHO created the Global Observatory for eHealth (World Health Organization, 2005b). The role of the Global Observatory for eHealth is to provide evidence-based guidance to countries and institutions involved in healthcare programs about the broad range of eHealth activities that are being implemented throughout the world and what is working and/or not working (Kwankam, 2007). The Observatory serves as a convener to enhance strategic thinking and guidance in various aspects of eHealth. It is one of several WHO initiatives developed to support the implementation of the World Health Assembly resolution.

As a first step, the observatory has conducted a world wide survey to obtain a baseline on eHealth activities in member countries (World Health Organization, 2005a). Key steps are being taken within this effort to promote the monitoring and evaluation of eHealth services for more

[4] http://www.itu.int/ITU-D/ict/publications/africa/2008/index.html

strategic decision-making. At the national and district levels, WHO promotes an approach that first looks at basic needs within the healthcare system and how appropriately and effectively ICTs can be used as tools to contribute to addressing them. It is the intention to view the use of technological solutions in relation to how their application can more effectively impact key MDG indicators including childhood and maternal mortality as well as healthcare worker density (Kwankam, 2007).

In an effort to better understand and document global technology trends, the WHO in collaboration with the European Union published Connecting for Health: Global Vision, Local Insight: Country Profiles 2006. This report, prepared for the World Summit on the Information Society, documents demographic, health, and ICT diffusion indices for over 190 countries (World Health Organization, 2006). This resource can be used by policy makers, technology companies, and health administrators as a guide to rank on which ICT to focus to address priority healthcare concerns. With the growing interest at the end of 2006 in mobile telemedicine and the use of mobile phones and other mobile communication technologies within the health sector, the WHO program has begun exploring the development of a mobile e-health or **m*Health*** strategy. As a first step towards the development of a strategy, WHO commissioned this mHealth Review in 2007. It has since been updated for the Earth Institute at Columbia University in 2008, to further document what is being done within this field as it specifically relates to low and middle income countries.

mHealth Trends

What is mHealth?
mHealth broadly encompasses the use of mobile telecommunication and multimedia technologies as they are integrated within increasingly mobile and wireless health care delivery systems (Istepanian & Lacal, 2003). It can be defined as "mobile computing, medical sensor, and communications technologies for health care" (Istepanian, 2004).

mHealth and eHealth

The WHO's report entitled, eHealth Tools and Services: Needs of Member States (2006), highlights many of the eHealth needs in low and middle income countries many of which also apply to mHealth. This review by

WHO is a direct contribution towards the proposed actions set forth in the report, namely: facilitating knowledge exchange and providing eHealth information (World Health Organization, 2005b). Of direct relevance to mHealth are increasing trends towards migrating many of the pre-existing eHealth systems onto mobile platforms. For example, many disease surveillance systems are increasingly becoming a combined system of computer databases, PDAs, and mobile phones networked towards monitoring and managing disease outbreaks (Rubio, 2007).

Mobile technologies and the future

Mobile communication technologies are tools that can be leveraged to support existing workflows within each of the areas specified above. There is much learning from eHealth that provides a critical lens through which to review existing technological trends and applications. First, mobile technologies are not objectives, but tools, that ought to be applied in ways to achieve local, national, and regional health objectives (Shields, Chetley, & Davis, 2005) as well as contribute to improving the lives of individuals (SatelLife, 2005). Second, there is insufficient impact data about how mobile technologies are influencing health outcomes, creating challenges to identify and replicate best practices (Kaplan, 2007; Shields, Chetley, & Davis, 2005). Impact evaluation is necessary to move beyond discussions of the potential impact that such technological solutions might have and anecdotal examples of how they are already being used for health. Third, mobile technologies are only as good as the information and communication to which they provide access (Shields, Chetley, & Davis, 2005). Access to reliable and relevant content at the right time is a critical consideration within both e- and mHealth (Pakenham-Walsh, 2007). And finally, there is a need to move away from pilot programs and case studies to more formal application and learning to set the foundation for national programs and policies (Shields, Chetley, & Davis, 2005).[5]

mHealth focus areas

Emerging trends of interest within mHealth include the use of mobile technologies in the following capacities:

[5] A comprehensive knowledge map of ICT and Health developed by the World Bank's InfoDev Program includes a limited number of case studies documenting the use of mobile technologies within the health sector (www.asksource.info/res_library/ict.htm). As appropriate these have been incorporated into this review.

Emergency response systems (road traffic accidents, emergency obstetric care, etc.)
Disease surveillance and control (Malaria, HIV/AIDS, TB, Avian Flu, chronic diseases- esp. diabetes)
Human resources coordination, management, and supervision
Synchronous and asynchronous mobile telemedicine diagnostic and decision support for clinicians at point-of-care
Remote patient monitoring and clinical care
Health extension services, health promotion, and community mobilization
Health services monitoring and reporting
Health-related m-learning for the general public
Training and continuing professional development for health care workers

Section 2.

Review of Technologies & Technological Capabilities

Over the past ten years, mobile communication technologies have entered the mainstream in high, middle, and low income countries in unprecedented and unanticipated ways. Peer-reviewed journal articles, case studies, news articles, and reports are now beginning to provide insight into the health-related benefits that are being derived (Curioso, 2006; Donner, 2004; Economist, 2005; Istepanian, 2004; Istepanian & Lacal, 2003; Johnson, 2008; Kaplan, 2006; Lacal, 2003; Mechael, 2006; Micevska, 2005; Wireless Healthcare, 2005). What remains lacking, however, is a systematic evaluation of such technologies and their effect on the overall delivery of healthcare (Fontelo, 2007).

As such, key mobile communication technologies under review in this report include:

I. Mobile phones
II. PDAs and smart phones
III. Patient monitoring devices
IV. Mobile telemedicine/telecare devices
V. MP3 players for mLearning
VI. Mobile Computing

A Technological Ecosystem

It is critical to view such technologies within an ecosystem of interoperable and functional components aimed at addressing key health technology objectives. Strategic planning and development processes should begin by identifying health priorities and then exploring potential technological solutions that can be tailored to work flow and achieving specific needs. Efforts to benefit from existing open source solutions are optimal for

achieving economies of scale, interoperability, as well as long term optimization and expansion support.

Broad Technological Capabilities

Before discussing the potential of these technology groups, it is important to highlight the main capabilities provided, namely voice and data access:

Voice is usually personal two-way communication, although automated systems may provide voice-recorded information.

Data access is primarily focused on visualizing static text but can also extend to interactive decision support algorithms, other visual image information, and also communication capabilities through the integration of e-mail and SMS features.

GIS and **GPS** integration with mobile technologies adds a geographical mapping component that is able to "tag" voice and data communication to a particular location or series of locations.

These combined capabilities have been used for emergency health services as well as for disease surveillance, health facilities and services mapping, and other health-related data collection.

I. Mobile phones

Uses of Mobile Phones

Generally studies that explore mobile phones and health have focused on their role in supporting a direct healthcare intervention (Kaplan, 2006) or as the cause of unsafe driving behaviors and emitters of potentially harmful radiation (Agar, 2003). Since 2005, scattered case studies and anecdotal examples documented in the literature on the use of text messaging for health, mobile diagnostic and decision support, disease surveillance and control, and mobile phones to address emergencies and chronic illness have emerged. A comprehensive wireless industry report divides this list into 101 explicit health-related activities, highlighting many of the opportunities becoming available within the health sector to maximize increased access to the technology (Wireless Healthcare, 2005). Within the context of such documentation, there is very little evidence on the health outcomes related to the direct application of mobile phones to support health objectives (Kaplan, 2006; Vodafone, 2006).

A Dearth of Mobile Phone Impact Studies

According to a Vodafone Policy Paper, mobile phone and health studies have been recent and largely focused on the "potential" benefits of the technology within the health sector and on their use in developed, rather than developing countries (Vodafone, 2006). Many of the existing studies look at the voice and text functions as contributing to improved access and efficiency within health care as well as the means by which young people can access confidential health-related information (Vodafone, 2006). As observed in other reviews, many of the examples of applications are in the pilot stage and have yet to be implemented or evaluated on a significant scale.

Mobile Phones as Direct Health Interventions

In 2006, a review explored studies, primarily in developed countries, that looked at direct interventions in which mobile and fixed-line telephones phones were used to address health conditions such as diabetes (patient blood sugar level monitoring), breast cancer (telephone counseling), tuberculosis (adherence to medication), treatment compliance for a variety of conditions, attendance at health facility appointments, depression outcomes, immunization rates, asthma management, and smoking

cessation (Kaplan, 2006). The review specifically explored the use of mobile phones for the "express purpose of supporting or altering one or more health outcomes" (Kaplan, 2006). Through an intensive web-based and library search, the author documented and compiled the results of evaluations of intervention studies of fixed-line and mobile telephone applications to address specific health care issues in developing countries.

The limited studies that were found were primarily small pilot projects which offer mixed results in terms of demonstrating the potential that fixed-line and mobile phones have to serve as a support for more effective delivery of healthcare services (Kaplan, 2006). Functional and structural properties of mobile phones namely low start-up cost, text messaging, and flexible payment plans, make them attractive to use as a healthcare intervention (Kaplan 2006). With the development of standardized health-related software applications, mobile phones can provide real-time feedback and pre-programmed portable automated services that enable support to increasingly decentralized health systems (Lacal, 2003; Mechael 2006).

Text Messaging for Health

The primary feature of mobile phones that has been most significantly documented in the context of health is text messaging, although there are very few empirical studies that have been published or otherwise made publicly available on the subject.

Text messaging via mobile phones has garnered increasing attention as a means of reminding patients of appointments in the United Kingdom, United States, Norway, and Sweden (The Economist, 2006). The results were a lowering of non-attendance to scheduled appointments, yielding significant savings in health costs for facilities and practitioners. In this case the benefit is cost-related rather than health outcome related. Studies highlight the potential of mobile phones to disseminate public health information and mobilize attendance to vaccination programs particularly in developing countries as well as to manage the treatment of diabetes in Scotland (The Economist, 2006). Recently, the Patient Care Messaging Service for Pharmacies provided by iPLATO has been implemented in London pharmacies, using texts to verify patients' smoking status and invite them to take part in smoking cessation services and follow-up treatment.[6]

[6] http://www.bjhcim.co.uk/news/2008/n807039.htm

Other health-related SMS-based systems are currently being implemented throughout low and middle income countries. In 2007, a program of text message reminders was being designed with a large teaching hospital in Johannesburg in an effort to make more efficient use of overworked health care workers (Praekelt Foundation, 2007, personal communication). SMS-text messaging has also been highlighted as a preferred means of communication for mobilizing support and communicating during emergency and disaster situations (GSM Association, 2005). FrontlineSMS has developed a system using mass texting for surveys and community mobilization, which is free for NGOs.[7]

Mobile Phones and Health Sector Strengthening

Apart from the use of mobile phones within a broader technological solution or as a stand alone intervention is the need to examine the national progression of mobile phone use by the health sector as well as the general public's access to health services and information.

An empirical study of health-related uses of mobile phones in Egypt, a low middle income country, explored how the general public along with the health sector was benefiting from mobile phones in 2002-2003 (Mechael, 2006). The findings of the study included that with no external stimulus, mobile phones are improving access to and coordination of both emergency and routine health services as well as contributing to overall family well-being (Mechael, 2006).

The study also identified key considerations that must be overcome in order to maximize their use within the health sector, namely 1) cost, 2) risk perceptions, 3) reliability of telephone systems in health facilities, 4) safety, liability, and cost recovery for unknown contacts as well as information and services provided at a distance, 5) lack of understanding and use of range of functions available through mobile phones, and 6) poor quality of health services (Mechael, 2006). Two key recommendations from the study were that mHeatlh intiatives ought to help formalize and standardize positive informal mobile phone and health activities and build support systems to maximize their benefits. For example, the necessary creation of health directories and call-in centers would enable faster and more directed consultation support for the general public and health professionals (Mechael, 2006).

[7] www.frontlineSMS.com

II. Personal Digital Assistants (PDA) and Smart Phones

General Uses of PDAs

PDAs, particularly in their hybrid combination with mobile phones, have become a platform for data collection, processing, and communication (Istepanian, 2004). They are perceived to be portable, durable, powerful and relatively easy to use with a short learning period for database managers and healthcare providers (SatelLife, 2005). They also enable access to information, such as diagnostic support guidelines and treatment protocols as well as provide a means of rapid data transfer (SatelLife, 2005).

Use of PDAs in Low and Middle Income Countries

Low and middle income countries are making advances in the use of PDAs and Geographical Information Systems (GIS) for data collection, consolidation, and reporting as well as disease surveillance and control (Shields, Chetley, & Davis, 2005). The Demographic and Health Surveys (DHS), as coordinated by Macro International, rely heavily on the use of PDAs for data collection.[8] The work of SatelLife to document its experiences in Ghana, Kenya, and Uganda in this area provides key opportunities for learning and scale-up (Bridges.org, 2003; SatelLife, 2005). Polio and Avian Flu surveillance programs use a combination of mobile phones and PDAs to monitor and report cases as well as to coordinate public messaging campaigns to notify citizens of potential risks (Chetley, 2006; Crampton, 2007).

PDAs for Clinical and Health Worker Support

A study of the degree to which PDA-based clinical reference information such as formularies, clinical databases and algorithmic diagnosis decision support software can assist clinicians at the point-of-care in remote parts of low and middle income countries is in preparation. Comparing cost effectiveness over the long-term and actual use to influence decision-making in comparison to traditional print resources is planned in Kenya (Dahlman, 2007). Apart from qualitative impressions, it is difficult to ascertain how the use of PDAs is contributing to improved health outcomes especially in these low and middle income county settings where patient follow-up is difficult (Bridges.org, 2003; SatelLife, 2005).

[8] http://www.orcmacro.com/Information/DataColl/mobile.aspx

Smart phones are also being used to provide bedside support (point-of-contact) for clinicians in many high income countries, through access to web-based information resources and patient data. One study conducted at Prince George Hospital in Maryland, USA showed that availability of reliable updated information from reliable web-based sources through smart phones improved evidence-based practice particularly for community hospitals and ambulatory clinics without wireless networks (Leon, Fontelo, Green, Ackerman, & Lui, 2007). This will likely have implications for the use of such technologies in low and middle income countries in the future.

III. Mobile telemedicine devices and patient monitoring systems

Uses of Mobile Telemedicine Devices and Patient Monitoring Systems

Mobile telemedicine devices have mostly been deployed in high income countries. These devices and systems have been developed as stand alone technologies that use wired and wireless telecommunications infrastructure to transmit patient information or are integrated as an add-on to mobile phones. It is perceived that sensor-aided telemedicine devices will generate significant cost savings for the health sector by reducing the number of patient visits to health facilities and enhancing detection of causes for action. As such the "patient becomes the point of care, not the doctor or the hospital" (Fuscaldo, 2004). There are now devices that enable self-measurement and monitoring/diagnosis of blood pressure (hypertension), lung function through a spirometer (respiratory disease) and controlled treatment through an inhaler, exercise and fitness, mobile ECG, among others. In addition to those mentioned earlier, such systems have also been developed by IBM, Ericsson Mobile, and Qualcomm. Self monitoring for patients offers higher autonomy, security, and control over their own health (Lacal, 2003).

Mobile Telemedicine Devices in Low and Middle Income Countries

For low and middle income countries, many of these sorts of solutions will likely become available in urban centers. Additionally, given demographic trends of an aging global population, these devices show promise for the extended care of the elderly (Lacal, 2003). By contrast, rural areas, where infectious disease priorities persist and human resources are limited, will require more basic technological solutions, such as voice-based teleconsultation between healthcare providers and citizens (Mechael, 2006).

Implementing Mobile Telemonitoring Programs

The question of whether there is sufficient 'evidence' to implement telehealth programs is frequently asked. An article published by Continua, an American telehealth and medical device consortium suggests that there is a critical need to move beyond the evidence question, towards devising successful telehealth business models and implementing programs. It cites results from an internal study on a home telemonitoring program for

congestive heart failure, completed by one of the largest health plans and health services provider in the United States. Results show drops in doctors' office visits, emergency room visits, inpatient admissions and inpatient length of stay, all of which imply a decreased cost burden on the American health system (Ayyagari, 2008).

IV. MP3 players and data storage devices

General Uses of MP3 players and data storage devices

Within discussions of mobile technologies and health, the newest technology to come under review for its potential to promote health objectives is the MP3 player. MP3 players are able to carry and organize large amounts of audible content, whether in the form of music or speech to large groups of people through the use of speakers and/or widespread distribution to individuals. So far, there are limited studies as to the changes in behavior that one observes when using MP3 players for mass communication.

MP3 players and data storage devices for mLearning

There is a growing trend in universities and schools to use iPods to deliver lectures and podcasts as part of the educational process (Carmichael, 2007), an approach which could easily be used to deliver health information. An innovative use of iPods to teach medical cardiology students how to identify various types of murmurs was recently launched at Temple University (Carmichael, 2007). Along with educating medical professionals, ipods may serve to educate patients as well. A cardiovascular surgeon at the Arizona Heart Institute is using iPods to educate his patients about diet, exercise, and basic anatomy and surgical procedures.[9]

MP3 players and data storage devices in low and middle income countries

Similarly to trends in high income countries, low and middle income countries may also begin to embrace MP3 players and iPod-like devices to enhance learning among health care workers in a more decentralized portable manner that enables both audio and video capabilities (Chetley, 2006). The organization One Media Player per Teacher (OMPT) specializes in providing iPods and low cost portable media players to resource-poor settings. As a means of improving access to education in remote and war-torn settings, their goal is to equip ten million teachers with portable media players in support of the MDGs. OMPT has supplied US$100 portable media players in Southern Sudan and Haiti.[10] Such

[9] http://www.nursezone.com/Nursing-News-Events/media-library.aspx
[10] http://www.ompt.org/

targeted provision of media players in low-income countries could be specifically deployed to train community health workers to recognize signs of severe illness, educate patients about management of chronic illness and communicable diseases, and prevent sexually transmitted illnesses.

V. Mobile computing and Convergence of Technologies

Mobile Software and Hardware Development

While eHealth symbolizes the future of health, and especially health care, its future lies in divergent technologies and ubiquitous technology systems. Increasingly, mobile communication technologies can run a rapidly increasing range of software applications (Lacal, 2003). Mobile software development is booming, particularly in high and middle income countries where the Windows Mobile Platform and Open Source are enabling smart phones (mobile phone and PDA hybrids) to provide basic computer functions while in motion (Iluyemi, 2007). Software development is also on the rise in low income countries. A recent *New York Times* article illustrated the proliferation of mobile software development in Nairobi, citing both opportunities for digital innovation and challenges for local developers. Such challenges include slow and expensive internet connections, power failures, and the lack of technical educational resources. These local mobile software applications, however, tend to consist of more basic code, which is ideal for mobile and wireless platforms, particularly for use in low and middle income countries (Zachary, 2008).

Hardware ranges from laptops to tablets to smartphones as well as specialized health-specific computing devices. Such systems will likely be tailored to suit an individual's needs and lifestyle through the combined integration of wireless technologies envisioned through third (3G) and fourth generation (4G) systems, making it easier to interactively acquire medical advice and information when and where one wants it (Istepanian, 2004).

The rapid growth of wide-ranging mobile health software applications is exemplified by the comprehensive United Nations Public Administration Network (UNPAN) report of Mobile Applications on Health and Learning, compiled in 2007 as part of UNPAN's Compendium of ICT Applications on Electronic Government. The review provides a technical summary of mHealth software applications while addressing impact where applicable. The Compendium organizes applications by geographic region and mHealth sector; that is, Mobile Health (health administration, health care delivery systems, health information, patient care) as well as Mobile Learning (instructional process, learning products, organizational training and informal learning, school administration) (UNPAN, 2007).

Ubiquitous Computing

Rather than computers as distinct entities, ubiquitous computing will embed computation into the environment and everyday objects. These include wearable devices that can signal to both the individual as well as a healthcare provider that a significant change in key indicators has occurred (Istepanian, 2004). In the future, ubiquitous computing will permit people to move around and interact with information even more easily and organically than they currently do. Short-range mobile transceivers embedded into various devices with increasing processing capability will permit communication between people and devices, and between devices (including medical devices) themselves, thus bringing the dream of health care for everyone, *wherever they may be,* a little closer. Many of the early examples in this area are from high income countries, but will likely transfer over time to low and middle income countries. Barriers in low and middle income countries will likely be their cost as well as competing infectious disease priorities.

Convergence of Technologies

There is no one solution that is available everywhere, and health administrators and technology developers have started combining different technologies in different environments:

Cell-Life – South Africa – A Convergence of Technologies

In South Africa there is a serious bottleneck in treatment of HIV and AIDS due to shortage of qualified pharmacists. This means that rural clinics cannot distribute medication. Cell-Life developed a system that combines a cell-phone, the internet and computers at various stages to allow the pharmacist (who is usually at a better equipped clinic) to package drugs for a rural clinic (which doesn't have a pharmacist) and then a driver takes the package to the clinic (Rivett, 2007). When the package leaves the pharmacy the package is equipped with a barcode that relates to the patient, the drugs and the clinic. The package is "signed out" and on the computer system of the pharmacist has an "in transit" message (Rivett, 2007). Once the package arrives in the clinic the nurse scans the package using a wireless scanner (in the scanner is a SIMcard that allows data transfer through the GSM network). Once the package is scanned in, an "arrived at clinic" message can be seen on the pharmacist system (Rivett, 2007). When the patient comes to collect it, it is signed out again and the status reads, "package collected by patient". The pharmacist now knows that the package has gone to the patient, and can start preparing the next month's supply (Rivett, 2007).

Section 3.
mHealth Applications and WHO's eHealth Mandate

In order to provide coherence to how mHealth can and is already contributing to the mandate of WHO, the following section and accompanying appendices highlight various case studies of the use of mobile communication technologies for:

1. Health promotion
2. Supporting the health work force
3. Enhancing service delivery

The area of **health promotion** includes the prevention of disease and adverse health conditions in an effort to preserve individual well-being. It also includes an individual's efforts to go from a state of illness to wellness.

The area of **supporting the health work force** includes enhancing the capacity of health care workers to more effectively perform their duties, including improving their access to health information.

Enhancing service delivery takes a systems perspective, which includes emergency response systems, health service coordination, delivery, and administration as well as improving access to services for individuals.

For further case studies, please refer to Appendix Tables 1-6:
Table 1. Treatment Compliance
Table 2. Health Worker Support and Mobile Telemedicine
Table 3. HIV/AIDS Prevention and Treatment
Table 4. Disease Surveillance
Table 5. Health and Wellbeing Promotion through Targeted Media
Table 6. Emergency Medical Services

1. mHealth for Health Promotion

The use of mobile communication technologies for health promotion can be explored from two broad angles:

- Increased demand for health services with improved access to telecommunications
- The direct application of mobile technologies by the health sector for the purpose of health promotion

mHealth and Increased demand for health services

Several studies specifically exploring linkages between the general public and the health sector in Bangladesh, Laos, and Egypt have illustrated that improved telecommunications with the introduction of mobile phones is leading to a more direct link between clients and healthcare workers as well as a perceived increase in demand for health services and health-related information (Mechael, 2006; Micevska, 2005).

Access to telecommunications extends benefits beyond individual households with shared uses often associated with accessing emergency-related information and transportation (Mechael, 2006; Micevska, 2005). These trends will likely intensify as more individuals and households avail themselves of mobile and fixed-line telephone services.

Mobile communications for Safety and Security

Increasingly, mobile phones are carried and domesticated as part of an individual's desire to preserve and maintain safety and security (Agar, 2003), becoming a part of the social image of the technology (Agar, 2003; Ling, 2004). Safety and security are two aspects of mobile phone use that are gaining increased attention in low and middle income countries with growing numbers of mobile phone users (Mechael, 2006). They have become a lifeline for many and are carried "just in case" of emergency (Ling, 2004). Special studies are currently underway regarding their use in natural disasters such as earthquakes and floods as well as in "extraordinary situations" such as terrorist attacks (Ling, 2004). With respect to the management of chronic health conditions, mobile phones are used to coordinate routine health care as well as emergency care, enabling increased mobility particularly among individuals with disabilities (Ling,

2004). As documented by a number of mobile phone researchers, the elderly are more able to communicate instantaneously with their children as well as health care professionals for guidance on their health than they were prior to having a mobile phone (Agar, 2003; Haddon, 2004; Ling, 2004).

Mobile Communications and Improved Livelihoods

There are also a number of socially determined health-related benefits cited in the literature regarding improved access to telecommunications, namely mobile phones (Chetley, 2006; Donner, 2005; Mechael, 2006). A key example is the work of the Village Phone Program initiated by the Grameen Bank in Bangladesh in 2001, which is now being replicated in Uganda and other countries (Chetley, 2006). The program provides mobile phones to women to sell airtime to the local community. The effects are improved economic conditions for participating households as well as improved access to telecommunications for access to health care providers and information (Chetley, 2006). These changes are creating economic opportunities that in turn have the potential to yield improved access to health information and services as well as improved quality of life and enhanced well-being.

A health-related extension of this program, called the Grameen Healthline,[11] was launched in November 2005 in Bangladesh. The system provides a number to the general public, which connects them to a registered physician who provides advice and referrals for emergency as well as routine health conditions. In 2007, the program was recognized by the GSM Association for its innovative use of mobile phones. As of October 2007, the program was providing medical advice to approximately 10,000 callers per day.[12]

Disease Surveillance and Control

Improved communication along with enforcement within epidemiological investigation and disease control has the potential to reduce the risk of exposure within the general public to outbreaks of Avian Flu and other infectious diseases. In such cases, health administrators are using a combination of fixed and mobile telephone systems within an investigation

[11] http://www.grameenphone.com/index.php?id=106
[12] http://www.grameenphone.com/index.php?id=330

team to identify the source of an outbreak, develop a response plan, mobilize the necessary action to be taken, and ensure enforcement of protective measures. Also, individual physicians receiving such cases can more quickly detect patterns and report such occurrences to local administrators.

Health and wellbeing promotion through targeted media

There are a growing number of anecdotal examples of general public and smaller target group campaigns that are using SMS to encourage young people to adopt positive sexual and reproductive health practices, particularly as part of broader HIV prevention programs. One such initiative is that of the STAR programme implemented by Hivos in collaboration with the Dutch telecom provider KPN, a capacity building initiative in East and Southern Africa that uses SMS to complement other HIV and AIDS outreach activities for young people. The system aims to increase awareness among young people, and the pilot program is showing improvements in interactivity among partner organizations and their constituents (Hivos, 2005).

There are significant opportunities for mass and targeted communication using SMS and pre-recorded voice messaging. These can be delivered to a specific group that has registered for such a service or through general public mass media campaigns. As a central part of its work, Media Lab Asia, an organization focusing exclusively on bringing the benefits of ICTs to the disadvantaged, uses mobile devises for "multimedia, local language and local content based health education and promotion" activities (Ramaraju, 2007). Mass texting can serve the dual purpose of prevention and emergency response in promoting well-being. As part of Cell-life's work in South Africa, an anti-xenophobia campaign was launched as a result of violence against foreigners. The aim of the texting scheme was to voice opposition to the violence, provide a method of reporting incidents, and to mobilize organizational and community responses.[13]

[13] http://mobileactive.org/say-no-xenophobia-cell-phones-against-south-africa-violence

2. mHealth for Supporting the Health Work Force

Mobile Telemedicine

Telemedicine/telehealth*,* has been defined by the World Health Organization as the use of ICT for the support of or the direct provision of health care, particularly where distance and locally available expertise is a critical factor (World Health Organization, 2005b). The term ***telehealth*** is increasingly being used as a replacement for ***telemedicine***, since it suggests a broader use of telecommunications technologies and applications as the focus of programs moves beyond health facilities to the care and monitoring of the elderly at home (*telecare*) (Klecun-Dabrowska & Cornford, 2001). In *telehealth* and the more widely understood *telemedicine*, health care professionals use information and communications technologies to exchange information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of health care providers. Much of the literature regarding telemedicine focuses on the use of e-mail and the Internet as the instrument of communication for support in diagnostic and treatment decision-making. The primary benefits of such programs include cost and time savings, mostly by reducing the number of patient to health facility visits for home based *telecare* as well as reducing transportation costs and medical fees associated with a physical consultation with a specialist.

One important category of *telehealth* is ***telenursing*****,** the use of telemedicine to carry out nursing care. The International Council for Nurses published its International Competencies for Telenursing, which integrates an in depth review of telenursing literature and the results of the 2004 telenursing survey to formulate telenursing competencies. The report emphasizes the need for broad telenursing guidelines and education, particularly in the areas of professional, ethical and legal practice, care provision and management, and professional development (Schlachta-Fairchild, 2007). The field of telenursing has the potential to inform telemedicine in low and middle income countries, where there is a significant shortage of physicians.

Telemedicine competencies

Such general competencies can be extended to the wider practice of telemedicine. A Model For Telephonic Medical Consults written by the Former United States Secretary of Health and Human Services outlines

possible guidelines and benefits of implementing telemedicine programs in the United States. These include lowered health costs through less hospital visits, along with decreased work absenteeism from medical appointments, transparent pricing schemes and incentives for physicians, as well as culturally competent care through the use of multi-lingual help lines (Thompson, 2008)

Specialized Telemedicine

Specialized telemedicine programs like teledermatology and teleophtalmology are gaining prominence within mHealth. A feasibility study of a teledermatology wound care system reported high acceptance rates for patients, nurses, and wound care experts. The system included an initial outpatient visit with follow up care accomplished through descriptions and digital photos sent via the web. Though this system was web-based, it showed that 89% of the images were high enough quality for providers to feel confident in making treatment recommendations (Binder, 2007). Such an image-based system could be transferred to a mobile platform, especially with the assistance of high-resolution attachments. They might also be modified for use with community health workers or family members who are attending to the wounds of their loved ones. In Tamil Nadu State in India, the Sustainable Access in Rural India (SARI) Program is providing wireless internet access to 8000 people in 50 villages. A sub-initiative has been developed in partnership with the Aravind Eye Hospital to provide on-line eye consultations (Chetley, 2006). Digital images along with symptom descriptions are transmitted by staff at a local internet kiosk to the hospital and a preliminary diagnosis and either treatment or referral recommendations are provided (Chetley, 2006).

Examples regarding telemedicine in developing countries traditionally focused on the use of technology to establish linkages between health professionals in more Westernized countries, such as England and France, and Africa for the treatment of a broad range of diseases. Increasingly, examples of telemedicine initiatives between urban and rural health care providers as well as facilities-based health care providers and patients at home are emerging from countries such as India, Pakistan, Russia, and Poland (Med-e-Tel, 2006). In Latin America, MedNET aims to connect rural regions in the Amazon with a medial network of physicians in urban areas.[14] As telehealth systems become more decentralized, mobile

[14] http://www.e-mednet.com/

communication technologies become more appropriate for the facilitation of decision support and referral systems. Within clinical care, mHealth has the potential to offer healthcare professionals interactive access to information such as patient history, laboratory results, diagnostic support, and treatment information at the point-of-care (where they are directly engaged with their patients) (Istepanian, 2004). There is also great anticipation within the health sector in low and middle income countries for mobile phones with high resolution cameras for mobile telemedicine.

mLearning and human capacity building

A key aspect requiring further documentation is the use of mobile communication technologies for mLearning and human capacity building within the health sector to address key shortfalls in medical education and training. Ongoing mLearning that promotes access to educational content reduces isolation of health workers and interactive post-graduate education experiences would be a welcome investment towards redressing many of the shortfalls within the healthcare work force. After two years of implementation by SatelLife of the Uganda Health Information Network, over 120 health facilities serving the needs of 100,000 people were able to access, send, and receive medical information through GSM configured PDAs (SatelLife, 2005). The application is a hybrid of mLearning as well as decision support for health care workers.

Health Work Force Support and Mobile Telemedicine - Ghana

Since January 2008, medical doctors in Ghana have enjoyed free calls while carrying out their duties. Courtesy of Onetouch, all registered members of the Ghana Medical Association receive free Onetouch starter packs, free doctor-to-doctor calls and SMS texting within Ghana, free physician directory assistance, and free bulk texting from the Ghana Medical Association and Ghana Health Service. The package aims to improve communication between health providers as well as improve the quality of healthcare by saving time, cutting communication costs, and allowing doctors to consult with one another more easily.

Challenges include some physician reluctance to seek advice from their colleagues as well as lack of awareness of the service. While the results of this program have yet to be assessed, this collaboration between local health authorities, physicians, and telecommunications companies serves as an important precedent in its aim to support the health work force. The program has logged approximately one million calls since its inception and has come to connect Ghana's 2,000 geographically isolated physicians who serve a population of 23-million.

Source: http://mobileactive.org/when-doctor-just-phone-call-away

3. mHealth for Enhanced Service Delivery

A key area where service delivery systems-level results are already being experienced through the application of mobile communication technologies for health is in the delivery of emergency healthcare and as well as remote patient monitoring. In emergency services the goal is to rescue life and reduce damage to patients. Based on a broad range of studies conducted in Europe, United States, Australia, and Egypt mobile phone subscribers have reported the utility of the technology in emergency situations (Chapman & Schofield, 1998; GSM Association, 2005; Horan & Schooley, 2002; Ling, 2004; Mechael, 2006).

The three aspects of emergency support that are directly related to health are: 1) responding to and recovering from natural and man-made disasters, 2) mobilizing ambulances and informal transportation to the scene of motor vehicle accidents and 3) addressing chronic medical conditions particularly among the elderly. In the case of accidents the respondents of empirical studies have reportedly been able to describe an emergency situation for which either they or someone that they knew used a mobile phone to mobilize support (Ling, 2004; Mechael, 2006). In addition for low and middle income countries that struggle with high maternal mortality rates, there are potential applications of the technology to addressing maternal and child health issues- namely obstetric emergencies (Mechael, 2005).

Apart from emergencies, there are additional case studies focused on specific health facilities integrating mobile technologies for service delivery as well as programs that focus on mobile support for the treatment of a particular disease. In Ethiopia, a prototype for a mobile medical system for hospitals has been developed based on an in-depth analysis of existing work flow patterns that uses mobile phones and PDAs to support the information and communication needs of healthcare providers (Kefale, Mekuria, & Bekele, 2006). Although this project is still in its early stages, the approach illustrates a positive trend towards the application of mHealth for enhanced health service delivery. Since 2001, Media Lab Asia has used mobile devices for generation of village GIS maps with health aspects to assist in the identification of health service gaps for better informed planning (Ramaraju, 2007).

mHealth and Emergency Response Systems

In December 2005, the GSM Association published The Role of Mobiles in Disasters and Emergencies. The report documents the use of mobile phones in emergency situations such as the Indian Ocean Tsunami, Hurricane Katrina, and terrorist attacks. A key lesson documented in the review highlights that text messaging is a more effective means of communication during emergency relief efforts as the messages are more likely to go through on overburdened cellular systems than a phone call (GSM Association, 2005). Other lessons included that mobile phones serve as early warning systems and their role in this capacity can be further strengthened. A key benefit of mobile phone based systems is that cellular networks are relatively resilient and easy to repair as part of stage one recovery processes (GSM Association, 2005). Timely access to communication and information is a vital aspect of response to and recovery from disaster situations (GSM Association, 2005). Systems applications for addressing emergencies are currently being implemented and explored. The organization Telecoms Sans Frontieres uses the improved telecommunications environment to set up communication systems as part of emergency relief efforts[15]. These include relief efforts for man-made, including conflict and war, situations, as well as natural disasters.

An analysis done in the United States and a related study conducted in Australia, explored the benefits within the health sector that come from improved access to telecommunications within the general population in relation to enhanced medical emergency responses. The analysis conducted in the United States documented the estimated increase in the number of wireless emergency calls from 1985 to 2001 and the reduction in time between fatal crashes and Emergency Medical Services notification (Horan & Schooley, 2002). In this analysis there was a positive correlation between increased access to wireless communications and time saved. The analysis also served to highlight an overall increased demand for Emergency Medical Services (Horan & Schooley, 2002). The study conducted in Australia explored similar improvements in the reporting of emergencies. The study showed that although the main focus of discussion around mobile phone use and health is in its negative effects in causing automobile accidents, it is in fact also contributing to improvements in responses to automotive emergencies (Chapman & Schofield, 1998).

[15] http://www.tsfi.org/tsfispip/?lang=en

The role of mobile phones in addressing road traffic accidents applies to high, middle, and low income countries alike; however, in countries with poor pre-existing telecommunications infrastructure, their benefits may be more dramatically experienced with the appropriate protocols for service coordination and delivery (Mechael, 2006). Related outcomes in the area of emergency response have been expressed in terms of fewer fatalities and complications, more efficient management of health personnel, and improvements in direct consultation between lay users and physicians as well as between physicians (telemedicine) (Mechael, 2006).

Section 4.
mHealth Partnerships

As new technologies are developed and deployed, it is paramount that both the business and public health communities understand the dynamic relationships evolving between the development of a particular technology and health. In order to ensure their value in poor countries, mobile communication technologies must be viewed as a production good rather than a consumer good (Kaul, 2001), which is often the case in rich countries. This means looking for ways in which people in poor countries can apply the technology more fully to achieve social goals and objectives, including those that "produce" better health.

Technology developers, predominantly in high income countries with the exception of India and South Africa, and users in rural communities in poor countries are two extremes within the ICT and global health network that enable a wide variety of health outcomes and efficiencies. The table below illustrates some of the key stakeholders involved in this ICT and global health network. For each member of the various network spheres there are internal and external interactions. Decisions made within one sphere have potential impacts on one or more of the other spheres. Depending on the technology in question the various actors may change and their roles fluctuate on an active-passive scale, resulting in a series of actions, reactions, and relationships (Michael, 2000). An example from Peru, illustrates the movements towards strategic partnerships that consider the needs and contributions of government, civil society organizations, health sector, and citizens (Murrugarra, Cannales, Tanner, Salizzoni, Lopez de Castilla, & Gildenston, 2007).

Sphere	Network Members
Industry (international, regional, district, local)	Investors, boards of directors, management, strategists, researchers, developers, sales, marketing, trainers, distributors, installation specialists, insurance companies, pharmaceutical and medical device companies
National Government and Policymakers	Ministries of Health, Trade, Communications, Transport, Education, Internal affairs, Foreign affairs; WHO, bi-lateral and multi-lateral donors
Local communities	Individual technology users in urban and rural communities, health care workers, employees of companies using ICTs, NGOs
Hardware and software applications	Mobile phones, accessories, computers, Internet, Global Positioning Systems, GIS, PDAs, MP3 players, Remote Monitoring Devices, etc.

Mobile communication technology and health network [adapted from (Mechael, 2006)]

Engaging Technology Developers

In direct relation to MDG Goal 8 Target 18, which states that "in collaboration with the private sector, make available the benefits of technology- especially information and communications," there is a call to explore strategic partnerships that maximize the social impact of ICT (United Nations, 2006). In many instances, industry giants are eager to share technological solutions in poor countries for telehealth and tele-education services as the mHealth commercial domain rapidly grows (Istepanian & Lacal, 2003). However, caution is encouraged that the design and deployment of solutions are driven by the needs of the health sector and in a way that is appropriate for the local environment (Mechael, 2007). Many mobile technology industry giants have made the strategic decision that adaptations and/or development of relevant software applications that yield health benefits would be a profitable investment, particularly in relation to developed country markets. However, there are now several companies that are extending this vision to include low and middle income countries.

"Corporate social responsibility" as well as Kofi Anan's "responsible globality" (Beard, 2000) are the "buzz words" for companies striving to have a positive social impact in order to maintain and expand their markets. The common goals and tensions between technology companies and those interested in their social impact must be identified and negotiated. An outgrowth of social responsibility, the social marketing of technology to the health sector, involves the direct marketing of ICT by service providers to the general public and the health sector with the proactive motivation of contributing to improved health outcomes. It also extends to the creation of health-specific software applications within those technologies that are rapidly spreading within the general public, namely mobile phones and smart phones.

In the movement towards enhanced Public and Private Partnerships, a mutual learning process between technology companies and the health sector is needed. This process would explore the potential for cost subsidies for health professionals along with the social marketing of hardware and health-specific software applications to the general public and health sector (Mechael, 2006). Such programs should be designed to more strategically use ICT as a tool for achieving existing health objectives. The issue of mobile software development will determine the availability

and development of appropriate low software for mobile devices. Big software players like Microsoft should be encouraged to release source code for development purposes, as well as provide technical support in adaptation, testing, and deployment of software applications (Iluyemi, 2007). The Continua Alliance[16], a technology and health alliance comprised of industry giants, should be encouraged to consciously incorporate developing countries agenda into their plans (Iluyemi, 2007).

Developing country interests should also be explicitly included in open source communities such as Open Health Tools (OHT), a collaborative effort between national health agencies, government-funded organizations and agencies, major healthcare providers, international standards organizations and companies from Australia, Canada, the United Kingdom and the United States to develop common interoperable healthcare IT products and services.[17] Another important open source community is OpenROSA, a consortium which aims to improve coordination among the many groups working on mobile data collections systems. By developing open source standards-based tools for mobile data collection and analysis, projects can become more mutable in order to facilitate the sharing of code, data, infrastructure, and ideas.[18]

Policy Makers, Academic Institutions, and NGOs

In order to test and scale up mHealth initiatives, working with a broad range of stakeholders will be critical. These include, but are not limited to National and District Level health and technology managers, policy-makers and donors, academic institutions, and NGOs and other implementing partners.

Some, but not all, policy makers and donors working to advance mHealth are the Danish International Development Agency (DANIDA), Department for International Development (DfID) in the UK, the International Telecommunications Union (ITU), Norwegian Agency for Development Cooperation (NORAD), Swedish International Development Agency (SIDA), United States Agency for International Development (USAID), United Nations Development Program (UNDP), United Nations Economic

[16] http://www.continuaalliance.org/home
[17] http://www.ehealthnews.eu/content/view/1072/26/
[18] www.openrosa.org

Commission for Africa (UNECA), United Nations Children's Fund (UNICEF), United Nations Fund for Population Activities (UNFPA), International Development Research Center (IDRC), World Bank's InfoDev Program, and the World Health Organization (WHO). Independent foundations are increasingly becoming active in supporting mHealth. These include the Bill and Melinda Gate Foundation, Kellogg Foundation, and Rockefeller Foundation. The GSM Association is an important stakeholder in the issues of infrastructure and devices[19]. Within the European Union Information Society Technology initiatives, there are also numerous mHealth applications already developed for both patients and health professionals that can be extended to low and middle income countries.

The Rockefeller Foundation has recently focused on eHealth, particularly promoting ICT use to improve the health of the poor. The foundation hosted a series of weeklong meetings from July 13 to August 8, 2008 at its Bellagio Center in Italy, "Making the eHealth Connection: Global, Partnerships, Local Solutions," with a week specifically focused on mHealth and mobile telemedicine.[1] The goal of the conference was to support eHealth initiatives through collaborative funding, design, and implementation of eHealth systems throughout the Global South. Background papers and presentations covered key themes such as the path to interoperability, public health informatics and national health information systems, health informatics and eHealth capacity building, access to health information and knowledge sharing, mHealth and mobile telemedicine, electronic health records, national eHealth policies, and unlocking eHealth markets.[20] The weeklong session on mHealth and mobile telemedicine, coordinated by the UN Foundation and Vodafone Group Foundation, set forth recommendations that have the potential to significantly advance the field of mHealth. These include the creation of an mHealth alliance as well as the incubation of four scalable mHealth systems; Commcare (a support tool for CHWs), mDoc (a mobile telemedicine clinical decision support system), BreakOut (a global disease surveillance system), and tools for positive living and wellbeing.

Academic Institutions with which collaboration could prove valuable include: Columbia University, University of California at Berkley, University of Cape Town (technology development), London School of Economics

[19] http://www.gsmworld.com/developmentfund/index.shtml

[20] These and other multimedia materials are available at http://www.ehealth-connection.org/conference-materials.

(evaluation frameworks), Johns Hopkins Center for Communication Programs (content and applications), Rutgers Center for Mobile Communication Studies (research), International Institute for Communication and Development (evaluation frameworks), University of Washington, Harvard University, Kingston University (mHealth applications development and testing), University of Manchester (m-Development), Universidad Peruana Cayetano Heredia (research and training in biomedical and health informatics), Makerere University in Uganda, among others. Partnerships between industry and research organisations should be encouraged to support appropriate design, testing, and evaluation of cheaper and user friendly devices for patient- and health worker-centric usage (Iluyemi, 2007).

Some of the strongest technical organizations in mHealth in low and middle income countries include Cell-Life and Meraka Institute from South Africa, Media Lab Asia in India, SatelLife and Voxiva, Dimagi and D-tree in the United States, SynapseHealth in the Philippines, and Grameen Bank's Technology Group in Bangladesh. There are also rapidly emerging mobile phone and health partnerships, including those between Nokia and Plan, the UN Foundation and Vodafone Group Foundation (See below), and the PEPFAR Initiative *Phones-for-Health* (See below). The Phones-for-Health Program, specifically targeting HIV and AIDS services, is perhaps the only one of its magnitude (national scale) to deploy mHealth management infrastructure that will enable healthcare providers and administrators to order medicines, download treatment guidelines, send alerts, and access training and other information materials (GSM Association, 2007). Implementation of this initiative is planned for 10 countries in Africa with potential expansion to address other diseases such as TB and malaria as well as to countries in Asia (GSM Association, 2007).

UN Foundation and Vodafone Group Foundation Partnership

The UN Foundation partnership with the Vodafone Group Foundation (VGF) began operations in October 2005, with a £10 million commitment from VGF matched by £5 million from the UN Foundation to support UN causes. The Partnership leverages Vodafone's core strengths – its mobile technology, global infrastructure, and capacity for mass consumer outreach – with the UN's scale, mission, and human capital. The partnership goal is to support activities and manage initiatives that use technology tools to help the UN address the world's toughest challenges more effectively and efficiently.

The United Nations Foundation is working with the Vodafone Group Foundation to address these challenges in Africa by collaborating with WHO and national health

ministries to build digital health data systems. These systems are powered by data gathered by on-the-ground health professionals equipped with personal digital assistants (PDAs) and flexible epidemiological surveillance software. The Partnership launched a major program in June 2006 to fund training, software, and mobile computing devices for the full complement of health data officers in Burkina Faso, Kenya, and Zambia to support the fight against measles, through the NGO DataDyne.

The United Nations Foundation's Rapid Response Emergency Telecommunication project works with UNICEF, the World Food Programme, and the UN's Organization for the Coordination of Humanitarian Affairs (OCHA) to improve access to life-saving technology and telecommunications tools in natural disasters, conflicts, and famines.

[For more information visit: http://www.unfoundation.org/vodafone/index.asp]

In 2008, in preparation for the Bellagio meeting on mHealth and mobile telemedicine, the UN Foundation and the Vodafone Group Foundation commissioned a comprehensive report, mHealth in the Global South: Landscape Analysis. Aiming to provide a foundational report and analysis of current mobile health work, the report examines strategies and factors involved in successfully implementing sustainable mobile technology. Conducted by Vital Wave Consulting, the review emphasizes mHealth as a business model. It examines stakeholder incentives and identifies participants in the mHealth 'value chain,' that is, the organizational relationships and steps required to deliver a commercialized product. Along with a summary of mHealth projects in the global South, the report is a symbol of the UN Foundation and Vodafone Group Foundation partnership. It communicates the need to make the mHealth business case and to forge more partnerships for scale-up (UN Foundation/Vodafone, 2008).

Many International NGOs, including AMREF, CARE, Catholic Relief Services, International Federation of Red Cross and Crescent, and Save the Children are applying mobile technologies to their health-related work, although there are very few who have documented their use. This is rapidly changing as efforts toward more strategic use of such technologies are becoming more prominent, as illustrated by some of the evaluations conducted in this area by institutions such as the International Institute for Communication and Development, International Development Research Centers, and Bridges.org. A survey by the UN Foundation and Vodafone conducted between December 2007 and January 2008 of 560 NGOs worldwide found that NGOs use of mobile phones for work for both broad and health-related social change was widespread and indispensible (Kinkade & Verclas, 2008). With volunteer communities like

mobileactive.org that unite people and organizations dedicated to using mobile technology for social change, new platforms for building partnerships and facilitating access to funding and technology are increasing.[21]

USAID- PEPFAR Mobile Phones and HIV/AIDS Program

The U.S. government along with several mobile phone industry companies have announced a public-private partnership known as Phones-for-Health in order to utilize cell phone coverage in the developing world to bolster health systems. The partners in the initiative are the GSM Association's Development Fund, the U.S. President's Emergency Plan for AIDS Relief (PEPFAR), Accenture Development Partnership; Motorola Inc., MTN and Voxiva. To begin with, this initiative will focus on 10 African countries, building on an already successful deployment in Rwanda and is also expected to be extended in Africa and Asia to address diseases like tuberculosis, malaria and other infectious diseases in future. The program already seems to have achieved some success in Rwanda, using the TRACNet system, which has been in use for the past two years to help manage Rwanda's national HIV and AIDS program (see Table 2 in Appendix).

Source:http://www.iht.com/articles/ap/2007/02/13/business/EU-TEC-Spain-Wireless-Conference-Health.php

[21] www.mobileactive.org/about

Section 5.
Considerations and Approaches

With the broader goal of providing access to and improving the quality of health services, aspects of mHealth should remain a component within the broader framework of eHealth. However, because of its market potential, certain aspects may be explored strictly as business ventures with social benefits. The WHO Global Observatory for eHealth should be well positioned to work together with partners to evaluate what works and what does not to promote the most strategic use of mHealth technologies to meet the health care needs of people. The opportunities for learning exist in isolated pockets. There is a need to map what is being done, what is possible, and to make mHealth activities visible to one another. In this regard, mobile communication technologies should be explored as part of a list of optimal tools and systems to directly address aims within the health sector.

Capacity Building

It is critical to use technology in a way that enhances how teams work together and follows existing flows of work with protocols to guide its utilization (Iluyemi, Fitch, Parry et al., 2007). While many individual health professionals are using mobile communication technologies in their work, there are very few formal integration programs that have built protocols to guide their use. In addition to protocols, training is also critical to maximize the full potential that technology can offer to health care administrators and providers. Universities ought to consider providing training in the use of e- and mHealth solutions as part of medical and health administration education curricula (Curioso, 2006). In addition, programs should ensure that adequate supplies of equipment are provided and that training, maintenance, and technology support are included as part of the integration process (Iluyemi, Fitch, Parry et al., 2007; Mechael, 2006). Where possible, the structure of hardware and design of software should take into consideration the needs and work patterns of health care workers as well as patients (Iluyemi, Fitch, Parry et al., 2007; Mechael, 2006). They ought to be designed in a way that is adaptable to a variety of implementation environments even within the same country (Rivett, 2007).

The use of mobile communication technologies should build on existing workflows within the health system and begin by identifying what the system needs to function more efficient and effectively. In addition, potential users should be included in the design and adaptation process to ensure buy-in and better chances of technology uptake. A key challenge for low and middle income countries is technology transfer without cultural considerations or locally developed content. This is compounded by the limited variety of appropriate technology solutions specifically developed with the conditions and realities of low and middle income countries in mind (Lacal, 2003).

The need for capacity building at the country level cannot be overemphasized. Ministries of Health should focus on local ownership of mHealth technology by building a cadre of tech savvy health administrators and eHealth specialists. Such local ownership includes the promotion of local software development and mHealth research and development in developing countries themselves. One potential partner in promoting such capacity building is the 'mobility project' by kiwanja.net, a collaborative project between academics, technicians, and educators in the field of mobile IT to develop tools and resources to promote mobile applications development for users in the developing world. The main focus areas of the mobility project include developing mobile-based programming tools and online mobile phone programming curricula.[22]

Monitoring and Evaluation

For programs to succeed, needs assessments, monitoring systems and outcomes evaluations should be thoughtfully designed from the outset of integration. Appropriate measures of evaluation ought to be integrated into the implementation process to assess the impact of interventions to help inform future programming and policy development (Shields, Chetley, & Davis, 2005). There should be a relatively standardized monitoring and evaluation program and indicators that cut across many similar programs so they can be compared between countries (Scott & Saeed, 2008). This is one aspect of leadership to which WHO will likely be called to catalyze. One available monitoring and evaluation resource is HIPNet and USAID's

[22] http://mobility.kiwanja.net/

Guide to Monitoring and Evaluation of Health Information Products and Services (Sullivan, 2007). The guide attempts to define, standardize, and categorize indicators to measure reach, usefulness, use, and impact of information products and services (Sullivan, 2007). While the guide represents a valuable attempt to standardize monitoring and evaluation for health information, the need for such a guide for health ICT programs is tantamount to measuring success in the area of mHealth.

Alternative Approaches

An mHealth Strategy should be divided into two major sets of initiatives: 1) citizen-centric and 2) health-worker centric (Iluyemi, 2007).

This will determine the types of approaches to be applied as well as the choice of technology design and functions. The latter looks specifically at the communication and information needs of various health sector stakeholders, while the former poses questions regarding a global shift towards citizen-centered healthcare.

Following the premise that ICTs are merely tools, not objectives in themselves, an alternative needs-driven approach might be considered whereby one begins by identifying information and communication needs (Pakenham-Walsh, 2007). This approach would then strive to achieve the following objectives:

1. Meeting the information and communication needs of individuals (so that they are more empowered to maintain and promote their own health and the health of their families)
2. Meeting the information and communication needs of front-line providers of health care (including lay caregivers, informal and traditional providers, primary health workers, district health workers, tertiary providers and others)
3. Meeting the information and communication needs of policymakers and managers (including, for example, directors of small hospitals, district medical officers, MoH staff, WHO regional and country staff) (Pakenham-Walsh, 2007)

These three layers of need raise a key question that might be considered by mHealth initiatives: "What can be done to improve communication among the full range of stakeholders so that all stakeholders work more effectively together to share expertise and experience? (Pakenham-Walsh, 2007). This would then be followed by the question: how can ICTs - and in particular the emerging mobile communication technolgies be harnessed to improve this communication?

In light of interest and shifting focus to more citizen-focused health services, it might be interesting to advance the innovative idea of leveraging consumers' own ICTs to improve their own, their family's, and their community's health (Lacal, 2007), instead of assuming that provider-centric ICT is the only and best way to leverage ICT.[23] As the numbers of mobile communication and wireless technology users grow, citizens will inevitably become better informed and maintain greater control over their own health care management (Istepanian, 2004). A critical consideration for the WHO Global Observatory for eHealth will be the role that the institution will play to ensure effective support and information is available for citizens in low and middle income countries.

Challenges

There are a number of challenges and barriers that ought to be acknowledged within the discussion of expanding the benefits of mHealth in low and middle income countries.

The first is cost, both at the macro systems level (Istepanian & Lacal, 2003) as well as at the level of the individual citizen and healthcare provider (Mechael, 2006). A key aspect for any of these technology systems to work is that they are affordable at point of use. A billing structure must be implemented that allows for a "reverse cost" approach, i.e. the MOH or other responsible party will pay for it. Otherwise it is not feasible or sustainable (Rivett, 2007). Cell-Life has recently instituted its first reverse billing line, which has increased the success of its systems significantly (Rivett, 2007).

[23] http://medicalautomation.org/conferences/index.php?confid=1 & http://lacal.net//files/hs/BYOHIT05.ppt

Second, there are limitations within the data transfer and mobile Internet capabilities available in the types of mobile communication devices that are currently being used in these countries (Iluyemi, Fitch, Parry et al., 2007; Istepanian & Lacal, 2003). Thirdly, access and delivery of health services in many low and middle income countries is complex, and the introduction of technological solutions may not be appropriate or a critical priority (Istepanian & Lacal, 2003). This particular challenge highlights the need to show the contribution that technology can make towards addressing key health priorities.

Fourth, there is a lack of operational compatibility and standards within existing mobile communication systems (Istepanian, 2004). The introduction of 3G wireless technology may help overcome aspects of this particular challenge by enabling the unification of existing standards under one umbrella (Istepanian, 2004). Through the efforts in software development of groups like OpenROSA[24] and OpenMRS,[25] movements are being made to address this issue of interoperability. Additional considerations include the lack of a solid evidence base from which more strategic decision making can be made in the area of mHealth (Istepanian & Lacal, 2003). mHealth project impact must be assessed not only by touting uptake and usage of a particular technology, but also by specifically addressing how the technology is affecting people's health outcomes and lives (Manji, 2008).

Legal and Ethical Issues

Beyond the best use of technology by the health sector is a broader discussion of when physical contact cannot be substituted by a technological solution. This is particularly relevant to the discussion regarding telemedicine for diagnosis and decision support for treatment. The types of guidance that can be provided vary depending on the capacity to assess a case with or without images, a physical examination, or laboratory tests (Mechael, 2006). Health conditions with complicated diagnostic measures might not benefit from remote consultations, requiring in-patient diagnosis and treatment (Mechael, 2006). Specialized protocols and training are needed to identify the situations in which phone or internet-based and other technology-enabled consultations are appropriate. Care

[24] www.openrosa.org
[25] http://openmrs.org/wiki/OpenMRS

must be taken to maximize their benefits by closely assessing the sorts of information to be gathered and communicated (Mechael, 2006). As is the case in eHealth in general, legal frameworks and liability boundaries are needed to provide guidance on the appropriate use of telemedical systems within national as well as across borders (Istepanian & Lacal, 2003; Lacal, 2003). In addition, mobile phones in low and middle income countries are often shared among household members (Mechael, 2006). In a recent review of telemedicine policies in Africa, it was revealed that while most Ministries of Health have places to engage in telemedicine, they do not have policies associated with these practices. In order to protect patients' and providers' rights, national and international ethical and legal frameworks are needed to guide the appropriate use of telemedicine. Secure information within mobile communication environments is crucial to maintaining patients' rights to confidentiality (Todrys & Mechael, 2008). The Earth Institute, through its mHealth activities within the Millennium Villages Project has taken a special interest in the development of ethical guidelines, policies, and training curricula for patient confidentiality and data security. This approach aligns with recommendations that "Safeguarding the privacy, confidentiality, and security of any public health informatics or e-health project is an important undertaking" (Curioso, 2006).

Section 6. Recommendations

Based on this review and discussions with a broad range of stakeholders, it is recommended that key mHealth stakeholders consider focusing their next steps on catalyzing the testing and scale up of interventions that show promise in achieving key health outcomes as laid out by the Millennium Development Goals for health. The WHO should also serve as a convener of key partners and broker of mHealth strategies, information, and evaluation frameworks. A 'test case project' ought to be designed in a way that specifically brings together various stakeholders (technology companies, donors, insurance brokers, health professionals, and social scientists) for a focused project with a specific and measurable goal (Kaplan, 2007). The project could provide a laboratory in which to identify keys priorities and challenges, with applications and approaches ultimately tailored to each individual country context. Through a process like this, trends and considerations that may be similar across countries (cultural, regulatory, and financial) will likely be revealed (Kaplan, 2007). This would then lead to the creation of a model for how others might approach similar integration processes and be complemented with a robust framework for monitoring and evaluation based on learning from other eHealth initiatives (Heeks, 2007), particularly with the increasing documentation of health information systems successes and failures (Heeks, 2006).

Since this Review was initially developed, several initiatives have taken a “test lab” approach to mHealth, including the Millennium Villages Project. In partnership with Ericsson along with MTN and Zain, MVP has developed a broad-based mHealth Strategy that examines the integration of mobile telephony and other technologies to achieve the MDGs, beginning with those for health. This initiative is being implemented in 10 countries in Africa and serves as an environment to test, deploy, scale up, and monitor and evaluate mHealth interventions within a broader eHealth program.

Health Arenas to Explore

The first area for consideration is Safe Motherhood in a particularly high prevalence environment. It is a key public health challenge that is often discussed in low and middle income healthcare fora as an area that will

benefit from mobile technology applications. There is significant interest in this area which may yield easily formed partnerships among the groups listed above. Based on this review, there are a multitude of mHealth technologies that can be applied to reducing maternal mortality and morbidity. These include the creation of emergency calling, referral, and decision support systems through the use of 2-way voice communication via mobile phones as well as SmartPhones onto which Safe Motherhood guidelines can be uploaded and used by healthcare workers. It is also an area in which it will be possible to explore how the health sector can derive additional benefits from the combination of transport and mobile telecommunications revolutions in many low and middle income countries.

A second area for consideration is improving child health and the reduction of childhood mortality and morbidity. Two critical areas for which there are existing platforms for learning and clear benefits to be gained are routine immunization and integrated management of childhood illness. In the area of routine immunization text messaging systems can be used to send reminders to registered parents for when their child is due for immunization and/or for immunization campaign days. In addition, PDAs and increasingly SmartPhones can be used to collect data for immunization records as well as to provide health promotion reminders and messages to healthcare workers during immunization activities. In relation to integrated management of childhood illness, decision support platforms exist, but have not yet been tested and deployed at a palatable scale.

Other areas include global disease surveillance in addition to addressing the diseases of poverty, namely HIV and AIDS, malaria, and TB- where significant investments are being made to reduce the gap in health systems coverage by the Global Fund as well as broader disease surveillance and control efforts for which many of the existing applications are already being used. From such activities, MoHs will be in a position to develop sustainability models that take into consideration the cost of implementing and maintaining mHealth systems and develop models for partnering to develop and implement these systems in low and middle income countries (Ramaraju, 2007).

As a convener and leader in health policy development, WHO's role in developing a knowledge and evidence base for mHealth activities cannot be understated. Specifically, this knowledge base would be comprised of a clearinghouse or portal of existing documentation that is updated regularly.

To do this, the WHO must begin by reviewing and strengthening weak design and evaluation frameworks within eHealth that can then be tested and applied to the suggested catalytic mHealth activities. The WHO ought to also consider the role of evolving National Observatory Groups in low and middle income countries in helping to identify and document promising applications within mHealth to create an environment of learning and exchange.

Conclusion

There is rapidly growing interest in maximizing the benefits of mobile communication technologies for health in low and middle income countries, but relatively limited and mostly pilot-stage efforts at best. Health care organizations must take the lead, as they are closer to patients than industry, to examine how such technology solutions may generate direct health benefits to patients, facilitate the work of overstretched human resources, create systems that are informed by data collected at the point-of-care, and yield cost savings for a more efficient healthcare delivery system.

Mobile communication technologies have the potential to reduce professional isolation- especially in rural areas and to provide ongoing support to health care workers as well as citizens. Technological solutions should be designed according to local realities and to meet local needs in such a way that practically and measurably contributes to the Millennium Development Goals for health. Three key areas in which early and rapid gains can be achieved are in the areas of Safe Motherhood, routine immunization and integrated management of childhood illness, and disease surveillance and control especially in addressing the diseases of poverty, namely HIV and AIDS, malaria, and TB- where significant resources have been mobilized to reduce the disease burden in low and middle income countries. Alongside such efforts, there is a critical need within mHealth for mechanisms to evaluate the benefits and pitfalls of technology applications and their ability to promote the desired health outcomes.

Healthcare policymakers and administrators must equip themselves with the knowledge needed to shift from small pilot programs to standardization and scale up. This can be achieved by providing appropriate technology solutions and training in e- and mHealth at a scale through which realistic benefits will be achieved. This updated mHealth report, which ought to be updated periodically given the rapidly changing field, is one of many steps towards initiating a dynamic dialogue among a broad range of industry, academic, policymaking, government, and non-government civil society partners that will enable these leaders to consider their roles in forging a strategic direction in mHealth.

References

Agar, J. (2003). *Constant Touch: A Global History of the Mobile Phone* Cambridge: Icon Books Ltd.

Ailinger (2008), R. Use of Electronic Monitoring in Clinical Nursing Research. *Clinical Nursing Research*. 17(2): 89-97.

Ayyagari, D. (2008). *Moving Beyond the "Evidence" Question in Telehealth.* Continua Newsletter. (http://www.continuaalliance.org/news_events/newsletters/march_2008/#article)

Beard, N. (2000). Global Health: Role of the Information Technology Industry: UK Partnership for Global Health.

Binder, B. et. al. (2007). Teledermatological Monitoring of Leg Ulcers in Cooperation with Home Care Nurses. *Arch Dermatol*. 143(12):Dec 2007.

Bridges.org (2003). Evaluation of the SATELLIFE PDA Project, 2002: Testing the use of handheld computers for heathcare in Ghana, Kenya, and Uganda. Cape Town: Bridges.org.

Bridges.org (2005). Evaluation of the On Cue Compliance Service Pilot: Testing the use of SMS reminders in the treatment of Tuberculosis in Cape Town, South Africa. Cape Town: Bridges.org.

Carmichael, M. (2007). iPods Teach Docs to Recognize Heartbeats: Medical Students use iPods to learn the sounds of unhealthy hearts. Rocking out to 'aortic regurgitation.' *Newsweek (Web Exclusive)*.

Chapman, S., & Schofield, W.N. (1998). Lifesavers and cellular samaritans: emergency use of cellular (mobile) phones in Australia. Sydney: University of Sydney: Department of Public Health and Community Medicine.

Chetley, A. (2006). Improving health, connecting people: the role of ICTs in the health sector of developing countries. In InfoDev (Ed.). Washington, DC: World Bank.

Crampton, T. (2007). Wireless Technology Speeds Health Services in Rwanda, *New York Times.* New York.

Curioso, W. (2006). New Technologies and Public Health in Developing Countries: The Cell PREVEN Project. In M. Murero, & R. Rice (Eds.), *The Internet and Health Care: Theory Research and Practice.* Mahwah, NJ: Lawrence Erlbaum Associates.

Dahlman, B. (2007). Feedback on Draft WHO mHealth Review (6). (Personal communication). New York.

Domingo, A.A. (2007). Feedback on WHO mHealth Review Draft (9). (Personal communication). Manilla.

Donner, J. (2004). Innovations in Mobile-based Public Health Information Systems in the Developing World: An Example from Rwanda, *Mobile Technologies and Health: Benefits and Risks.* Udine, Italy.

Donner, J. (2005). The use of mobile phones by microentrepreneurs in Kigali, Rwanda: Changes to social and business networks: Annenberg Research Network on International Communication Workshop.

Economist, T. (2005). The doctor in your pocket [Medical technology: Nearly everyone in the developed world carries a mobile phone- so why not use it to deliver health care?, *The Economist*.

Economist, T. (2008). Leaders: The limits of leapfrogging; Technology and development. *The Economist.*

Fontelo, P., Liu, F., Muin, M., Tolentino, H., & Ackerman, M. (2006). Txt2MEDLINE: Text-Messaging Access to MEDLINE/PubMed, *AMIA Annual Symposium Proceedings* pp. 259-263).

Fontelo, P. (2007). Feedback on WHO mHealth Review Draft (10). (Personal communication). Bethesda.

Fuscaldo, D. (2004). Soon, Cellphones Will Monitor the Vital Signs of the Chronically Ill, *The Wall Street Journal On-line.* New York.

Fynn, R.W., Jager, D.d., Chan, H.A., Anand, S., & Rivett, U. (2006). Remote HIV/AIDS Patient Monitoring Tool Using 3G/GPRS Packet-Switched Mobile Technology. In IEEE (Ed.), *The 4Th International Seminar on Appropriate Healthcare Technologies for Developing Countries.* London: IEEE.

Granot, Y., Ivorra, A., Rubinsky, B. (2008). A new concept for medical imaging centered on cellular phone technology. *PLoS ONE*: 3(4) April 2008.

GSM Association (2005). The Role of Mobiles in Disasters and Emergencies pp. 1-34). London: GSM Association.

GSM Association (2007). Phones for Health: Major Public-Private Partnership to Use Mobile Phones to Fight the HIV/AIDS Pandemic: GSM World.

Haddon, L. (2004). *Information and Communication Technologies in Everyday Life: A Concise Introduction and Research Guide* Oxford: Berg

Haynes, S. (2008). Cellphones Bringing a :-) to Remotest Africa. *The Christian Science Monitor.* January 15, 2008.

Hedberg, C. (2002). Mobile Phone use for TB Diagnosis in South Africa (Personal communication). London.

Heeks, R. (2006). Health information systems: Failure, success, and improvisation. *International Journal of Medical Informatics*, 75, 125-137.

Heeks, R. (2007). Feedback on WHO mHealth Review Draft (8). In P. Mechael (Ed.). Manchester, UK.

Hivos (2005). ICTs to Fight Against HIV/AIDS, *i4d: information for development* pp. 8-9. (http://www.i4donline.net/dec05/hivos.asp)

Horan, T., & Schooley, B. (2002). Interorganizational Emergency Medical Services: Case Study of Rural Wireless Deployment and Management: Information Systems Frontiers.

Iluyemi, A. (2007). Feedback on Draft WHO mHealth Review (3). (Personal communication). London.

Iluyemi, A., Fitch, C., Parry, D., & Briggs, J. (2007). Health Information Systems for Community Based Health Workers: A Case for Mobile and Wireless Technologies. In P. Cunningham, & M. Cunningham (Eds.), *IST-Africa 2007.* Maputo, Mozambique: International Information Management Corporation.

Istepanian, R., & Lacal, J. (2003). Emerging Mobile Communication Technologies for Health: Some Imperative notes on m-Health. In IEEE (Ed.), *The 25th Silver*

Anniversary International Conference of the IEEE Engineering in Medicine and Biology Society. Cancun Mexico: IEEE.
Istepanian, R. (2004). Introduction to the Special Section on M-Health: Beyond Seamless Mobility and Global Wireless Health-care Connectivity. *IEEE Transactions on Information Technology in Biomedicine*, 8(4), 405-413.
ITU (2003). Mobile overtakes fixed: Implications for policy and regulation. Geneva: International Telecommunications Union.
Johnson, C. (2008). "The results are in…And you're going to be fine." *The Boston Globe*. http://www.boston.com/business/healthcare/articles/2008/05/18/the_results_are_in_and_youre_going_to_be_fine/?page=1
Kaplan, W. (2007). Feedback on WHO MHealth Review (5). (Personal communication). Boston.
Kaplan, W.A. (2006). Can the ubiquitous power of mobile phones be used to improve health outcomes in developing countries? *Globalization and Health*, 2(9), Open Access (pp.1-14).
Kaul, I. (2001). "Public goods: Taking the concept to the twenty-first century". In D. Drache (Ed.), *The Market of the Public Domain* (pp. 255-273). London and New York: Routledge.
Kefale, A., Mekuria, B., & Bekele, D. (2006). Mobile Medical System for Ethiopian Hospitals. Addis Ababa: United Nations Economic Commission for Africa.
Kinkade, Ss & Verclas, K. (2008). *Wireless Technology for Social Change: Trends in Mobile Use by NGOs.* UN Foundation and Vodafone Group Partnership.
Klecun-Dabrowska, E., & Cornford, T. (2001). Evaluation and Telehealth: An Interpretative Study, *34th Hawaii International Conference on System Sciences.* Hawaii: IEEE.
Kurth AE, C.W., Wolpin S, Segura P, Cabello R, Berry D. (2007). Personal Digital Assistants for ART Adherence and Safer Sex Behavior Support: A Novel Intervention in Peru, *2nd International Conference on HIV Treatment Adherence. Co-hosted by the International Association of Physicians in AIDS Care (IAPAC) and the National Institute of Mental Health (NIMH)*.
Kwankam, Y. (2007). Making ICT work for Health:WHO Priority eHealth Programs, *Med-e-Tel 2007.* Luxembourg: www.medetel.lu.
Lacal, J. (2003). Cell Phones and Tele-Medicine. In Healthcom (Ed.), *The Fifth International Workshop on Enterprise Networking and Computing in Healthcare Industry.* Santa Monica, California.
Lacal, J. (2007). Feedback on Draft WHO mHealth Review. (Personal communication). New York.
Leon, S., Fontelo, P., Green, L., Ackerman, M., & Lui, F. (2007). Evidence-based medicine among internal medicine residents in a community hospital program using smart phones. *BMC: Medical Informatics and Decision Making*, 7(5), (Accessed online: www.biomedcentral.com/1472-6947/1477/1475).
Ling, R. (2004). *The mobile connection: The cell phone's impact on society* London: Morgan Kaufmann
Marshall, L. (2007). Feedback on the WHO mHealth Review Draft (7). (Personal communication). Cape Town.

Manji, Firoze. (2008). Mobile activism or mobile hype? *Gender and Media Diversity Journal.* Volume 4. April 2008.
Martinez, A. et al. (2008). Simple telemedicine for developing regions: camera phones and paper-based microfluidic devices for real-time, off site diagnosis. *Analytical Chemistry* 80: 3699-3707.
Mechael, P. (2005). Mobile Phones for the Promotion of Maternal and Child Health in Developing Countries (An Egyptian Case Study) http://www.i4donline.net/May05/casestudyegypt.asp. *i4d*, May 2005.
Mechael, P. (2006). Exploring Health-related Uses of Mobile Phones: An Egyptian Case Study, *Public Health & Policy* (p. 264). London: London School of Hygiene and Tropical Medicine.
Mechael, P. (2007). Creating an Enabling Environment for mHealth. Information and Communications Technology, 2007. ICICT 2007. ITI 5th International Conference, 16-18 Dec. 2007
Med-e-Tel (2006). Med-e-Tel 2006 Proceedings (www.medetel.lu), *Med-e-Tel 2006.* Luxembourg.
Micevska, M. (2005). Telecommunications, Public Health, and Demand for Health-Related Information and Infrastructure. *Information Technology and International Development*, 2(3), 57-72.
Michael, M. (2000). Introduction: Situating technology and technolozing situations. In J. Urry (Ed.), *Reconnecting Culture, Technology and Nature: From society to heterogeneity* (pp. 1-17). London: Routledge.
Morak, J, Kollmann A, Schreier G. 2007. Feasibility and Usability of a Home Monitoring Concept based on Mobile Phones and Near Field Communication (NFC) Technology, In: Kuhn K et al. (Ed). Proceedings of Medinfo2007. IOS Press, p 112-116.
Mossman, K. (2008). A modular microscope attachment for cell phones could improve the quality of telemedicine. *MIT Technology Review*. http://www.technologyreview.com/read_article.aspx?ch=specialsections&sc=telecom&id=20433&a=
Motorola (2004). Motorola and Partners Telemedicine Trial Mobile Solution to Monitor Chronically Ill Patients: Motorola (www.motorola.com/mediacenter/news/detail/0,,4723_4023_23,00.html).
Motorola (2005). Motorola, the Clinic Hospital of Barcelona, the Telecommunication Engineering College of the Polytechnic University of Madrid and Amena collaborate to evaluate MOTOHEALTH Solution: Motorola (www.motorola.com/mediacenter/news/detail/0,,5241_5237_23,00.html).
Murrugarra, L., Cannales, M., Tanner, E., Salizzoni, F., Lopez de Castilla, D., & Gildenston, S. (2007). The e-Health Initiatives and Challenges in Peru: e-Health is Essential in Latin America: www.eHealthonline.org.
Musoke, V.M. (2002). Simple ICTs reduce maternal mortality in rural Uganda: A Telemedicine Case Study: Medicus Mundi Switzerland (http://www.medicusmundi.ch/mms/services/bulletin/bulletin200202/kap04/16musoke.html).

Neergard, Lauran. (2008). Nagging Via Text Message to Help Teens Remember Meds. Associated Press: May 12, 2008. http://www.wsbt.com/news/health/18865824.html
Pakenham-Walsh, N. (2007). Feedback on Draft WHO mHealth Review (2). (Personal communication). United Kingdom.
Pinsker, M., Kastner, P., & Schreier, G. (2007). A telemedical therapy-management-system with rule-based active patient feedback, *Med-e-Tel 2007.* Luxembourg.
Ramaraju, G.V. (2007). Feedback on WHO mHealth Review Draft (12). (Personal communication). India.
Rivett, U. (2007). Feedback on WHO mHealth Review Draft (11). (Personal communication). Cape Town.
Rubio, F. (2007). Feedback on Draft WHO mHealth Review (4). (Personal communication). Peru.
SatelLife (2005). Handhelds for Health: SatelLife's Experiences in Africa and Adia pp. 1-56). Watertown, MA: SatelLife.
Sawahel, Wagdy. (2008). Researchers devise 'mobile' medical imaging system. scidev.net: May 16, 2008. http://www.scidev.net/en/news/researchers-devise-mobile-medical-imaging-system.html
Schlachta-Fairchild, L. (2007). *International Competencies for Telenursing*. International Council of Nurses.
Scott, R & Saeed, A. (2008). Global eHealth - Measuring Outcomes: Why, What, and How. A Report Commissioned by the WHO Global Observatory for eHealth.
Shields, T., Chetley, A., & Davis, J. (2005). ICT in the health sector: Summary of the online consultation: infoDev.
SimPill (2007). SimPill Adherence Management pp. 1-38). Cape Town: SimPill.
Stecker, C. (2002). Home-based Care in Uganda: Using Mobile Phones for Referrals (Personal communication). London.
Sullivan, T. (2007). Guide to Monitoring and Evaluation Health Information Products and Services. USAID.
The Economist (2005). The doctor in your pocket, *The Economist*.
The Economist (2006). A text a day, *The Economist*.
Thompson, T & Arthur D & Boxer, R. (2008). A Model for Telephonic Medical Consults: Guidelines for Decision Makers.
Todrys, K & Mechael, P. (2008). The Ethics of Telemedicine in Africa: The Millennium Villages Project Experience. The Earth Institute. Pending Publication.
UNICEF and Women's Net (2007). *Rapid Assessment of Cell Phones for Development.* Written and compiled by Sally-Jean Shackleton.
UNICEF. (2008). *New AIDS film in Georgia circulated using mobile phones*. http://www.unicef.org/ceecis/media_8237.html
United Nations (2000). United Nations Millennium Declaration (General Assembly Resolution 55/2). New York: United Nations.
United Nations (2007). The Millennium Development Goals Report. New York: United Nations.
UNPAN (2007). Compendium of ICT Applications on Electronic Government [Volume 1: Mobile Applications on Health and Learning]. New York: United Nations.

UN Foundation and Vodafone (2008). *mHealth in the Global South: Landscape Analysis*. [report by Vital Wave Consulting]
Vodafone (2006). The role of mobile phones in increasing accessibility and efficiency in healthcare. United Kingdom: Vodafone.
Wireless Healthcare (2005). 101 Things To Do With A Mobile Phone in Healthcare.
Woods, G. (2006). Providing Decision Support for Antiretroviral Therapy in a Resource Deprived Setting using Mobile Technology. In IEEE (Ed.), *The 4th International Seminar on Appropriate Healthcare Technologies for Developing Countries.* London: IEEE.
World Health Organization (1946). The Constitution of the World Health Organization. Geneva.
World Health Organization (1978). Declaration of Alma-Ata, *International Conference on Primary Health Care.* Alma-Ata, USSR.
World Health Organization (2000). World Health Report 2000: Health Systems: Improving Performance. Geneva: WHO.
World Health Organization (2005a). Global eHealth Survey. Geneva: WHO.
World Health Organization (2005b). eHealth Tools and Services: Needs of Member States. Geneva: WHO.
World Health Organization (2006). The World Health Report 2006: Working Together for Health. Geneva: WHO.
World IT Report (2006). Egypt: Number of mobile subscribers hit 14 million: http://www.worlditreport.com/Africa/96752-Egypt__Number_of_mobile_subscribers_hit_14_million.htm.
Zachary, G.P. (2008). Ping: Inside Nairobi, the next Palo Alto? *The New York Times*. July 20, 2008.
Zeroug, M., & Sari, Z. (2006). Algerian Medical Freelancing Experience: Enabling with Solutions to Meet Critical Needs. In I.S.f.T.a. eHealth (Ed.), *11th ISfTeH International Conference.* Cape Town, South Africa: ISfTeH.