

# **m-Health: Exploring the Impact of Wireless Technology in Health Care**

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## **Abstract**

As wireless technology continues along its path of evolution, new capabilities are constantly introduced in the form of innovative wireless business applications. These emerging wireless applications present a value proposition that targets previously ignored or less efficiently addressed areas of interest for either consumers or businesses. This is the mandate for Mobile Commerce (m-Commerce). With increasing penetration rates for wireless devices and a growing acceptance (by both consumers and businesses) of m-Commerce for enabling fulfillment of desired functions, niche segments are constantly being investigated and qualified for fit with wireless technology. The health care sector appears to be one such niche segment that is poised to benefit by adopting wireless solutions. The use of wireless devices and corresponding wireless applications in health care is commonly referred to as mobile health (m-Health). M-Health proposes to radically change the way health care is currently conducted, as wireless technology enhances the quality of patient care, but also yields operational efficiencies within the health care industry. This paper attempts to provide an overview of m-Health. We start with an introduction of m-Commerce and an examination of its key characteristics. An overview is presented of the Health Care market landscape, followed by a discussion of the value proposition that m-Health creates. Needs addressed and challenges faced by implementing m-Health initiatives are then examined. The paper ends with a review of m-Health applications, some conclusions, and potential directions for future research.

**Keywords:** m-Health, m-Commerce, e-Commerce, wireless, applications, health care, m-Health challenges, m-Health value proposition, privacy, security.

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## **1. Introduction**

Over the last decade wireless technology has advanced at a rapid pace, giving rise to many innovative wireless devices and supporting technologies. Building on the growth of electronic commerce (e-Commerce), wireless industry players aspired to benefit by addressing the need for electronic transactions and specifically those that would be best supported through wireless connectivity. As all enabling devices (i.e. pagers, cellular phones, personal digital assistants (PDAs), laptop computers) for this medium shared one common characteristic, mobility, the emerging channel became known as mobile commerce or m-Commerce (Leiner et al. 2002).

m-Commerce continues to grow in popularity among consumers, who turn to their wireless devices for more than just voice communication (Accenture 2001). Web browsing, text messaging, and wireless payments are already available through mobile phones, while corporate wireless users have become empowered through the ability to remotely access data stored in corporate databases. Industries at the forefront of implementing wireless solutions include finance, retail, and advertising. Health care is one of the industries that are lagging in the adoption of wireless solutions, due to the presence of a plethora of challenges. However, a great opportunity exists for this industry, as there are several benefits to be gained through the implementation of wireless applications in health care; this strategy is commonly referred to as Mobile Health, or m-Health.

M-Health is a combination of three technology components: wireless (also referred to as handheld or mobile) computing devices, wireless networking technology, and a centralized information system. M-Health proposes to radically change the way health care is currently conducted, as wireless technology can enhance the quality of patient care, but also yield operational efficiencies within the health care industry.

As wireless communication technologies driving m-Commerce are also responsible for the infrastructure needed in m-Health, the paper starts with an introduction of m-Commerce and an examination of its key characteristics. Section 3 continues with an overview of the Health Care market landscape, followed by a discussion of the value proposition that m-Health creates in Section 4. Section 5 explores challenges faced by implementing m-Health initiatives. Section 6 provides an overview of m-Health applications. The paper ends with some conclusions and potential directions for future research.

## 2. m-Commerce Overview

The name “m-Commerce” arises from the mobility associated with the enabling devices, namely wireless devices such as digital cellular phones, Personal Digital Assistants (PDAs), pagers, wireless laptops, and even automobiles. These devices can access the World Wide Web wirelessly and utilize its various capabilities, such as Web browsing and playing online games (Little 2001), as well perform non-Internet related activities but still utilize the wireless network (e.g. text messaging). m-Commerce is an extension of e-Commerce as they share fundamental business principles, but m-Commerce acts as a new channel through which value can be added to e-Commerce processes. It also provides for new ways through which evolving customer needs could potentially be met.

m-Commerce is carried out over wireless networks that allow users to transmit data between mobile and other computing devices without requiring a wired connection. Wireless networks today have reached the third-generation in some countries. “3G”, as it is more commonly called, supports voice functionality, higher-speed transmissions for high-quality audio and video, as well as providing a global “always on” roaming capability (Peck 2001). In addition to the advancement of wireless networks, several products have been introduced to the market this year that provide extended capabilities by leveraging and combining features of previously distinct wireless devices, such as mobile phones, wireless Personal Digital Assistants (PDAs), and wireless laptops, into a single hybrid wireless device (Pocket 2001). This convergence trend is expected to continue in the foreseeable future to support consumer demands for mobile devices that can provide a wider range of capabilities (Keyte 2001).

The mobility of wireless devices is the first of two key characteristics of m-Commerce. The second key characteristic is reachability, the ability to connect with the mobile user anytime and anywhere. These two characteristics, mobility and reachability, yield several value-added attributes, including instant connectivity, convenience, and improved quality of service.

Concentrating on these two key characteristics and three value-added attributes of m-Commerce, the health care sector has begun exploring the opportunities made available through the adoption of wireless technology. Defining the market landscape for health care will help identify specific areas in which wireless applications can provide benefits.

### 3. Health Care Overview

The health care industry is fragmented and involves numerous players (Fulcrum/Deloitte 2001). To better understand the primary interactions in this market, Figure 1 classifies a number of players in three categories, namely: suppliers, providers, and payers. These three categories are defined below:

- *Suppliers*: These are the companies that provide the back-end of a health care system offering supplies ranging from hospital beds to drugs, all of which are needed in addressing patient needs.
- *Providers*: These are organizations, whose mandate is the well being of the individual, and they are at the front-end of a health care system. Each with their respective target market for patients, they provide expertise and support during needed treatment.
- *Payers*: These are the parties responsible for reimbursing the health care providers upon use of their services.

This high level view of the market assists in understanding the structure of the international health care industry by eliminating the specifics associated within any particular country (e.g. in certain countries “payers” may not include Managed Care Organizations).

SUPPLIERS	PROVIDERS	PAYERS
Pharmacies	Clinics	Patients
Information Systems	Hospitals	Employers
Medical Devices / Supplies	Home Care	Governments
Pharmaceuticals / Diagnostics	Nursing Homes	Health Insurers
Capital Equipment Distribution		Managed Care Organizations

**Figure 1.** Health care market landscape (Adapted from: Schwartz 2002)

Furthermore, it is important to understand the hierarchy that exists in the largest constituent for providers, hospitals, as they present the greatest opportunity for wireless technology, given the size of a typical operation. Staff in hospitals include administration, nurses, primary care physicians (PCP), and specialists. Traditionally an in-patient would have to register with administration, receive a screening inspection by a nurse, who in turn would notify a PCP, who finally would call upon a specialist if needed. These internal interactions as well as those between companies of the three categories are currently to a great extent manual and any existing supporting technology is outdated. This is where m-Health creates a value proposition for health care, which is discussed in the next section.

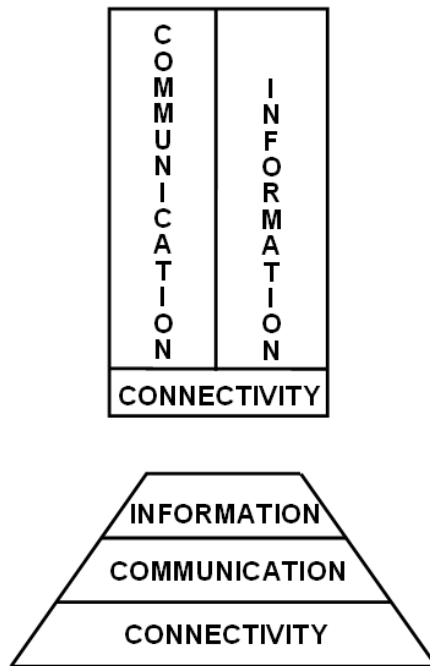
## 4. m-Health Value Proposition

The profession of health care practitioners in a hospital setting is characterized by mobility. The mobility of the hospital staff (defined in Section 3) prevents them from receiving notification and gaining access to pertinent information in a timely manner. This is where the use of wireless technology can generate the greatest benefits. Applying the framework of consumer needs addressed by m-Commerce (Coursaris and Hassanein 2002), the needs of health care practitioners that can best be addressed by m-Health will become apparent:

- **Connectivity Needs:** Connectivity provides the basic platform on which wireless communications take place. In a ubiquitous wireless environment that overcomes geographic (i.e. location of the consumer) and compatibility (i.e. inter-operability of networks) constraints, consumers become capable of true “anytime, anywhere” communication. While compatibility may be an issue for home care providers in accessing databases of pertinent information (e.g. a patient’s electronic medical record), in a hospital setting the issue of compatibility is eliminated (assuming a standard policy for a single wireless network carrier across the organization’s departments is in place). Therefore, what remains critical is the “reachability” of the health care practitioner – this can be addressed by implementing a wireless network across the facilities taking care for not creating any “pockets” of uncovered areas by the wireless network.
- **Communication Needs:** As defined in the broad sense, communication with others can be for either business, or personal purposes (i.e. with other consumers or personal networks), and may be carried out within an information, entertainment, or commerce context. Adapting it to health care, communication would be for a business purpose and would be carried out in an information context only.
- **Information Needs:** m-Consumers need access to static or dynamic information. Examples for these two categories would include a yellow pages-type directory (static) and cross-referencing of wireless Websites for prices or specifications of a particular product (dynamic). In addition, mobile users need access to location-specific information (e.g. finding a nearby restaurant based on the user’s search criteria and current location). Applying the information need to health care, it is predominantly static, whereby providers attempt to retrieve needed information, such as drug databases, patients’ electronic medical records, and inventory information.
- **Entertainment Needs:** Users want to turn to their mobile devices to get useful and practical entertainment solutions, such as access to games or leisure information. Since this need targets the consumer, it does not apply to health care.
- **Commerce Needs:** Two main elements are required to enable mobile consumers to conduct m-Commerce transactions: presentation of product/service information; and a wireless payment mechanism. The value in consumers making payments wirelessly arises from the convenience it offers. For example, mobile users might not require coins/bills to make certain physical purchases (e.g. from vending machines), digital purchases (e.g. purchases on a wireless Website), or even bill payments (e.g. Mobile Bill Presentment and Payment). While the use of wireless devices can facilitate improved inventory management for health care providers, orders placed

through wireless devices would most likely be linked to an overall supply chain management system in place.

Therefore it becomes apparent that the first three consumer needs, connectivity, communication, and information are transferable to health care (see Figure 2). Communication and information needs present wireless technology's value proposition to health care providers by facilitating notification of time-critical alerts and access to information that can improve the quality of service at the point of care.



**Figure 2.** M-Health needs

Communication can be carried out by means of voice, numeric and alphanumeric or text messaging. Voice communication can be facilitated by equipping staff with mobile phones and ensuring a reliable wireless network so that signal loss would not occur. This approach lends itself best when either interaction is required with the recipient physician or when the information to be relayed needs to be placed in context, something that the alternate communication modes cannot perform as efficiently. An incoming call, however, can impact physicians negatively as it would be intrusive and interruptive, since the physician requires to answer the phone immediately to receive the incoming information.

The above impact of interruptive notification is reduced when physicians receive a numeric, alphanumeric or text message. The incoming message can be ignored and viewed at a later time,

allowing the physician to complete the task at hand. The downside to notification messages, or alerts, is the limited information relayed from the source, the challenge the physician faces to place the information in context, and finally the time required by the sender to key in the message. In addition, given the unidirectional nature of the notification system by most pagers today, the recipient is not able to reply to the incoming message, eliminating the possibility for a feedback mechanism.

Examining the areas that notification services can be used in, the following applications arise (Reddy 2002):

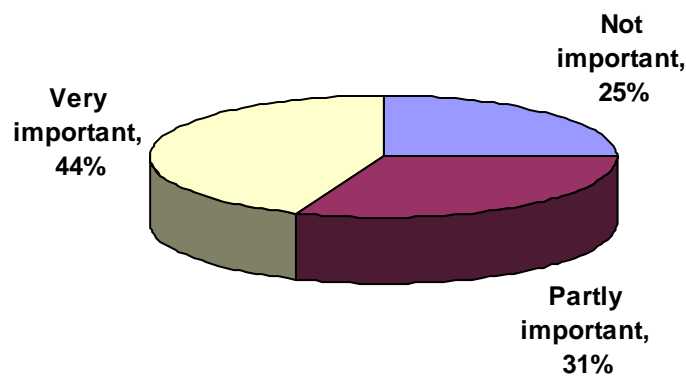
- *Critical laboratory alerts*: Critical lab values are sent to physicians as they arise
- *Critical trend alerts*: Lab values are checked over time and if critical trends are observed physicians get notified
- *Dynamically-adjusted alerts*: Physicians get notified when a patient's physiologic data reach pre-defined levels
- *"Exception condition" alerts*: These notices are triggered either by extraordinary single events or by a combination of events at one time or over time.
- *Medication alerts*: These alerts return information on potential adverse drug effects, given the patient's medication order combined with their physiologic and lab data.

Having examined the need for communication, the second component of the value proposition presented by m-Health is information. The value added by implementing m-Health initiatives is found in the extent of information that can be readily accessed by a physician who is equipped with a wireless device. This component will continue to strengthen as the capabilities of the wireless devices continue to grow. Applications addressing the physicians' need for information can be categorized according to the following four areas (Ammenwerth 1999):

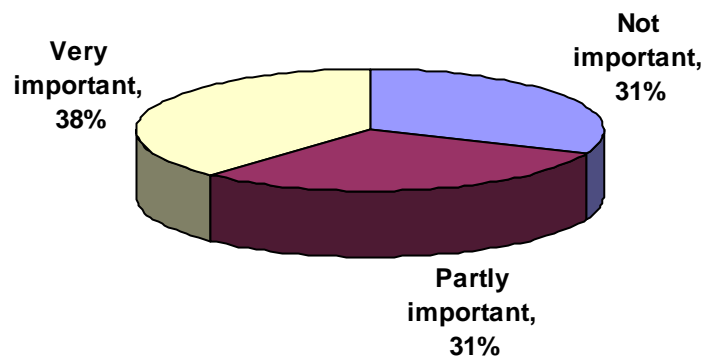
- *Medical knowledge*: Physicians gain access to medical information such as pharmaceutical inventories, medical literature, as needed (e.g. while visiting patients)
- *Mobile documentation*: By completing forms electronically, physicians save time, the time delay for completing the request is reduced, and potential subsequent transcription errors are eliminated.
- *Patient information*: Physicians can retrieve a patient's medical history by accessing their electronic medical record, including laboratory results, diagnoses during current and/or previous hospital stays.

- *General information:* Physicians gain access to often needed general information, such as their personal address books, appointments schedule, telephone books, and encoding catalogues.

In an experiment conducted in a hospital setting in Heidelberg University hospital, Germany, participating physicians were asked to assess the need for mobile communication and mobile information during their work. As shown in Figures 3 and 4, 44 percent and 38 percent of the participating physicians expressed that it was very important during their work to have the possibility of mobile communication and mobile information respectively.



**Figure 3.** Responses of physicians to the question: “How important is it for you to have the possibility of mobile communication during your work?” (n=16)  
(Adapted from: Ammenwerth 2001)



**Figure 4.** Responses of physicians to the question: “How important is it for you to have the possibility of mobile information during your work?” (n=16)  
(Adapted from: Ammenwerth 2001)



The above classification for the types of information that hospital physicians could benefit by accessing, are also transferable to the other health care providers, namely practitioners in clinics, home care, and nursing homes. Nursing homes and clinics do not display the same requirement for practitioner mobility as that of a hospital setting, and therefore the value proposition may not be as strong for those settings. Home care, on the other hand, demonstrates a significant degree of mobility and therefore the associated practitioners could benefit from the use of wireless devices in retrieving information as well as be reachable at all times.

## 5. m-Health Challenges

While the benefits associated with mobile computing outlined in the previous section create a strong value proposition, there are challenges that arise from the implementation of such wireless initiatives in health care. Referring to (Coursaris and Hassanein 2002), a wide range of concerns were identified in the m-Commerce consumer environment. These concerns are listed below and analyzed in the context of m-Health as well:

- **Privacy:** A wireless user's fear that their personal information could be manipulated without their knowledge and/or consent is raised through the issue of privacy. This concern revolves around several electronic privacy principles that are outlined in (Agranoff 1993). In health care, where wireless users (e.g. physicians) are accessing others' personal information (i.e. patients' medical records), the privacy concern is not raised by the user, but rather by the subject of the information being accessed.
- **Security:** Consumer fears regarding the safety of the information exchanged over a wireless network increases with the degree of interaction and the sensitivity of the information exchanged. M-Health involves personal and highly sensitive information, and therefore the associated security concern is high. Main aspects of security concerns revolve around the issues of privacy, integrity, and availability of information. Integrity implies the information is of original source and not altered by unauthorized parties, availability suggest information is made available for authorized parties as needed, and privacy was defined above (Kalaja 2000)
- **Reliability:** It is critical that connection quality be maintained regardless of the network's coverage, since a loss of the connection can result in a loss of data (Nielsen 2000). Given the potentially life-threatening scenarios that m-Health applications may be involved in, network reliability becomes critical.
- **Download times:** Mobile users should not be forced to spend excessive amounts of time to access desired content (Cole 2001). Physicians attempting to access needed information are subject to extreme time constraints, and therefore all the elements impacting download times (e.g. bandwidth, wireless device memory and processing power) should be selected to minimize the lag associated with information retrieval.

- **Cost:** Consumers are concerned with the multitude of subscription plans for wireless service. Cost concerns are also present in m-Health, but here the consideration involves the relevant cost of implementing a wireless solution in the health care facility and the associated return on that investment.
- **Usability:** Information retrieved on wireless devices should suit not only the user's needs, but also the medium. Content needs to be re-purposed for wireless devices (McGinity 2000). Usability raises the questions of how easy it is for the mobile user to access the information sought and what the quality of the overall experience is. Factors influencing the quality of the overall experience include a user's ability to read the screen, input data, manipulate files, and access sites of interest. As m-Health applications begin to handle files that include high definition images requiring a large display area, wireless devices will need to be capable to sustain both the application's as well as the user's requirements.

A recent study on e-Commerce concerns identified privacy and security as the top two concerns for consumers (Head and Hassanein 2002). These concerns are expected to have an increased impact on m-Health given the sensitivity of the information accessed through wireless devices.

In addition to the issues identified above, there are two additional key challenges involved in implementing m-Health, the first of which being the integration of the wireless technology to the existing infrastructure. Integration involves two major components. The first component is the interoperability of the wireless architecture with the existing systems. Most hospitals are operating legacy systems that require a form of middleware or gateway so that the two technologies can communicate. The second component of integration is the accessibility of the information stored in multiple databases. Translation mechanisms may need to be installed that will facilitate presentment of the information to the new end nodes (wireless devices) without being restricted as to what is accessible by the device type. Implementation for both of these components is feasible, but can be costly. Furthermore, integration needs to consider the various roles of the affected practitioners and the lack of a standard terminology among specialists. A sound business case is required for each facility respectively, as the technical requirements would be different in each case depending on the existing infrastructure, the specific process of care in place, and the selected applications for implementation (Ancona 2001).

The next key challenge is the concern over the safety of the wireless technology. Electromagnetic interference (EMI) with medical devices due to wireless communication equipment has been influenced by anecdotal reports, legal concerns, and uncertainty. Consequently, hospitals are either prohibiting the technology (and lose out on the associated benefits of wireless solutions) or allowing it without appropriate management.

The answer lies in between the two approaches, since detailed testing has shown that appropriate system engineering and medical device management can allow compatible operation of wireless devices throughout the hospital (<http://www.mohca.org/presentations/2>). In addition to the EMI, radio frequency (RF) radiation concerns add to the challenge of acceptance for wireless solutions on health care. Although results to date have been inconclusive, this concern has arisen due to some experimental data suggesting a possible link between exposure and tumor formation in animals. These results have not been independently replicated and other studies have failed to find evidence for a causal link to cancer (RFC 2002).

Hoping to leverage the benefits against the challenges identified above, m-Health applications are being constantly investigated and overview is given in the next section.

## **6. m-Health Applications**

Reflecting on the value proposition of m-Health, wireless devices are expected to play an increasingly important role in health care information systems and their use in delivering medical care. So far the capabilities of wireless technology have not been demonstrated through practical m-Health solutions. Although there are several mobile communications applications in development, real-world applications are still rare. A listing of the various applications currently available or in the development stage follows:

- Communication: Both direct (i.e. voice) and indirect (i.e. messaging / alerts)
- Digital Assistant: Supporting access to general information, including address book, scheduling, databases, organizational tasks
- Integrating Healthcare Applications
  1. Emergency Department
  2. Order Entry
  3. e-Prescribing
  4. Point of Care
  5. Clinical Trials
  6. Charge Capture
  7. Information Capture (dictation, structured, and/or away from work)
  8. Accessing information for decision support

As pointed out above, most of these applications are still in the development stage. Challenges discussed in the previous section refrain hospitals and other providers from investing in wireless solutions. However, a positive element in potentially switching to wireless processes is that 95

percent of health care practitioners in the United States use wireless devices. This suggests a shorter learning curve for US health care practitioners, and consequently they are in the position to set the example for the rest of the world to follow.

US mobile vertical market revenue forecast 2005: \$275 M (Merrill Lynch 2001)

## **7. Discussion & Conclusions**

m-Health promises to radically change health care practices. Through wireless solutions, health care providers can remain connected, be reachable, and gain access to needed information in a timely manner. Applications including decision support tools and access of electronic medical records will enable physicians to make more informed decisions, thus reducing the risk of error and enhancing the quality of patient care. In addition m-Health, through the optimization of processes (e.g. reduction of paperwork, decreased lag in notification and information retrieval), yields a more efficient and effective delivery of patient care.

While practitioners may recognize the benefits of m-Health, it is only when the executive team understands and embraces this emerging technology that the associated benefits will be realized. For this condition to be met, the challenges identified in this paper would need to be effectively addressed. With security concerns at the forefront, appropriate solutions are constantly being explored. One such solution is the use of small hardware I.D. tokens that are inserted into the mobile devices before use. This approach protects the information from being accessed by unauthorized parties. Also, traditional authentication mechanisms (e.g. login with user ID and password) and innovative solutions (e.g. biometrics) will offer health care executives a plethora of security solutions to choose from (Tabar 2000). Another important choice that the executive team will need to make will be which technology platform to adopt. Wireless device type(s), operating system(s), and supporting middleware and/or database management system(s) are critical in the successful implementation of m-Health. Only then will the practitioners be in the position to take full advantage of this new technology (Nelson 1999).

Early estimates suggest that time savings for practitioners associated with m-Health will be greater than 40 percent, and human errors will be greatly reduced or even eliminated. Known errors include misplacing files (e.g. a patient's medical record) and misinterpretation of practitioners' handwriting (Ancona 2001). The latter accounts for 98,000 deaths per year in the US, resulting from wrong prescriptions issued.

There are several wireless applications that are gaining popularity among health care practitioners. Key characteristics of these applications include the simplification of many of the tedious aspects of clinical work, as well as a reduction in expenses and an improvement in patient care.

These wireless applications range from voice recognition applications for patient note taking, eMedical Records, eReferral, ePrescribing, and ePatient monitoring (in-hospital and out-patient). This presentation will present how these are being used currently in clinical settings and provide some real case studies of such use today - while expanding on how pharma companies can take advantage of these new systems.

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