

# Feasibility of Mobile Phone-Based Management of Chronic Illness

Joshua C. Smith, MS<sup>1</sup>, Bruce R. Schatz, PhD<sup>2</sup>

<sup>1</sup>Dept of Biomedical Informatics, Vanderbilt University School of Medicine, Nashville, TN

<sup>2</sup>Dept of Medical Information Science, University of Illinois, Urbana, IL

## Abstract

*According to the CDC, chronic conditions such as heart disease, cancer, and diabetes cause 75% of healthcare spending in the United States and contribute to nearly seven in ten American deaths. However, despite the prevalence and high-cost of chronic disease, they are also among the most preventable of health problems<sup>1</sup>. How can we use technology to improve self-care, reduce costs, and lessen the burden on medical professionals? Devices to help manage chronic illness have been marketed for years, but are these specialized devices really necessary? In this paper, the authors identify the aspects of the major chronic illnesses that most need to be controlled and monitored in the US today and explore the feasibility of using current mobile phone technology to improve the management of chronic illness. Here we show that even the average mobile phone is capable of improving the management of all relevant health features in some way.*

## Introduction

One of the principal challenges confronting healthcare today, both in the United States and the rest of the world, is the effective management of chronic illnesses such as heart disease, cancer, diabetes, arthritis, and obesity. Chronic health conditions are long-term diseases, injuries with long lasting effects, and perpetual structural, sensory and communication abnormalities<sup>2</sup>. According to the United States Centers for Disease Control and Prevention (CDC), seven out of every ten Americans who die each year will die of a chronic disease<sup>1</sup>. Chronic conditions also cause major limitations in the activities of one out of every ten Americans. The cost of medical care for those with chronic conditions has risen to more than 75% of the \$2 trillion the US spends annually on healthcare<sup>1</sup>. According to the World Health Organization (WHO), chronic conditions are comparably prevalent, expensive, and deadly in the rest of the world<sup>3</sup>.

Despite these numbers, the results of preventative care are encouraging and, according to the CDC, the cost of preventative care is far less than the cost of the complications from an unmanaged condition<sup>1</sup>.

Experts agree that people with chronic illnesses can be successfully treated in their homes and that technology can, and must, play a vital role<sup>4</sup>. But, what diseases, and what aspects of these diseases, should be targeted? Devices to help manage chronic illness have been marketed for years, but are these specialized devices really necessary? The primary question addressed by this paper is whether or not mobile phone technology has progressed to the point where it might be useful in facilitating better care and improved disease management for people with chronic conditions.

## Background

Healthcare professionals caring for patients with chronic conditions often gather health information only during occasional office and hospital visits. Since visits occur infrequently, this data may not paint a completely accurate picture of the patient's health, making it difficult for the doctor to help manage the condition. In addition, most of the impetus of managing a chronic condition is on the patient, many of whom face difficulty in understanding both their disease and the proper way to care for themselves. Fortunately, technology in the form of *health dialog systems* can both improve clinicians' access to patient data and help patients better understand and manage their conditions.

Health dialog systems connect patients in their homes to their care providers, as well as relevant health information. Over the last two decades, many of these systems have been tested in clinical trials and other settings and have been found to be both effective and useful<sup>5</sup>. One of the first successful systems designed to manage chronic health was the *Health Buddy*, developed in the late 1990s and still in use today. It facilitates patient education, as well as encourages medication and lifestyle compliance<sup>6</sup>. It originally connected to doctors' offices through telephone lines, but today makes use of the Internet, modern wireless technology, and a host of peripheral devices. In 1999, Berlin and Schatz introduced Internet Health Monitors, a daily health monitoring system based on individuals using their home PCs to answer questions about their health once each day<sup>7</sup>. A study by Kaiser-Permanente published in 2000

showed that video devices replacing in-home care providers were found to be “effective, well received by patients, capable of maintaining quality of care, and to have the potential for cost savings<sup>8</sup>.” Intel’s recently released *Health Guide* combines an in-home patient device with an online portal for information sharing, enabling clinicians to remotely manage care<sup>9</sup>. As mentioned above, health monitors and chronic condition managers are both effective and commercially viable, but do consumers really need to purchase an expensive, standalone device if they want to improve the management of their condition?

Over the last decade, researchers have been using mobile phones to monitor the spread of chronic diseases, such as HIV/AIDS and malaria, throughout the developing world<sup>10</sup>. In Africa alone, mobile phones have been used to educate millions about chronic diseases, put individuals in touch with healthcare professionals, and remind users to take medication. As of last year, there were 276 million mobile phones in the US covering almost 90% of Americans<sup>11</sup>. Can mobile phones improve management of chronic disease in the US, as well?

## Methods

To determine whether or not mobile phones would be a useful tool in improving the management of chronic illness in the US, we first identified the major chronic conditions to be addressed. Next we defined the aspects of these conditions that need to be managed for the best outcomes and then identified examples. Finally, we identified important device features needed for management and discuss the potential of several current phone models.

### *Chronic Illnesses and Health Features*

The authors developed the list of major chronic conditions from the seminal US Department of Health and Human Services report *Healthy People 2010: Understanding and Improving Health*<sup>12</sup>. The report reflects the recent advances in preventative medicine, disease surveillance, and relevant information technology. The 28 focus areas provided in the report, along with prevalence, mortality, and management information from the CDC<sup>1,13</sup>, were used to identify 10 major chronic condition areas. Using the above resources, each condition was then decomposed into the aspects of the condition that need to be managed and monitored to best control the illness; we refer to these as *health features*. We identified 14 health features, many of them involved in multiple conditions (Table 1). To determine if a mobile phone could be used for that particular health

Disease Areas	Associated Health Features
Arthritis, Osteoporosis, and Chronic Pain	Access to care, Diet, Education, Medication, Physical Activity (PA), Weight
Cancer	Access to care, Diet, Education, Medication, PA, Substance abuse
Cardiovascular Diseases	Access to care, BP, Diet, Education, Heart rate, Medication, PA, Respiration, Stress, Substance Abuse, Weight
Chronic Kidney Diseases	Access to care, BP, Diet, Education, Medication, Substance Abuse, Weight
Diabetes	Access to care, BP, Blood glucose, Diet Education, Medication, PA, Substance abuse, Weight
Hypertension	Blood pressure, Diet, Education, Medication, Weight
Mental Health & Disorders	Access to care, Depression, Education, Medication, Stress, Substance abuse
Overweight	BP, Education, Diet, PA, Weight
Respiratory Diseases	Access to care, Air quality, Education, Heart rate, Respiration, Substance Abuse
STDs/HIV/AIDS	Access to care, Education, Medication

**Table 1.** Diseases and associated health features.

feature, an extensive search of the scientific and popular literature was performed to find examples. Each feature is described below and specific examples are cited for relevant features.

### *List of Health Features*

- 1) *Access to care* mainly refers to the ability communicate with a provider in the case of questions or an emergency. This could be done through voice, SMS (text) messaging, applications for scheduling visits, and traditional voice calls. In terms of emergency care, mobile phones sold in the US report the users’ location when 911 is dialed, either using an onboard GPS locator or the location of the current cell tower.
- 2) *Air quality* is important to those with respiratory diseases such as Asthma and COPD. Researchers at the California Institute for Telecommunications and Information Technology (CalIT2) have already constructed small, low cost air sensors that integrate with mobile phones, detect carbon monoxide and other pollutants, and transmit that information to a web page where anyone can view it<sup>14</sup>. Sufferers then use this information to avoid areas of high concentrations.
- 3) *Blood pressure* is generally measured using a sphygmomanometer. Wireless sphygmomanometers that transmit information to mobile phones for analysis by patients and doctors are currently on the market<sup>15</sup>. Mobile phone monitoring of patients with cardiac problems and hypertension has already proven successful in managing the conditions<sup>16</sup>.
- 4) *Blood glucose* levels are the most important concern for sufferers of diabetes. Levels are checked

with a blood glucose meter (glucometer). Three years ago in South Korea, mobile phone manufacturer LG released the LG KP8400 – a phone that is also a glucometer, allowing patients to upload their reading directly to clinicians for analysis<sup>17</sup>. SMS messages to report blood glucose levels, remind patients to take readings, and provide feedback have been shown effective, as well<sup>18</sup>.

5) *Depression* often affects those suffering from chronic illness. In Japan, an interactive service allows users to answer cognitive therapy questions on their mobile phones. Replies are analyzed and the user directed to seek help, if necessary. Users are also provided with information on a variety of mental health topics<sup>19</sup>.

6) *Diet* refers to nutrition and its integral role in health and controlling chronic conditions. For example, hypertensives should avoid sodium, diabetics must monitor carbohydrates, etc. Research has shown mobile nutritional support is effective<sup>20</sup>. One service in Japan allows users to take a photo of their meal with their mobile phone and send it, via Multimedia Messaging (MMS), to dieticians who report back the estimated nutrition information<sup>21</sup>.

7) *Education* is crucial to proper self-care. Mobile phones have been proven very useful in this area. Studies using mobile phones for public health education on diseases ranging from asthma<sup>22</sup> to HIV<sup>10</sup> have had dramatic success.

8) *Heart rate* monitoring is important during exercise and for those with cardiovascular and respiratory diseases. The Japanese phone maker NTT DoCoMo's Health Phone can check heart rate by simply taking a succession of quick, close-up pictures of the thumb<sup>23</sup>. Bluetooth heart rate monitors designed to work with mobile phones are also widely available.

9) *Medication* is essential for the management of many chronic illnesses and mobile phones have been shown to improve medication adherence in the US, UK and China<sup>24</sup>. Many US wireless carriers currently offer customers applications with medication reminders, indications, dosing, side effects, drug interactions, and photos.

10) *Physical activity* plays a very important role in health. Several Japanese companies sell Bluetooth pedometers for mobile phones, as well as phones that incorporate an electronic pedometer using an accelerometer, a device that measures movement<sup>25</sup>. Global Positioning System (GPS) locaters in phones allow users to track distance traveled and have been linked to significantly improved outcomes for those using them for weight loss<sup>25</sup>. Endurance training for those with COPD has also been improved through the use of mobile phones<sup>26</sup>. The use of accelerometers to detect loss of consciousness in the chronically ill has been shown to be both realistic and effective<sup>27</sup>.

11) *Respiration* is important in diseases such as COPD and asthma. Peak flow meters, devices that measure airflow, can alert patients to the tightening of the airways hours or even days before any other asthma symptoms are present<sup>28</sup>. Using mobile phones to encourage monitoring and recording of peak flow information has proven successful<sup>29</sup>. Methods requiring only a mobile phone could also be useful; sounds generated by breathing problems are an indicator of disease activity, and it has been shown that mobile phone recordings clearly discriminate tracheal breath sounds in asthma and could be a non-invasive method of monitoring airway diseases<sup>30</sup>.

12) *Stress* is a concern with chronic illness, as it tends to exacerbate most chronic conditions. In Japan, a society known for high stress levels, mobile phone applications that help determine stress levels have proven popular with consumers and financially viable<sup>19</sup>. One system uses a short questionnaire to determine stress or depression, and can help the user contact a mental health professional, if necessary.

13) *Substance abuse* refers to any drugs problems, but particularly tobacco and alcohol. Many programs that use SMS or MMS messages to encourage smoking cessation and reduction in alcohol consumption have been developed for mobile phones, almost all of them showing positive results<sup>31,32</sup>.

14) *Weight* is an influential factor for many of these chronic conditions. Bluetooth scales, able to communicate with mobile phones or other devices for later analysis, are widely available to aid weight loss or to monitor patients with congestive heart failure<sup>15</sup>.

#### *Device Features*

Each of our health features has been successfully managed using a mobile phone. The device features that can be used to implement these different techniques are listed in Table 2. Specific examples for most are given above, but more implementation options can be inferred. Table 3 contains features information for mobile phones currently available from major US carriers<sup>33,34,35</sup>, as well as phones referenced earlier in this paper.

#### **Results**

Past work shows that mobile phones have been used successfully for all identified health features. All phones in Table 3 are capable of SMS messaging and most are capable of running applications. It is most unexpected that even the simplest mobile phone has the capabilities needed to manage all identified health features in at least some way, even if not the most optimal. This is especially promising since newer phones are becoming more feature-rich every year.

## Discussion and Future Work

We have shown that it is technically feasible and, according to past research, quite possible to improve the management of chronic illness using mobile phones. However, it is not trivial to combine these features or implement them on a mass scale. Many important issues must first be addressed.

As mentioned earlier, much has been done in Africa and the developing world using mobile phones with Malaria and HIV/AIDS. The experience from that work will undoubtedly be useful in designing systems for use in the US. The success of those efforts reveals that researchers have already begun to tackle many of the issues involving design, proper training, connectivity, and usability.

For some of the more complex management we have discussed here, usability and user-interface design are of prime importance. Current health phones focus mostly on niche markets, like fitness; the medical market, largely unaddressed, would certainly need more sophisticated interfaces. New touch interfaces, such as the Apple iPhone and the Google Android platform, are a significant improvement in terms of usability. That being said, current work in Human-Computer Interaction and Biomedical Informatics are certain to contribute more to the usability of mobile phones for health management in the future.

Additionally, the fact that users in Japan and Korea are adopting similar technology is encouraging, but it does not necessarily mean that Americans will do the same. Cultural attitudes towards mobile phone management of chronic illness, as well as motivation of those who suffer from these conditions to take a more active role in their care, must be studied further.

Device Feature	Associated Health Features
Applications & Data Network	Access to care, Air quality, Blood pressure, Blood glucose, Depression, Education, Heart rate, Medication, Diet, Physical activity, Respiration, Stress, Substance abuse, Weight
Accelerometer	Access to care (loss of consciousness), Physical activity
Air Sensor	Air quality, Respiration
Glucose Meter	Blood glucose
Bluetooth	Blood pressure, Blood glucose, Heart rate, Physical activity, Respiration, Weight
Camera	Education, Heart rate, Diet
GPS	Access to care, Physical Activity
SMS/MMS	Access to care, Air quality, Blood pressure, Blood glucose, Depression, Education, Heart rate, Medication, Diet, Physical activity, Respiration, Stress, Substance abuse, Weight
Voice	Access to care, Respiration

**Table 2.** Device and related health features.

This paper has illustrated the technical feasibility of managing chronic illness with current mobile phones. The rapid evolution of mobile phone technology ensures that the capabilities of the “average phone” will only improve, further expanding the possibilities. There is still much work to be done, but we believe the mobile phone will eventually lead to both improved care and improved disease management for those suffering from chronic illness.

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Mobile Devices	Apps & Data	Accelerometer	Air Sensor	Blood Glucometer	Bluetooth	Camera	GPS	SMS / MMS	Voice
iPhone 3Gs <sup>34</sup> (Apple smartphone, \$199 w/ contract)	X	X			X	X	X	X	X
G1 with Google <sup>35</sup> (smartphone, \$99 w/ contract)	X	X			X	X	X	X	X
NTT DoCoMo Health Phone <sup>23</sup> (Japan)	X	X	X		X	X		X	X
LG KP8400 <sup>17</sup> (Korea)	X			X		X		X	X
Samsung Knack <sup>33</sup> (\$39 w/ contract)								X	X
Nokia 2705 <sup>33</sup> (\$29 w/ contract)	X				X		X	X	X
Samsung Rugby <sup>34</sup> (\$179 w/ contract)	X				X	X	X	X	X
Samsung Gravity <sup>35</sup> (free w/ contract)	X				X	X		X	X
LG Chocolate Touch <sup>33</sup> (\$99 w/ contract)	X	X			X	X	X	X	X

**Table 3.** Current mobile phones and device features.

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