Mobile health: Four emerging themes of research

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ABSTRACT

Mobile health has been receiving a lot of attention from patients, healthcare professionals, application developers, network service providers and researchers. Mobile health is more than just some healthcare applications on a mobile phone and it can involve sensors and wireless networks in monitoring various conditions, mobile devices to access numerous healthcare services, healthcare professionals to make decisions and provide emergency care, and for the elderly to manage their daily activities in independent living. More specifically, m-health can result in major advances in (a) expanding healthcare coverage, (b) improving decision making, (c) managing chronic conditions and (d) providing suitable healthcare in emergencies. To help realize these advances, there are major research challenges that need to be addressed. We classify these challenges in four categories of (a) patients related, (b) healthcare professionals related, (c) IT related and (d) applications related challenges. Within each category, we identify several research problems, and we present some high-level and preliminary solutions along with an agenda for future research. The paper may provide a platform for future research and decision-making related to patients, healthcare professionals, applications, and infrastructure. These decisions will significantly impact how future mobile health services will be designed, developed, evaluated, and adopted globally.

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1. Introduction

Mobile health is broadly defined as "healthcare to anyone, anytime, and anywhere by removing locational and temporal constraints while increasing both the coverage and the quality of healthcare" [59]. Mobile health is much more than just accessing healthcare applications on a mobile phone as m-health can involve sensors and wireless networks in monitoring various conditions, mobile devices to access a variety of healthcare services, healthcare professionals to make decisions and provide emergency care, and the elderly to manage their daily activities for independent living among other things. Thus mobile health can include numerous sophisticated applications that deal with disease prevention & wellness [61], monitoring and remote care [47,62], mobile decision making [1], and emergency interventions [59]. In addition, several applications on horizon include highly personalized health monitoring [42], mobile healthcare data access [23], and sophisticated mobile telemedicine [65].

We do not claim that m-health can fix all the healthcare problems, but it can improve the reach of healthcare, decision making, management of chronic conditions and emergencies. Mobile health can truly change the way healthcare services are delivered: from the current *healthcare professionals-controlled* to *healthcare professionals-managed.* One of the major effects of m-health is empowering patients with information to help them make suitable healthcare decisions, follow advice and medical regimen, and in general have better control of their healthcare. The availability of numerous m-health applications, more

than 100,000 at the time of writing this paper, is a major step towards such empowerment of patients. Some other areas of improvement include reduction in cost, more efficient processes, and meeting some of the workload needs of healthcare professionals. Certainly much more work is needed to evaluate the effectiveness of mobile health in terms of quality of decision making, quality of care, efficiencies of healthcare processes, outcomes of patients, and reduction of overall cost.

1.1. Related advances

Several advances in sensing devices, miniaturization of low-power electronics, and wireless networks [5] are fueling the emergence of mobile health. The wireless technologies can be effectively utilized by matching infrastructure capabilities to healthcare needs. These include the use of location tracking, intelligent devices, user interfaces, body sensors, and short-range wireless communications for health monitoring; the use of instant, flexible and universal wireless access to increase the accessibility of healthcare providers; and reliable communication among medical devices, patients, health-care professionals, and vehicles for effective emergency management.

The recent FCC spectrum allocation for mobile medical telemetry can improve both the quality and quantity of medical data that can be transmitted from patients to healthcare professionals [23]. The interoperability among various systems is being addressed by the development of medical standards, industry alliances, and consortiums, such as the IEEE 802.15.6 wireless body area networks (WBANs), Continua Alliance and the European Telecommunications Standards Institute's eHEALTH [23].

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Table 1
M-health comparison in developed and developing countries.

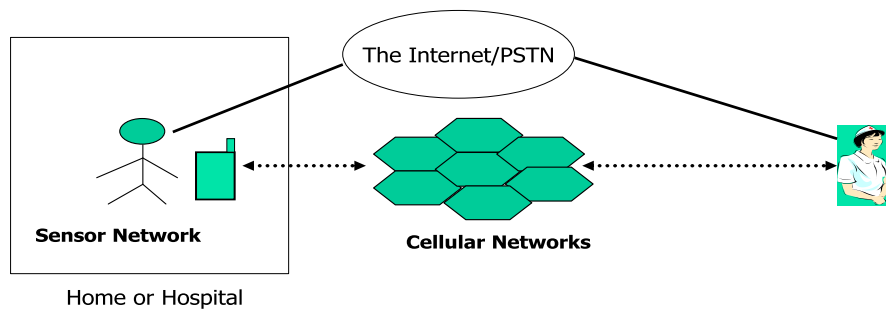| Attributes	Developed countries	Developing countries	Comments
Infrastructure	Well developed	Somewhat developed and access/reliability challenges	The interoperability of infrastructure still needs to be addressed
Most suitable applications	Mobile apps for health management	Information on diseases, reminders for care, remote care	Revolutionary (primary) in developing countries, evolutionary (secondary) in developed countries
Barriers	A lack of clear policy, cost of access, security & reliability challenges	Lack of infrastructure, cultural and social barriers, lack of education, role of alternate medicine	Numerous barriers can be studied in adoption of m-health in developing and developed countries
Regulatory environments	Evolving	Evolving	One of the biggest challenges
Future of m-health	Secondary but important healthcare role	Potential for primary healthcare role in underserved/rural areas	Many challenges need to be overcome

One of the major advances fueling the growth of m-health is the worldwide availability of mobile technologies, such as mobile phones of 3rd and 4th generation (3G and 4G), that are usable almost anywhere anytime. The decline in price of access, improved portability and comfort of people in using mobile technologies have all helped m-health moving forward at a rapid pace.

1.2. The role of m-health

M-health can play many different roles based on the patients' conditions, their needs and availability of healthcare services. The roles include providing necessary healthcare information anytime anywhere, providing remote and expanded care, access to healthcare professionals anytime anywhere via mobile devices, integrated and real-time information to healthcare professionals for decision making, and the broadcasting of information in cases of disasters.

M-health can reach to places where little or no healthcare is available such as rural areas especially in developing countries and can also allow people in urban areas and developed countries to access some healthcare services while being mobile/away from their places. M-health is likely to be incremental in the developed countries as it plays an adjunct role to what is already supported by e-health. M-health is likely to be revolutionary in developing countries, where little infrastructure is available and presence of mobile phones can lead to rapid adoption of mobile health, especially in rural and remote areas. M-health in developing countries will play a major role in health interventions [8], prevention of communicable diseases [61] and in improving health literacy [33]. A comparison of m-health in developed and

(a) Mobile Health in Developed countries with 3G/4G Wireless Networks
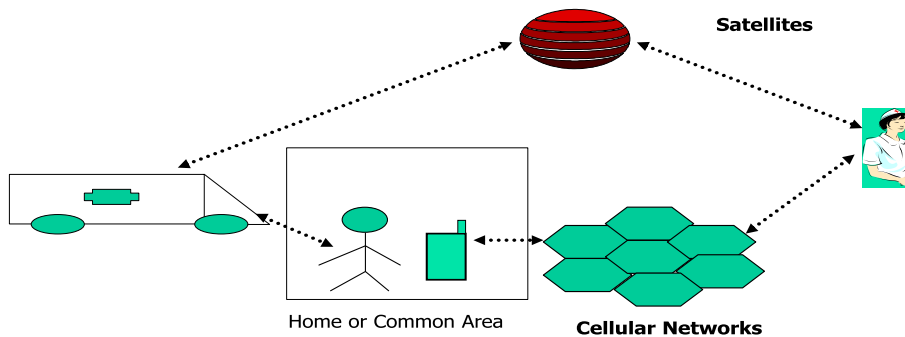
(b) Mobile Health in Developing countries with 2G/3G Wireless Networks

Fig. 1. M-health in developed and developing countries.