Wireless Applications in Health Care & Reverse Innovation

It’s all about Politics, Greed and Money

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Summary

Wireless-based and wireless-enabled devices and applications are one of the contributions which ICT (Information and Communications Technology) can make to improving the outcomes and limiting and even reducing the costs of health care for a population. Some innovations in this arena are emerging first in relatively poor economies (“reverse innovation”), and are also applicable and could help improve access to and the quality and economics of health care in rich countries as well. The latter face growing challenges of rapidly rising health care costs as a result of their aging populations, demands for access to new expensive medical technology, and the spread of chronic conditions such as diabetes. Nowhere is this challenge more acute than in the U.S.

The most formidable obstacles to the sensible and beneficial exploitation of m- and w-health opportunities in U.S. health care are political and institutional, not economic or technological. They have their roots in a remarkably rigid and inappropriate application of a “free market” ideology that is being exploited by cynical politicians and selfish, financially powerful interests who profit from the current dysfunctional operation of health care in the U.S. In order to protect their privileges, these powerful individuals and organizations are prepared to lie shamelessly to exploit the fears and ignorance of many Americans who respond favorably, in ways that are admirable in many other contexts, to words such as “freedom” and “individual responsibility”, yet end up supporting policies and actions designed to prevent meaningful reform and restructuring of health care delivery and to ensure the perpetuation of very cruel and unnecessary health-related outcomes for many of their neighbors, and perhaps themselves. These reforms would work to the economic benefit and wellbeing of the U.S. population by creating incentives that actually support rather than inhibit healthy outcomes. They would reduce the scope of special interests to benefit on a large and increasingly unsustainable scale from a system that in many ways is designed to support purely financial motivations, even when these operate to frustrate improvements in the quality, costs and outcomes of health care itself.

1 M for mobile, W for wireless
Introduction

Mobile, or more broadly wireless, communication is one of the many capabilities within the very broad arena of ICT (Information and Communication Technologies) that can bring significant improvements in the quality, effectiveness, and costs of health care outcomes for a population. This arena, known as m-health or more accurately w-health since it does not always involve mobile networks, is also an example of reverse innovation. Reverse innovation is the term given to innovative products and services that are developed and first implemented in relatively poor economies that have until very recently only been the recipients of innovations developed elsewhere in the leading economies of Western Europe, North America, and Japan. The fruits of reverse innovation can then turn out to be applicable and valuable for significant market segments in much richer economies, or even capable of transforming those markets, e.g. inexpensive MRI (magnetic resonance imaging) equipment developed in India. Reverse innovations typically have to be useful and affordable for buyers and users with very limited financial resources, and to be capable of reliable and effective operation in environments with poor or underdeveloped infrastructure in terms of electrical power, transportation, clean water, and repair and service facilities, and adverse conditions with regard to temperature, humidity, and cleanliness. These characteristics of the reverse innovations can then become sources of competitive advantage and/or opportunities for addressing new customers in rich markets whose needs are being poorly (or not at all) addressed by locally developed products and services.

Reverse innovation is one of the major consequences of true globalization, i.e. the “globalization of globalization”, in which scientific, engineering and design skills and inventiveness are no longer confined to the richest economies, but can be found anywhere in the world from Brazil to India, and China to Africa. Even the term “reverse innovation” should probably be replaced with the more accurate term of “ubiquitous innovation”, to avoid the self-centered connotation of the positive word “forward” with the countries (Europe, North America, Japan) that dominated the global economy in the 20th century.

This article outlines some of the initiatives in m- or w-health that may be valuable everywhere, both in regions such as Africa and India but also in rich countries faced with the challenge of managing the increasing costs of delivering health care. These costs are being driven by the combination of aging populations and rising demands for the use of increasingly expensive technology, as well as the spread of chronic conditions such as diabetes. This challenge is most acute in the U.S., which spends far more on health care both proportionately and in absolute terms than any other country, with outcomes that are relatively mediocre. Yet many Americans, despite a self-image of pragmatism, seem entrenched in an ideological rigidity and hostility to evidence and facts about health care
that constitute the greatest obstacle to meeting this challenge. Ironically this ideology, which is accompanied by words such as “individual responsibility”, “freedom”, and “free market forces”, is comparable in the extent of its perversion of the meaning of the concepts2 it professes to admire and respect, to the unyielding attitudes of French Communists. They persisted in presenting the Soviet Union as an ideal example of a society to emulate long after evidence of its inhuman regime became apparent. Some of these Communists continued to defend and praise the Soviet Union despite ample evidence of the horrors and pervasiveness of Soviet gulags, and even after the brutal suppression of the Hungarian uprising of 1956 and the Czechoslovak spring of 1968 by the Soviet army.

Ideological rigidity or ludicrous interpretations or outright rejections of the facts in the American environment are epitomized in the remarks of the new Republican Majority leader, i.e. Speaker, of the House of Representatives, John Boehner. Whenever he trumpets his opposition to health care reform he refers to the current situation in the U.S. as the “best health care system in the world.” This statement either betrays an astounding and shameful ignorance3 on his part, or much worse it demonstrates an even more shameful and cynical willingness to lie, boldly and on a large scale, in pursuit of a narrow minded and utterly selfish objective to gain and retain power (elected office) for himself and a few others, regardless of the damage inflicted on many millions of Americans.

In a more optimistic mode, the remainder of this article outlines the potential for wireless-enabled capabilities to improve the ways in which health care is and can be delivered and administered, while not neglecting the barriers that inhibit their widespread application, especially in the U.S. context.

**Wireless Applications and Opportunities – A Push-Pull Relationship with Health Care**

**Introduction**

Important opportunities to improve health care for both curative and preventive purposes are being developed that are aimed at improving connectivity and communication between patients and their care providers. These opportunities necessarily include as one element connectivity to and from medical devices and systems. One of the major goals of these opportunities is to promote the extension of care beyond hospitals, clinics and doctors’ offices to patients’ homes and other locations. Wireless communications is an important and essential part of these efforts, both because wireless is essential to achieve the ultimate

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2 Orwellian language comes to mind as in Orwell’s own “War is Peace”, or the more subtle and hence more subversive U.S. example of “Death Panels” introduced to describe, completely falsely, sensible counseling about end-of-life issues as a plan to select which people should not receive treatment and be left to die

3 The statement may be true for himself and his fellow members of Congress, but is manifestly far from applicable to tens of millions of his and their constituents.
goal of availability anywhere, at any time, and because some applications are inherently wireless-dependent. These applications involve communication to and from devices in motion, e.g. medical sensors and devices implanted in patients who are active or as a minimum ambulatory, or patients being transported in ambulances.

However, despite their potential value there are significant obstacles in the U.S. to the introduction of new wireless-based products and applications into health care. These obstacles are created by some of the current systemic dysfunctional aspects of the health care sector, notably the criteria that govern how, whether, and which expenditures on behalf of and by patients themselves are or are not reimbursed. Other obstacles are linked to specific wireless-related issues of security and privacy of information, and the very different structures of the wireless and health care industries whose cooperation is needed in some cases in order for new applications to be deployed effectively and efficiently.

Wireless applications can contribute ("push") to achieving the stated goals of sorely needed health care reform, namely controlling its costs and improving the effectiveness and availability of its delivery. At the same time the extent and speed with which wireless products and services aimed at health care are acquired and deployed will depend ("pull") upon the success of efforts at fundamental reforms in health care. Investments in and use of wireless-enabled offerings would, and ideally will be stimulated by reforms which introduce different and more balanced, outcome-oriented sets of incentives for providers, payers and patients that encourage and reward preventive as much as curative interventions, while making it attractive to devote efforts and investments to improving broad wellness outcomes as well as to treating diseases and health problems after they have arisen.

The development of successful wireless applications for health care depends on a combination of progress in wireless technologies themselves, wireless-enabled sensors and medical devices and associated software, as well as batteries and the creation of platforms that facilitate the integration or interoperability of multiple devices and systems. The promise of wireless in health care lies in its capabilities to improve disease management, detect health problems earlier and on a more timely basis when they can often be treated less expensively, and achieve substantial cost savings through outcomes such as reductions in the hospitalization rates and in-facility stays of the chronically ill and elderly. The situation in which a hospital is financially primarily motivated to maximize its bed occupancy rate, like a hotel, is a particularly striking example of the counterproductive aspect (if the desired outcome is maximum wellness) of current health care reimbursement schemes in the U.S.

Today the general public’s awareness of the roles and interactions of wireless technology and services with health care may well be based mainly on the negative consequences and
risks (real and/or imaginary) associated with wireless products and services. Awareness of these consequences is fueled by: (a) Admonitions not to use cellphones in health care facilities, especially around electronic equipment on the grounds of their potential interference with the proper functioning of this equipment; (b) Concerns (highly controversial) about the risks of the prolonged use of cellphones held to the ear, or of living in the neighborhood of cellphone towers, that can allegedly lead to health problems such as cancerous tumors, not forgetting (c) Accidents resulting from the distracting use of cellphones to send or receive voice calls or text messages while driving a car, bus, or subway train or even just walking in the street.

This article on m- and w-health is aimed at other much more positively oriented roles of wireless - as sources of solutions not problems - which are based on the applications and uses of wireless capabilities and services to improve the delivery, quality, timeliness, and availability, as well as reduce the total or life cycle costs of health care. Wireless communication can be used to provide timely, convenient on demand (triggered by a human request and/or an event in a patient) access to and transfer of health care-relevant information. Some elements of this portfolio of positive roles for wireless communication have been presented to the general public thanks to TV programs such as “House” and much earlier “Emergency”, which have included episodes that involve the use of satellite wireless links for telemedicine in remote areas (one episode of House), and of terrestrial wireless links to enable physicians to provide “online” medical directions to emergency medical technicians in the field (“Emergency”).

**Benefits and Inhibitors of Wireless Communication in Health Care**

The value of wireless communication derives from its ability to enable clinicians to monitor patients remotely and give them timely health information, reminders, and support. In principle wireless communication can extend the reach of health care by making it available (of course not all of it, e.g. major surgery) anywhere, anytime. For example wireless-supported outpatient care can make it possible for some elderly patients who would otherwise have to live in very costly nursing homes to continue to live much less expensively at home, or avoid or limit the length of some hospitalizations.

However, there are a number of obstacles or at least unanswered questions that will determine whether and to what extent and if so how rapidly this potential of wireless communication will be realized. They include:

1. **Health industry issues**, such as:
   - Uncertainties about provider reimbursement – who will pay for the wireless-enabled products and applications and how much will they be willing or able to pay?
   - Unclear clinical benefits – can convincing evidence be developed of the health benefits (and/or cost savings in the broader context)?
Concerns about privacy and security – wireless communication is often seen whether justified or not, as being inherently less secure and private than fixed networks, reinforcing broad concerns about access to and possible misuse of electronically stored and transmitted information.

Tortuous and expensive paths for introducing wireless innovations into health care products and services, such as those involving FDA approval.

2. Technological issues, such as:
   - Lack of information standards (fragmentation of health industry between and among private insurers, other payers, and providers) – will key players agree on standards so that common platforms can be developed that facilitate the integration and interoperability of devices and systems produced by multiple sources?
   - Potential information overload for providers.

3. Coordination of wireless services sector with health care
   - The wireless industry contains a few large and many small services providers, which only very partly and accidentally overlap with the service areas, markets and customers of key participants in the health industry, such as hospitals.

Technologies for Wireless-Based Health Care Applications

The most extensive and well known wireless technology is the very widespread deployment of licensed wide area cellular networks with national and even increasingly global coverage, and the expanding uses of cellphones and other mobile and portable terminals capable of handling broadband data, image and even video communication as well as narrowband voice and text traffic. In order for this huge and very costly infrastructure to be used to deliver health-related applications it has to leverage several related technologies, including short and medium range wireless networks and miniaturized sensors (for monitoring) and medical devices (for treatment). Also important is battery technology which determines among other factors which wireless applications are feasible, or can be sustained on battery power alone at the terminal or user end for as long as is required or desired.

Combinations of these technologies are necessary for exploiting a variety of opportunities to monitor patients’ physiological functions remotely, provide information to and from, and enhance support for patients to manage their own health, and in addition assist clinicians to anticipate and respond to patients’ adverse health events effectively and rapidly.

Short- and Medium-Range Wireless

A variety of short-range (up to 10 meters) digital network technologies have freed computers and other devices from being tethered to wires and cables. Perhaps the most familiar example is Bluetooth, a widely used technology that links wireless headsets to cell phones. Bluetooth can also transmit data from a physiological monitor on the body to a nearby external receiver.
Wireless fidelity (Wi-Fi) is a medium-range network standard, the second most recognized wireless technology after wide area cellular networks, that enables laptop computers and other devices to connect wirelessly to the Internet from “hot spots” in millions of homes, offices, and public places.

There is also significant development effort being put into other short and medium wireless technologies such as NFC (near field communications), new generations of Wi-Fi systems, and UWB (ultra wideband communications), which operate at various different frequencies and over various distances. This article is not meant to be a survey of wireless technologies, suffice it to say that many substantial improvements in the performance and feasible applications of wireless communication are anticipated which will benefit wireless-based health care as well as many other applications of wireless capabilities.

**Sensors and Medical Devices**

Miniature sensors are now available that can accurately monitor a range of physiological functions, including physical activity, respiration, body temperature, heart rate, muscle function, blood glucose levels, and oxygen saturation. Increasingly, many sensors are small enough to be worn on or implanted in the body. When their output is linked to external networks, these sensors provide opportunities for remote patient monitoring.

There is growing interest in implantable devices that permit radio communication from within the body, for applications such as:
- Cardiac devices
- Insulin pumps
- Neuro stimulators
- Swallowable diagnostic pills
- Chronic pain relief
- Artificial sight.

A critical element in the effectiveness of sensors and medical devices is the accompanying software that processes their outputs and aids interpretation of the data they generate by tracking trends or detecting important events. Thanks to hardware and software improvements, the accuracy and sensitivity of sensors have been steadily increasing, and the capabilities of medical devices improving, while their sizes and costs have been declining. For example, closed loop dosing, i.e. automatic dosing control based upon measured results, can bring benefits of improved accuracy to patients as well as enhance the information available from pharmaceutical trials in applications such as asthma flowmeter/inhaler and diabetes glucose meter/injection devices.

Another capability of growing interest for future wireless medical devices is image transfer. Applications such as remote monitoring, remote supervision of surgical operations, and point-of-care solutions require high integrity transmission of still and video images, intelligent compression algorithms and techniques to identify the useful data, and avoidance of unwanted, i.e. misleading artifacts.
Batteries

Portable wireless devices depend on batteries to power their operations. The larger the battery the more energy and hence operational life (or time between recharging) it can provide, however the size and weight requirements of many portable devices impose strict limits on the battery size and weight that can be accommodated.

Although research is leading to improvements in battery performance, no major breakthroughs appear likely in the near future. Battery technology is not subject to the famous Moore’s Law of semiconductor technology which has fueled continued orders of magnitude improvements in performance/price over several decades. Much of the recent gain in the performance of portable devices such as cell phones and health monitoring devices has been, and future gains will be, achieved by reducing their power needs rather than by increasing the capacity of batteries.

Applications of Wireless to Health Care

An important theme in the application of wireless technology to health care is that of the “networked patient “. “Networked patient” technology including wireless communication can connect patients and their treatment devices, such as inhalers, with healthcare support professionals and a range of online applications. It can allow healthcare specialists to monitor medication adherence, reduce long-term treatment costs, and improve patient access to, and interaction with, healthcare providers. A system based on a wireless healthcare device platform can connect to an online personal healthcare application through a personal computer or “smart phone”, reminding the patients to take their treatment and sending compliance information to the relevant personal healthcare portal. Both patients and healthcare specialists can access the secure information to monitor progress and connect with one another. Non-patient-specific data from a population of users can also be aggregated and analyzed to provide medical researchers, insurance providers and even policy makers with information to better evaluate a specific therapy's efficacy, improve patient outcomes and lower costs. Pharmaceutical companies with new therapies in Phase IV trials can directly access usage data to demonstrate and document compliance, correlating ongoing use with improved outcomes.

Connecting patients and their therapies with the broader healthcare community makes possible a number of other new and valuable applications to support patients and ensure their proper monitoring and treatment. Parents of children with chronic medical problems and caregivers looking after seniors can monitor compliance and be alerted if a therapy is not being followed correctly. Both patients and caregivers can also be directly rewarded with appropriate incentives for achieving increased compliance. Moreover, they can participate in social media- and other Web-based healthcare communities, sharing information and receiving encouragement from others. The system can also enable remote monitoring to facilitate early detection of potential problems, and lead to preventive or
anticipatory intervention that will avoid the much higher costs of treatments that may have to be pursued if the problems are not detected until later.

In addition to therapeutic applications, wireless communication can also play a useful role, in addition to and/or to complement fixed online communication, in improving administrative procedures in the health care sector, from making and reminding patients of appointments, to facilitating patients’ providers’, and insurers’ interactions with billing systems.

A recent noteworthy development is that the arrival of Apple’s iPhone on wireless (cellular) markets, first introduced in 2007, has generated an explosive growth of applications aimed at or adapted for mobile users from 3\textsuperscript{rd} party developers that are useful – or entertain – for a wide variety of purposes. Health care is among these purposes, including for example physicians’ practice management applications which doctors can access on the iPhone from any location with network coverage that encompass:

- Schedule and scheduling management
- Clinical record management
- Patient accounts management
- Accounts receivable management
- Electronic insurance billing
- Insurance claims management
- Managed care management
- Digital radiography
- Online patient registration and communication

Table 1 shows a few examples of wireless health care applications including the information flows and modes of communications that are involved. One trend in these applications as in many other online applications foresees an expanded role for the transfer of broadband video and multimedia information.

**Table 1: Examples of Wireless Health Care Applications**

<table>
<thead>
<tr>
<th>PHYSIOLOGICAL MONITORING</th>
<th>Sensor Placement</th>
<th>Information Flow</th>
<th>Communication Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>Portable</td>
<td>Wearable</td>
<td>Implantable</td>
</tr>
<tr>
<td>Cardiac</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Glucose</td>
<td>Y</td>
<td>A</td>
<td>Y</td>
</tr>
<tr>
<td>Vital signs</td>
<td>Y</td>
<td>Y</td>
<td>A</td>
</tr>
</tbody>
</table>
1B. Patient Communication and Support

<table>
<thead>
<tr>
<th>Function/Activity</th>
<th>Communication Flow</th>
<th>Information Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Upstream</td>
<td>Downstream</td>
</tr>
<tr>
<td>Appointment Reminders</td>
<td>Y</td>
<td>A</td>
</tr>
<tr>
<td>Health Education</td>
<td>Y</td>
<td>A</td>
</tr>
<tr>
<td>Patient Compliance</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Patient Engagement</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Remote Consultations</td>
<td>Y</td>
<td></td>
</tr>
</tbody>
</table>

*Y: In use; A: Anticipated use*

**Examples of Reverse Innovation in Wireless Health Care**

There are a growing number of instances of m-health business models being implemented in poor countries that could also prove to be valuable for significant segments of the population in developed economies such as the U.S., for example in providing health care in rural areas. In some areas in India health workers move around with backpacks that carry diagnostic equipment. A mobile device captures and interprets the data, which can then be used in telemedicine consultations. This model could be applied to serve remote, especially poor rural populations everywhere who cannot easily travel to distant hospital and medical facilities.

More broadly the collection of health and patient information and the training of rural health professionals, enabled by wireless communication where there may be no communications alternative in poor economies, are leading to applications that can also be applied to improve access to health care in otherwise underserved regions in wealthy countries. Furthermore, the development of inexpensive diagnostic and other types of medical equipment and devices that are designed to be effective and affordable in the economic and operating environments of poor countries can enable health care to be provided less expensively and more extensively in many locations in rich countries, including urban and suburban as well as rural areas, both improving access to and reducing the costs of timely diagnoses and treatment.
Conclusion

The prospects for wireless-enabled products, applications and services in health care reveal a confusing and, like the entire health care sector in many respects, a very frustrating outlook. Wireless applications offer substantial potential benefits, but achieving them is being inhibited and in the worst case blocked by substantial obstacles of which in practice the purely technological ones, although by no means negligible, are far from the most formidable. The successful and productive development, implementation and use of wireless applications in health care require multidisciplinary domain expertise (communications, medical, pharmaceutical) as well as an ability to address and meet the complex, time consuming and formidable financial demands of seeking and obtaining approval from the FDA.

But then there is the knotty question of finding who can and will pay for deployment and use of the products and associated services, and whether there are enough of these buyers and buying power to justify investment in product and applications development and commercialization. For example, it sounds - and is - crazy, but hospitals can lose significant revenues if they find ways to reduce the length of hospital stays of some of their patients, even if these initiatives reduce the total costs of care and deliver equal or superior outcomes. They are penalized financially if they pursue and invest in approaches, such as those which “networked patient” systems can provide, that result in shorter hospital stays and overall savings in treatment costs. At the same time private, for profit insurers are motivated to minimize their costs to reach their profit objectives (returns to shareholders), for which purpose denying claims for service or reimbursement, or delaying reimbursement payments, are obvious tactics, even on flimsy justifications, regardless of the harm these denials may inflict on the health of the patients concerned. Insurers also put pressure on hospitals to minimize the stays of some patients, to minimize the amounts they have to pay out, thereby perversely in many cases actually raising the ultimate costs of treatment if the patient has to be re-admitted as result of complications because of inadequate care and monitoring available to them away from the hospital. These are two examples of the dysfunctional nature and operation of the current U.S. health care “system”, which in important ways works counter to the pursuit of the twin objectives of efficiently overseeing and managing the **total costs** of health care, and focusing on achieving the best possible results for the **overall health and wellness** of the population. Unfortunately the interests and incentives driving major health care players in the current environment too often conflict with these objectives instead of supporting them through collaboration and mutual reinforcement for the ultimate benefit and welfare of patients or “customers”, as the workings of suppliers in ideal “free markets” are in theory supposed to do.
The recent health care reform in the U.S. does in principle tackle some of these perverse aspects of health care in the U.S., for example by limiting the scope of the ability of private health care insurers to deny treatment to their policy holders. However it remains to be seen how widespread and profound an impact this reform will have in practice, especially given the determination of the Republican Party to pursue every possible avenue to frustrate its intent, and their success so far in convincing many Americans that the status quo, with all its cruel outcomes and consequences, is preferable.

Wireless is an essential, although only one component of online applications that can help control the otherwise apparently inexorable rise in health costs and overcome the inadequate and fragmented access to affordable effective, wellness-oriented health care that are slowly but surely strangling the U.S. economy. This trend is eroding, as much as do great disparities in wealth and opportunity, or in the world of telecommunications the so-called “digital divide”, the sense of the country as a society that respects core common values, purposes, and interests and a shared sense of purpose even within enriching and stimulating diversity. Progress in technological capabilities – wireless and other – is both more certain and easier to achieve than transformation of what is wrong with the U.S. health care system so that applications built on this technological progress can make significant contributions towards achieving lower costs and improving outcomes, to bring us to, if not the “perfect” at least a “healthier” day. The looming alternative is a “perfect storm” of inexorably rising costs consuming an intolerable portion of our resources, accompanied by declining health care outcomes for all except a small wealthy minority. This is the path which opponents of health care reform would have us continue to blunder along, whether out of ignorance or deliberate, short-sighted selfishness. Their goal can be characterized as the opposite of the sentiment expressed in a famous speech by Winston Churchill referring to the Battle of Britain in 1940 when the Royal Air Force saved the UK from a German invasion, namely “Never has so much been taken from so many by so few.”

The extent of and rapidity with which the benefits that wireless-enabled health care applications can deliver will be realized will depend ultimately on our success in transforming the motivations and incentives that govern the decisions, behavior, and investment choices of key players in the health care sector.