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# Analyzing User Acceptance of Mobile Technology in Clinical Settings through Point-of-Care Mobile Applications

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ANALYZING USER ACCEPTANCE OF MOBILE TECHNOLOGY IN CLINICAL SETTINGS THROUGH POINT-OF-CARE MOBILE APPLICATIONS

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**ABSTRACT**

The advent of mobile phones has led to global connectivity surpassing any global conversation previously known. However, despite having access to this global network through mobile devices and ever expanding internet access, many developing countries still lack basic medical technology.

In many resource-poor medical settings, existing monitors used to process and display medical data received from various sensors (temperature, blood oxygen saturation, heart rate, blood pressure, etc.) are either missing or unreliable. Furthermore, these devices are rarely designed with an interface appropriate for the needs of the end user.

Additionally, the use of mobile apps for medical purposes is increasing in developing nations. However, very little structure exists to properly evaluate the usability and potential of specific medical apps.

My project aims to provide an alternative to traditional monitoring systems by creating a mobile application for smartphones and tablets that serves to display patient vital signs through a modality that is easily learned and understood by the targeted end user. My project proposes to utilize current mobile phone technology available in rural, developing communities, as well as clinical settings in developed countries, to process and display patient vital signs for diagnostic and point of care purposes. The focus of this study was the experimental analysis of the mobile application user interfaces to promote widespread acceptance and continuous use of the technology for more consistent recording of patient vital signs.

Three user interfaces were created for both smartphone and tablet devices and tested at two locations: Oaxaca, Mexico and Clemson, SC. These interfaces were systematically reviewed by measuring potential end users' response to the technology following their direct interaction with the mobile applications. User experience was assessed using a survey that evaluated layout and function of the applications. Statistical analysis of the survey results revealed a variety of correlations between interface design and usability. It was also determined that the technology has the potential for widespread, global implementation. However, further studies integrating the mobile sensors into the interface design should be performed to determine the full potential of the technology.

## DEDICATION

To my parents, who taught me that one of life’s greatest gifts is the ability to learn

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# CHAPTER 1: INTRODUCTION

## 1.1: Motivation

The advent of mobile phones has led to global connectivity surpassing any global conversation previously known. However, despite having access to this global network through mobile devices and ever expanding internet access, many developing countries still lack basic medical technology.

It is well documented that vital sign monitoring is essential for proper care[1]. In many resource-poor medical settings, existing monitors used to process and display medical data received from various sensors (temperature, blood oxygen saturation, heart rate, blood pressure, etc.) are either missing or unreliable[2]. Additionally, diagnoses are limited by clinicians' lack of training on these devices, both in use of the equipment and repair of the equipment[2]. Many of the vital sign measuring devices provided to resource-poor clinics are donated, often lacking instructions in the native language of the end user (if any instructions are provided at all). Furthermore, these devices are rarely designed with an interface appropriate for the needs of the end user[2]. This equipment is usually outdated, making replacing parts difficult to find. In addition to resource-poor settings, mobile clinic settings in developed countries, such as blood donation buses, are hindered by the large size of vital sign recording devices.

In addition, the ubiquity of mobile devices in the United States and other developed nations has led to the creation and increasing popularity of medical mobile apps. While these apps have the potential to become a revolutionary tool in modern medicine, very little standardized methods have been devised to measure the usability of medical apps.

My project aims to utilize current mobile phone technology available in rural, developing communities, as well as mobile clinic settings, to process and display patient vital signs for diagnostic and point of care purposes. The focus of my research is the experimental assessment of the mobile application user interfaces to promote widespread acceptance and continuous use of the technology to ensure consistent recording of patient vital signs.

### 1.2: Research Aims

Aim 1: Design Mobile Apps for Patient Vital Sign Measurement

A series of patient vital sign mobile device apps were developed for both cell phones and tablets. The apps allowed for point of care patient vital sign display on Android based devices. A total of 6 mobile apps were developed for this study.

Aim 2: Test User Interfaces for End User Acceptance

A survey was designed to systematically test the usability and applicability of the patient vital sign apps developed for the study by potential end users of the technology. Surveys were conducted with nurses in a hospital in Oaxaca, Mexico and nursing students at Clemson University in Clemson, SC. Statistical analysis of the survey results was performed to determine app usability.

Aim 3: Determine Location-Based Relevancy

Study populations for usability and interface evaluation were selected from both the United States and Mexico. Minor interface alterations were conducted to adapt the patient vital sign apps to each population. Comparative statistics were performed with the survey results of each participant population subset (U.S. vs. Mexico) to determine the location-based response of the app technology.

**1.3: Overview of Thesis Structure**

In Chapter 2, the history and importance of patient vital sign testing in diagnosing and treating medical ailments will be discussed. Additionally, a brief review of current instrumentation for patient vital sign test and monitoring will be provided, with a particular focus on instrumentation in resource-poor settings. The conception, development and significance of mobile, smart device applications will be discussed; both in general terms and as they pertain to the medical profession and clinical settings.

The methods for app development, survey development, survey distribution and administration, and statistical analysis of the survey results will be discussed in Chapter 3.

In Chapter 4, the results of the surveys from both General Hospital in Oaxaca, Mexico and Clemson University Nursing department will be presented. A discussion of the clinical relevance and implication of these results will be conducted in Chapter 5.

In Chapter 6, conclusions drawn from the study will be presented and suggested future studies will be offered.

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# CHAPTER 2: BACKGROUND

## 2.1 Introduction

From personal fitness monitors to banking tools to social media platforms, mobile apps for wireless devices such as smartphones and tablets have revolutionized how society utilizes mobile technology. With mobile devices becoming increasingly prevalent in settings as diverse as elementary school classrooms to executive boardrooms, it is not surprising that there is a great interest in applying mobile technology to a variety of medical needs and procedures.

Since the mobile app developed for this study is intended to measure and display patient vital signs, we will first give a brief overview of patient vital sign measurement, monitoring and its clinical significance. The history of mobile technology and its introduction to the medical field as well as barriers for introduction of mobile apps into medicine will be discussed. Finally, a brief overview of mobile app usability evaluation will be presented.

## 2.2: Patient Vital Sign Measurement

The earliest record of persons measuring vital signs is dates back to 3000 BC with ancient Egyptians who used biometric measures to identify individuals[1]. In the Edwin Smith Papyrus, an ancient Egyptian medical text, the measurement of pulse is described[2]. An excerpt from the Smith Papyrus detailing the measurement of the pulse is shown below:

*"Now if the priests of Sekhmet or any physician [29] put his hands (or) his fingers upon the head, upon the back of the head upon the two hands, upon the pulse, upon the two feet, he measures (h't the heart, because its vessels are in the back of the head and in the pulse; and because its pulsation is in every vessel of every member."*[3]

Though the discovery of many of the bodily functions regularly measured and recorded as vital signs in modern medicine can be dated back thousands of years[2], the recording of patients' vital signs as a standard practice of care has only been conducted much more recently. The first reference to vital sign measurement as a standard practice of nursing care was in 1893 in an autobiographical account by Mary Roberts Rinehart, in which she states, "at 4 o'clock temperatures were taken."[4] In Toronto in 1893, and in Australia in 1934, nursing textbooks reference the measurement of temperature, pulse, and respiration, but not blood pressure (BP) collection[5]. Blood pressure was added as a standard vital sign to most nursing texts in the 1950s and more widely in the 1960s[5].

While very few alterations have occurred to the definition of vital signs since the 1950s (temperature, blood pressure, pulse rate and respiration), vital sign measuring devices have undergone drastic changes. For example, thermometers used for patient temperature measurement have changed drastically over the last three centuries years. The first oral thermometer to measure a patient's temperature was developed by Santorio in 1612 and was over a foot in length, making it cumbersome to accurately collect a patient's temperature[6]. It wasn't until 1866 that a smaller, 6-inch version of the mercury-filled glass thermometer was developed by Clifford Allbutt[6], which allowed for much easier temperature measuring and the practice became more widely adopted. Recent advances in thermometer design have included digital thermometer, electronic direct and predictive thermometers, infrared ear thermometers, and dot matrix or phase-change thermometers[6].

Figure 2.1: Drawing of one of three thermometer designs by Santorio[7]

Another vital sign measuring device that has experience significant technological improvement is the pulse oximeter, which is used to measure pulse rate and blood oxygen saturation. The original clinical pulse oximeter that was marketed by Hewlett Packard in the 1970's was a self-calibrating, 8- wavelength oximeter that weighed over 35 pounds and cost approximately $10,000[8]. Biox Corporation first introduced the use of Light Emitting Diodes (LED's) for the red and infrared light sources in oximeters and they, along with Nellcor and Novametrix, worked to reduce the cost and size of oximeters[8]. Accuracy of pulse oximeters continued to improve throughout the 1990s. Today, many oximeters are battery powered and self-contained, no longer needing an external display screen to read out pulse and blood oxygen saturation measurements.

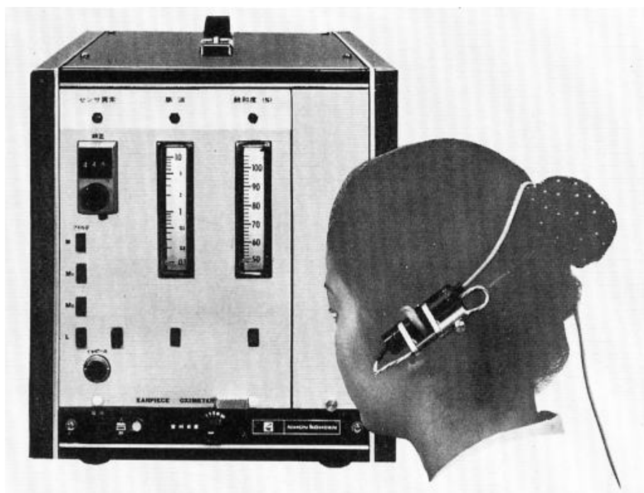

Figure 2.2: OLV – 5100 Ear Oximeter developed by Nihon Kohden in 1974[9]

In the United States and other developed nations, measurement and documentation of vital signs is a commonplace practice that is essential to the diagnosis and treatment of disease. However, in rural or resource-poor settings, which often lack appropriate supplies, electricity and staff, vital sign measurement and recording, if performed at all, is often unreliable and inconsistent[10]. During trips to hospitals and clinics in Tanzania and Mexico, it was observed that many of the patient vital sign monitors were broken, missing necessary components, or simply abandoned due to lack of instruction or repair information. Examples of broken and outdated patient vital sign displays are shown in Figures 2.3 and 2.4.


Figure 2.3: Patient monitor with malfunctioning alarms in Tanzania

Figure 2.4: One of multiple patient monitors in Mexico abandoned due to missing parts

Accurate vital sign measurement has been proven to provide essential, baseline data for treatment decisions and historical trends[11]. Lack of appropriate patient vital sign measurement and monitoring in these resource-poor settings has the potential to put the patient's health at greater risk.

**2.3: History of Mobile Devices and Mobile Device Applications**

The Motorola DynaTAC 8000X was released in 1983 as the first commercially available cell phone. Measuring 13 x 1.75 x 3.5 inches and weighing 28 ounces with a battery that lasted less than half an hour on average, the original cell phone was more of a novelty than a functional device[12]. This phone could place calls and had a very simplistic contacts application[13]. Improvements in battery technology, and subsequent decreases in cell phone prices, allowed cell phones to become more functional, as well as more ubiquitous.

Figure 2.5: DynaTAC 8000x Advertisement

Many of the first cell phone apps were simplistic games that could be played using the buttons on the phone to control the movement of pixels on the screen. Some of the most notable early apps were Snake, Tetris, and Pong[13].

In the early 2000's, cell phone users desire for increased cell phones functionality led to the development of the Wireless Application Protocol (WAP), which is essentially a version of Hypertext Transfer Protocol designed to work within the memory and bandwidth constraints of cell phones[13]. Early web pages developed for WAP were much more simplistic than their Hypertext Transfer Protocol counterparts to better accommodate the slower speed, low resolution, and small screen size of early cell phones[13].

Despite initial excitement, WAP fell short of its commercial expectations, mostly due to high costs and slow speeds. This led to the development of Proprietary Mobile Platforms. With the reduction in cost for memory, devices were able to run compact versions of operating systems, such a Windows and Linux[13]. One of the first mobile phones with a proprietary mobile platform was the Palm OS, which utilized the Sun Microsystems Java platform[13]. The Apple iPhone iOS was subsequently introduced in 2007 followed by Google Android in 2008[14].


Figure 2.6: Example of early Palm OS Apps[15]

Mobile device apps became significantly more popular following the introduction of 3G wireless digital networks, particularly after 2005, when High-Speed Downlink Packet Access (HSDPA) was implemented into 3G and expanded its data carrying ability[14].

In 2010, Apple introduced the iPad tablet computer, whose ease of use, portability, and a comparatively large screen led to the rise of tablets as a computing tool[16]. Google Android OS based tablets that were released later that year further increased the popularity of tablet technology[16].

As of 2012, the Apple mobile app market had reported over 30-billion app downloads[14]. By January 2014, Apple over 1 million apps were available through the iTunes Appstore[16].

**2.4: Mobile Device Technology in Medicine**

It is not surprising that with the high popularity of mobile apps for general use that there has been a significant interest in the potential application of the technology for medical purposes. There currently exist a plethora of mobile apps targeted at health care providers. These medical apps are designed for a variety of purposes including: information and time management; health record maintenance and access; communications and consulting; reference and information gathering; patient management and monitoring; clinical decision-making; and medical education and training[16]. Medical apps have become so popular among healthcare providers that in 2008 the Apple App Store created a dedicated medical app category[17]. A study performed in June 2012 found that doctors' ownership and use of mobile devices is highly pervasive, with 87% using a smartphone or tablet device in their workplace[18].

Medical apps have been developed for a variety of uses within medical clinics, hospitals, and learning environments. Over 1,500 mobile medical applications have been developed to assist both patients and their clinicians in managing care[19]. Table 2.1 represents some of the most popular mobile apps used by physicians, as measured by number of downloads. As can be seen from this table, the majority of theses medical apps have non-diagnostic functions.

| | |
|---|---|
| **Information Management** | |
| Evernote | Note-taking and organization |
| Notability | Note-taking and organization |
| iAnnote | PDF Viewer |
| GoodReader | PDF Viewer |
| Box | Cloud storage and file sharing |
| Dropbox | Cloud storage and file sharing |
| Google Drive | Cloud storage and file sharing |
| **Communication and Consulting** | |
| Doximity | Social networking site for MDs |
| **Reference and Information Gathering** | |
| Epocrates | Drug and medical reference |
| Dynamed | Drug and medical reference |
| Skyscape/Omnio | Drug and medical reference |
| Micromedex | Drug reference |
| Dynamed | Medical reference |
| UpToDate | Medical reference |
| Medscape | Medical reference |
| John Hopkins Antibiotic Guide | Medical reference |
| Sanford Guide to Antimicrobial Therapy | Medical reference |
| Medpage Today | Medical news |
| **Patient Management and Monitoring** | |
| Diagnosaurus | Differential diagnosis |
| Pocket Lab Values | Laboratory reference |
| Lab Pro Values | Laboratory reference |
| Archimedes | Medical calculator |
| MedCalc | Medical calculator |
| Mediquations | Medical calculator |
| Calculate | Medical calculator |
| AHRQ ePSS | Screening and prevention tool |
| **Medical Education and Training** | |
| Medpage Today | Continuing medical education |
| QuantiaMD | Continuing medical education |

Table 2.1: Example of popular medical apps used by physicians[16]

A major factor driving the widespread adoption of mobile apps in medical settings is the need for better communication and information resources at the point of care[16]. This may be even truer for resource-poor and rural settings, where local resources and staff are often scarce and lack basic necessities. An advantage of apps for point of care support is that they often replace the function of software typically used on desktop computers, which do not provide the mobility often needed in point of care settings that mobile devices are capable of providing[16].

### 2.5: Barriers to Diagnostic Mobile App Market Entry

As can be seen from Table 2.1, many of the most popular medical apps are for file storage, reference tools, and medical calculators. Despite popularity of medical apps among physicians, of the medical apps available, very few apps are designed for diagnostic or treatment purposes. Perhaps one of the largest barriers to diagnostic mobile apps entering the medical field is the regulatory oversight required for the applications. In the U.S., the primary regulator of medical devices is the U.S. Food and Drug Administration (FDA). The FDA's primary function is to "protect consumers and enhance public health through maximizing compliance with regulated products and minimizing risk"[16]. The FDA has regulated the development, production and use of medical devices for many years. As mobile apps have trended towards diagnostic tools, the FDA has implemented more stringent oversight in the regulation of medical mobile apps. The increasing number of mobile apps being developed for diagnostic purposes prompted the FDA to issue draft guidance concerning the regulation of mobile medical applications in July 2011[19]. On February 9th 2015, the FDA released the "*Mobile Medical Applications Guidance for Industry and Food and Drug Administration Staff*" document. This document explicitly details the oversight and regulation the FDA will have in controlling medical mobile apps. Included in this document is regulations concerning mobile apps that serve as diagnostic tools, stating:

"*Mobile apps that use attachments, display screens, sensors or other such similar components to transform a mobile platform into a regulated medical device are required to comply with the device classification associated with the transformed platform.*"[20]

According to this FDA document, all medical apps that replace the function of currently FDA regulated medical devices will be regulated by the same standards as the device it is replacing. This level of oversight presents a challenge for many app developers. While FDA regulation will help ensure patient safety and require proof of efficacy, it may prevent many potentially beneficial apps from reaching the market due to the increased cost, lead time for production, complexity, and paperwork associated with the testing and clinical trials required for FDA approval of a medical device[19]. It should be noted that the FDA does not regulate the recently popularized wearable devices that track basic bodily functions for personal fitness purposes, such as the FitBit and Apple Watch as these devices are not considered medical devices[19]. A table of medical apps that the FDA will apply regulatory oversight is shown in Table 2.2.

| Description | Examples |
|---|---|
| Mobile applications that are an extension of one or more medical device(s) or displaying, storing, analyzing, or transmitting patient-specific medical device data | Remote display of data from bedside monitors<br>Display of previously stored EEG waveforms<br>Display of medical images directly from a Picture Archiving and Communication System (PACS) server<br>Control of inflation/deflation of a blood pressure cuff<br>Control of the delivery of insulin by an insulin pump |
| Mobile applications that transform the mobile platform into a medical device by using attachments, display screens, or sensors or by including functionalities similar to those of currently regulated medical devices | Attachment of a transducer to a mobile platform to function as a stethoscope<br>Attachment of a blood glucose strip reader to a mobile platform to function as a glucose meter<br>Attachment of electrocardiograph (ECG) electrodes to a mobile platform to measure, store, and display ECG signals |
| Mobile applications that allow the user to input patient-specific information and through the use of formulae or processing algorithms, output a patient-specific result, diagnosis, or treatment recommendation to be used in clinical practice or to assist in making clinical decisions | Mobile applications that provide a questionnaire for collecting patient-specific lab results and either: (1) compute the prognosis of a particular condition or disease; (2) perform calculations that result in an index or score; (3) calculate dosage for a specific medication or radiation treatment; or (4) provide recommendations that aid a clinician in making a diagnosis or selecting a specific treatment for a patient |

Table 2.2: Examples of mobile apps requiring FDA oversight[19]

Another regulatory barrier for the development of mobile health apps is the need to ensure that patient privacy and confidentiality is maintained when using app technology. In the United States, all patient information must comply with secure handling laws set forth in the Health Information Portability and Accountability Act (HIPAA), which was enacted in 1996[21]. While the telemedicine industry has historically maintained patient privacy and protection as a central priority[21], mobile devices present new, complex, and challenging issues related to security. Many of these new security challenges arise during both storage and transmission of electronic patient data[21]. With apps, a patient's confidential medical information can be stored on mobile devices, processed within these apps, and transmitted over networks to and from providers[21]. In order to achieve HIPAA compliance, app developers must employ a variety of security features, shown in Table 2.3, and authentication techniques, shown in Table 2.4, that protect against security breach and information theft of patient data within mobile apps.

| SECURITY OPTIONS | PROS | CONS |
|---|---|---|
| Web server | Security standards for transmission exist | Lack of native functionality of mobile devices |
| | Data stored on secure server, not mobile devices | Dependent on server access |
| Mobile framework | Standardized method between applications and operating systems | Costs for development and testing |
| | Not dependent on operating systems | Working across different mobile platforms |
| OS | Security standards built in | Different OS companies |
| | Shared costs | Complexity for common standards |
| | Partnerships | |
| Combination | Strengths of each option | Time consuming to build |
| | Partnerships | Many dependencies |
| | Standardized across platforms | |
| OS, operating system | | |

Table 2.3: Pros and Cons of Various Security Options for Medical Mobile Apps[21]

| AUTHENTICATION CATEGORY | METHODS |
|---|---|
| Something known | Password |
| | Personal identification number |
| | Pass phrase |
| Something possessed | Mobile device identification number |
| | Tokens (USB, cryptographic, authentication, key fob) |
| | Dongle |
| | Smart card |
| | Radiofrequency indentification |
| Something unique to the person | Fingerprint |
| | Iris scan |
| | Retina scan |
| | Voice print |

Table 2.4: Authentication Methods for Protection on Mobile Medical App Data[21]

While HIPAA clearly defines requirements for patient information security in the United States, patient security regulations and protections vary from country to country, presenting a challenge for a broad, global implementation of medical app technology[22]. Additionally, studies show that health care providers, as well as lay persons, have concern that increased reliance on handheld devices will compromise the confidentiality of their medical information[22]. Concern over data security following the loss of a cell phone or tablet used for gathering patient information has been prevalent among providers[22].

Additionally, currently available medical device infrastructure has the potential to limit the widespread popularity of diagnostic-type mobile apps. For a medical mobile app to be competitive in the healthcare market, the app technology must show a distinct advantage over the currently available medical device[23]. In order to prove efficacy of diagnostic functionalities, many diagnostic-type mobile apps would need to undergo clinical trials, which are both time consuming and expensive[23]. It may prove difficult to obtain funding to test a diagnostic mobile app if a pre-existing device already satisfactorily performs the functions of the app.

**2.6: Usability Testing of Mobile Device Application Interfaces**

With the rapid rise in development and popularity of medical mobile apps, very little structure exists to systematically evaluate the usability of these apps. Unlike other medical resources, such as peer-reviewed journals, there is no standard process to develop and publish a medical resource app[24]. While some preliminary evaluation tools have been produced to evaluate medical app content[24, 25], there is very little existing information regarding standard evaluation guides, and users are often relegated to making decisions about medical app efficacy and usability through trial-and-error or online line review websites[24]. Of available medical mobile apps, more than 95% have not been tested[25]. Currently, many users select mobile apps chiefly on cost of the app[26].

However, high levels of usability are essential to mobile app integration in clinical practices. Poor usability of medical mobile apps can result in interrupted workflow, delays, and introduction of errors[25]. The effects of poor usability often lead to dissatisfied users, decreased effectiveness, and increases in error costs[25], all of which have the potential to be detrimental to an app's success.

Despite a lack of medical mobile app specific evaluation methods, a variety of methods exist for evaluating the usability of general use mobile apps. A technology's usability is defined as "user-computer interactions and the degree to which the technology can be successfully integrated to perform a task in the intended work environment." Three standard approaches exist for the evaluating usability of user interfaces: Inspection-Based Evaluation, User-Based Evaluation, and Model-Based Evaluation[28]. In general, user-based testing is hypothesized to be the most appropriate method for testing medical apps because it allows for direct input from potential end users of the technology, which is essential for diagnostic tools that require evaluation by users experienced with the diagnosis protocols. Specific testing methodologies for usability and their application to medical apps will be further explored in the 3.2: Usability Testing of Medical Mobile Applications.

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## CHAPTER 3: METHODS

### 3.1 Overview

This chapter details the mobile app development, survey design, and vital sign sensor implementation performed in this study. Additionally, study population and participant selection, as well as surveying procedures, are defined. All methods detailed in this chapter were designed to satisfy the goals of the study.

### 3.2 Usability Testing of Medical Mobile Applications

It is well established that usability of mobile applications is essential for the acceptance and continued use of an application. Usability of a technology is defined as user-computer interactions and the degree to which the technology can be successfully integrated to perform a task in the intended work environment[1]. A consumer survey conducted in March 2011 showed that of all apps downloaded, 26% are used only once and that of the people who confirm using their apps, 74% discontinue use by the 10th use[2]. This study also stated that a 32% of study participants claimed that their main reason for discontinuing use of a mobile app was due to its “lack of user friendliness”, or lack of usability[2].

Despite increasing popularity of mobile apps among healthcare professionals, very few studies have been conducted that include health professionals input in the usability and quality assessment of these health apps. In a particular study assessing mobile apps for pain management, health professional involvement as a resource during app development and assessment was found in only 16 (14%) of 111 pain management apps[3]. While some recent research has focused on the design of evaluation methods for medical mobile apps[4], no standardized evaluation tools currently exist to systematically measure quality of these apps[5].

Additionally, many medical mobile apps that were properly reviewed demonstrated poor end-user usability. In a study performed by Whitlock and McLaughlin, three apps for tracking blood glucose were assessed and it was found that each product presented a number of usability issues, including small text, poor color contrast and scrolling wheels[6].

One aim of this study was to assess the usability of each of the mobile app interfaces developed in this study, as described in 3.3 Mobile Application User Interface Design. Very few standardized evaluation methods exist for assessing usability of medical mobile apps. However, usability testing is well defined for general human-computer interactions. Based on International Standards ISO 9126, usability comprises “a set of attributes that bear on the effort needed for use, and on the individual assessment of such use, by stated or implied set of users’ and user, when used under specified conditions.”[7] ISO 9126 further defines usability as “the capability of a software product to be understood, learned, used and attractive to the user, when used under specified conditions.”[7] The main components of ISO 9126’s concept of “quality in use” are illustrated in Figure 3.1. Development of user interface assessment tools for this study was guided by the principles in this standard.

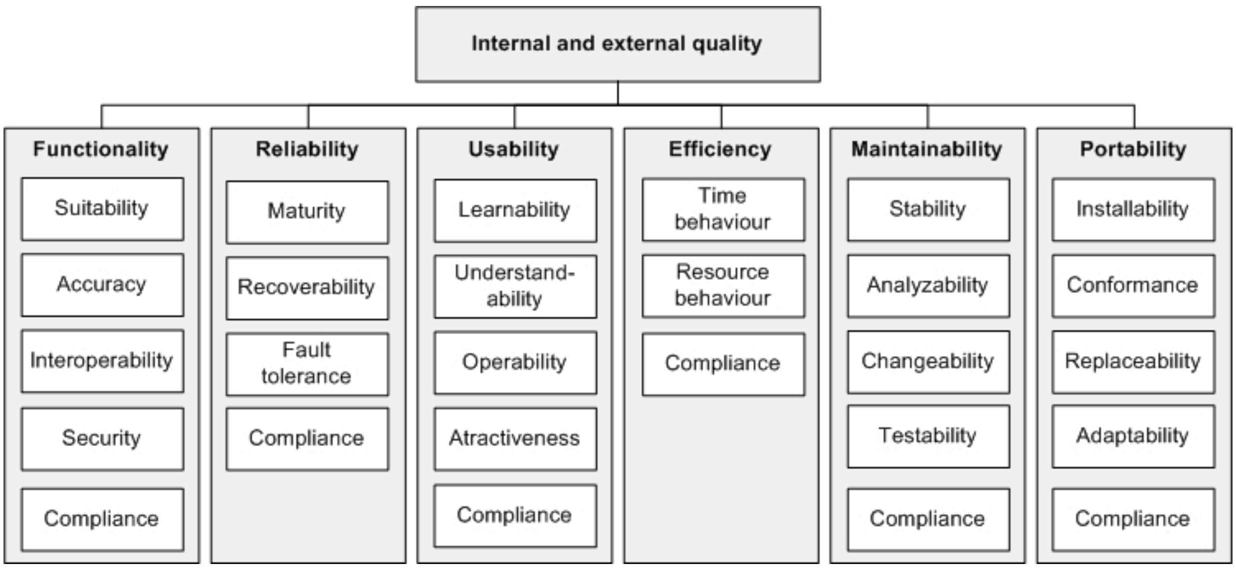


Figure 3.1: Diagram of ISO 9126: Quality in Use[8].

While the use of mobile apps for diagnostic or monitoring purposes is uncommon in healthcare, healthcare providers already use medical devices that incorporate human–computer interfaces. Examples of common medical devices that incorporate human-computer interfaces include infusion pumps, monitors, surgical robots, electronic medical records (EMRs), and radiology systems[9]. Many of these systems are evaluated for usability following traditional human-computer interaction evaluation methods that have been adapted for the healthcare field. By combining current methods for evaluating mobile apps and traditional practices for evaluating medical devices that incorporate human-computer interactions, a methodology for assessing the user interface of the mobile apps developed for this study was created.

Currently, four main classes of evaluation methods exist for evaluating human-computer interactions[10:]

1. Analytical methods – focus on predictive models for user performance
2. Usability Inspection Methods – 'expert' evaluation (also called heuristic evaluation)
3. User Reports – subjective response from potential end users
4. Observation – field or laboratory-based observations of user activity

Determining which study method is "best" is highly subjective and frequently disputed in literature[10]. Selection of evaluation study design is often dictated by the study's purpose (iterative design, initial prototype feedback, field testing, etc.) and availability of resources (expert personnel, finances, time constraints). These study methods can be more broadly classified as inspection-, user-, and model-based evaluations. In general, inspection-based and user-based evaluations are preferred over model-based evaluations due to model-based evaluation's increased cost and limited application[9].

For this study, user-based evaluation methods were selected because of they allow for direct input from potential end-users. User-based testing methods include "user performance measurements, log-file and keystroke analyses, cognitive workload assessments, satisfaction questionnaires, surveys, interviews and participatory evaluation."[11] Questionnaires, surveys, interview and participatory evaluation all allow for direct user feedback about underlying causes of potential usability problems, which is particularly useful during the prototyping and testing phases of design.

User-based tests, in general, are performed in either laboratory or field ("in use") settings. Laboratory settings have the advantage of being highly controlled and interruption-free, but lack context, which may lead to inaccurate perception of the technology and its use by the test subject[12]. While field studies allow for the technology to be evaluated in its most contextual, "natural" setting, potential interruptions could cause test subjects to become distracted and detract from objective evaluation of the technology[12]. For this study, a laboratory-based survey study was selected because it allows for direct feedback from targeted end users about specific features of the user interface and can be performed at minimal cost. In order to conduct this user-based test, a survey was developed and a sample population was determined.

### 3.3 Mobile Application User Interface Design

In order to study the applicability and acceptance of mobile applications for clinical use, a series of interfaces was developed. All user interfaces were developed for smart devices with Android-based operating systems with an Application Program Interface level between the ranges of Application Program Interface level 8 and Application Program Interface level 21. These interfaces were written in Java using

Eclipse Luna developer software. Java code for all interfaces developed for this study can be found in Appendix A.

In total, six unique user interfaces were developed for this study. Three user interfaces were created for display on cellular phones (smartphones) and three were created for display on tablet devices. All user interfaces display the patient temperature, pulse rate, and pulse oximetry. Additionally, all interfaces include a summary screen in which all three vital signs recorded in the app are displayed on the same screen.

Three unique workflows were created to guide the user through the vital sign measurement process following a specific path. Each unique workflow was then designed to have a “mirrored” appearance across both device types. This allows for better viewing of the app on each device by avoiding screen crowding (primarily on the cell phone) or unintentional screen vacancies (primarily on the tablet). By mirroring app appearance across device types, the user is less likely to experience unintentional bias towards a specific interface or device medium due to lack uniformity in user interface appearance between devices.

All interfaces were designed to be compatible with Arduino-based vital sign sensors. The vital sign sensors are designed to transmit the vital sign information to the mobile apps using Bluetooth. The information for the specific vital sign will be recorded by the sensor and transmitted for display upon “Button Click” of the corresponding vital sign button in the interface. These sensors will be further discussed in 3.6 Vital Sign Sensor Integration.

The first user interface is titled "Health App 1" on both the cell phone and the tablet. Of the three apps created for the study, this app contains the most buttons required to obtain a full set of vital signs (seven buttons) and the most screens viewed by the user (four screens). The workflow of this app can be seen in Figure 3.2.

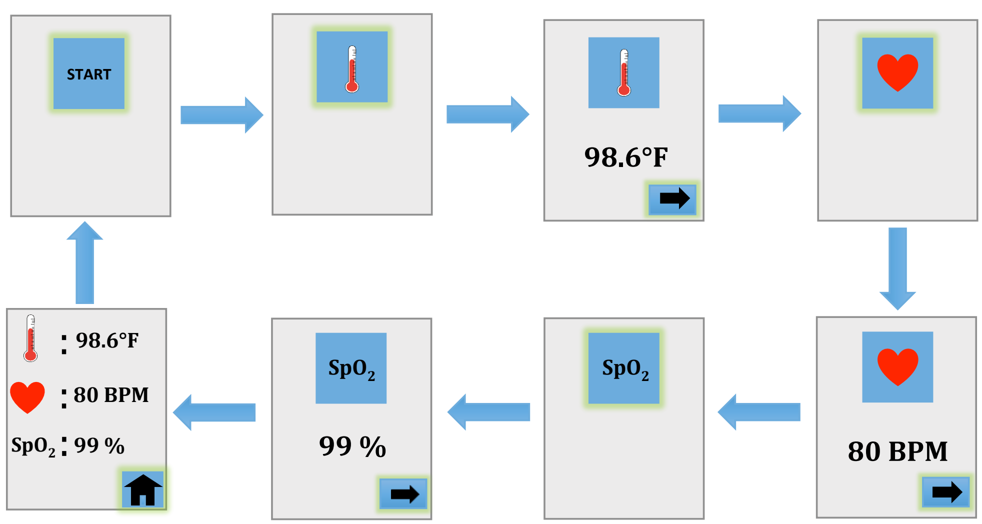


Figure 3.2: Workflow Diagram of "Health App 1" for Both Tablet and Cell Phone

This app interface allows users to see each vital sign on an individual screen, followed by a summary screen of all three vital signs recorded in the session. The user may start a new session by pressing the "Home" button on the lower right-hand corner of the summary screen. This will clear all previously displayed vitals data and return the app to the initial display, the temperature "prompt" screen.

The second app interface, titled “Health App 2” on both the cell phone and the tablet, requires three buttons and one screen to obtain the full vital sign data. The workflow of this app can be seen in Figure 3.3.

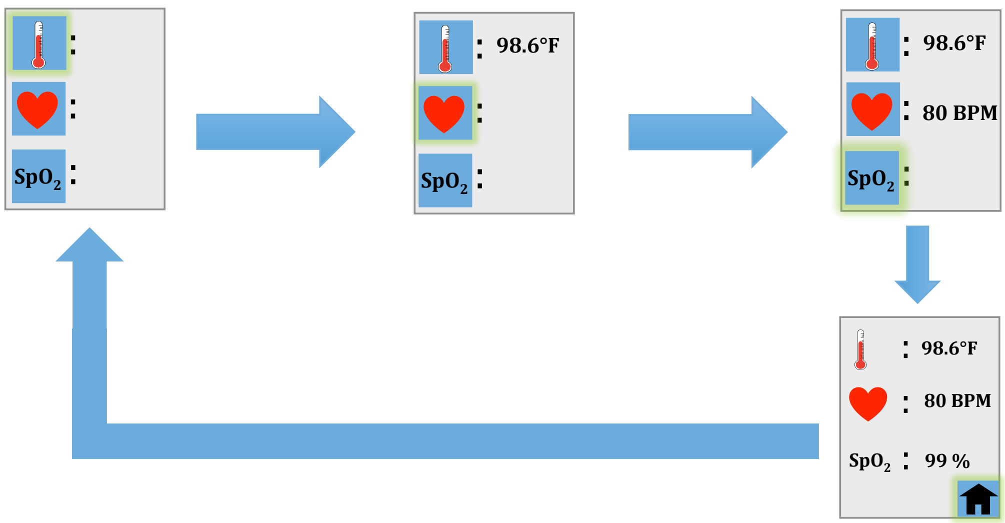


Figure 3.3: Workflow Diagram of “Health App 2” for Both Tablet and Cell Phone

This interface allows users to see all vital signs on a single screen. Using this app, the user selects each vital sign to be displayed individually. This allows the user to determine the order in which each vital sign is displayed. Additionally, the user may choose which vital signs are displayed in a session and is not required to display all vital signs before starting a new session. The user may start a new session by pressing the “Home” button on the lower right-hand corner of the summary screen. This will clear all previously displayed vitals data and return the app to the initial display, three vital sign buttons with no displayed values.

The third app, titled "Health App 3" on both the cell phone and the tablet, contains the fewest buttons required to obtain a full set of vital signs (one buttons) and one screen. The workflow for this app can be seen in Figure 3.4.

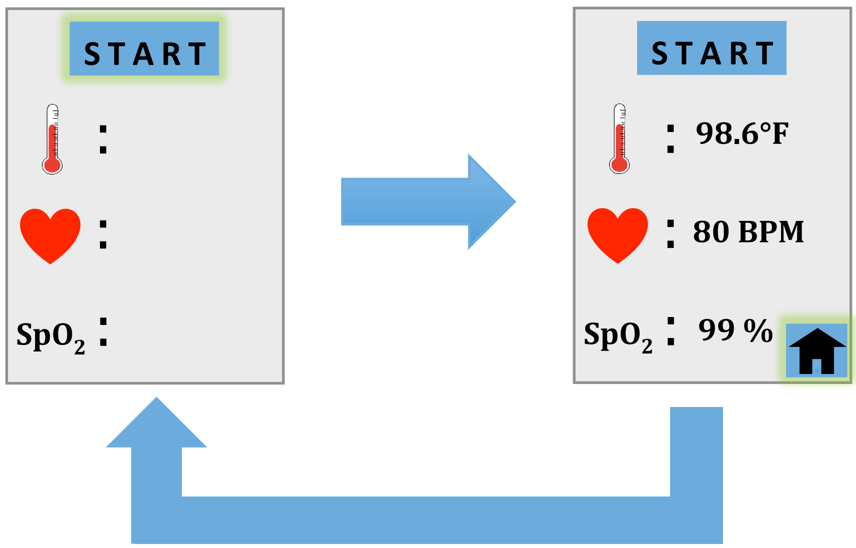


Figure 3.4: Workflow Diagram of "Health App 3" for Both Tablet and Cell Phone

This interface allows the user to view all vital signs simultaneously on a single screen by pressing the "Start" button, resulting in a more rapid display of data. The user may start a new session by pressing the "Home" button in the lower right-hand corner of the screen. This will clear all previously displayed vitals data and return the app to the initial display, three vital sign images with no displayed values and the "Start" button.

The main identifiable difference between the three interface designs is alterations in their horizontal depth. Horizontal depth is defined as the depth that exists between pages within a single level of the menu hierarchy[13]. By increasing horizontal depth, the content contained within the application is divided into an increased number of sequential links that the user must follow, rather than a large list within one page. In this study, Health App 1 has the greatest horizontal depth and Health App 3 has the least horizontal depth. Increasing horizontal depth has implications for both user-perceived complexity and interface layout - screen size interactions. This relationship will be further explored in Chapter 5.

Another key component of user interface development was the creation of an interface that accommodates for changes in screen size. For both tablet and cell phone user interfaces, the screen size itself is reduced from traditional computer monitor sizes. The reduction of screen size for both device mediums has variety of implications that must be considered when designing an effective user interface. Prior studies investigating the effects of small displays indicate that reduced screen size is closely related a variety of user behaviors including alterations in navigation, searching, and browsing[1]. Another study performed testing the effect of reduced screen size demonstrated that reducing a screen size to that of a small display reduced user effectiveness up to 50% for the observed task compared to the user effectiveness of that task performed using a traditional computer monitor[14]. This can influence user interface design in a both content and layout.

A major challenge of the app design was creation of interfaces that equally accommodated both the smartphone and tablet devices. All three user interfaces were designed to be “mirrored” across both the smaller smartphone screen and the larger tablet screen. This allowed for the proportions of the icons and text to remain consistent between both display mediums. For this study, the smartphone-based interfaces were tested with the Samsung Galaxy S3 (4.8”, 720 x 1280 pixel resolution) and the tablet-based interfaces were tested with the Samsung Galaxy Note 10.1 (10.1”, 1280 x 800 pixel resolution). A comparison of the interface appearance between the two devices is demonstrated in Figure 3.5.

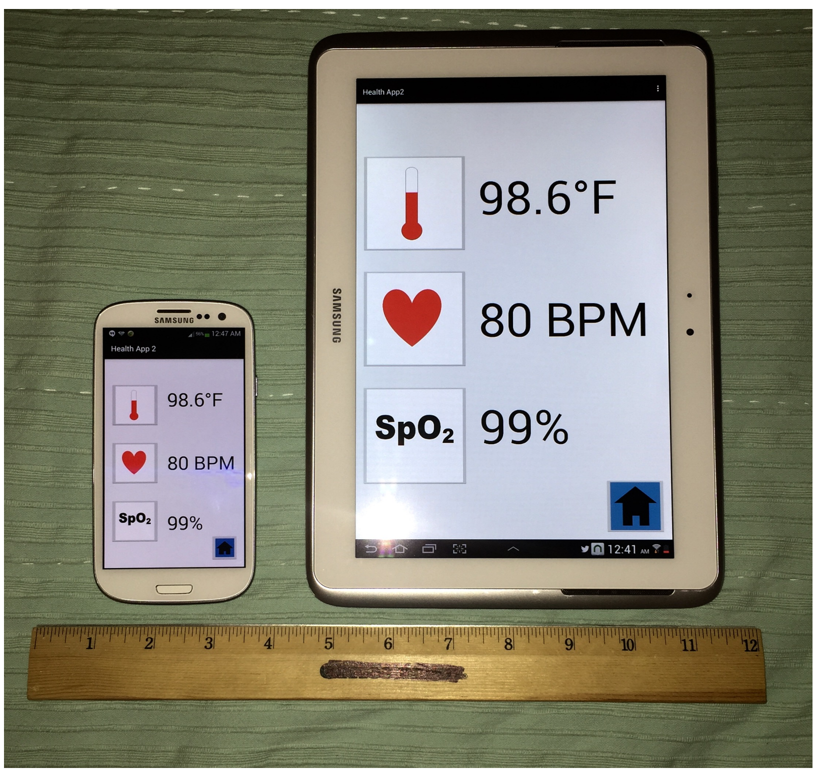


Figure 3.5: Comparison of Smartphone and Tablet User Interface Displays.

There are two common ways to create app interfaces with displays based on screen size: fluid layouts and size-based design. Fluid layouts utilize a flexible grid and flexible content, which ensures that an app can scale to a device's full width[3]. Creating fluid layouts in achieved by referencing content position and size to that of the "parent layout". The resolution and dimensions of the device on which the app is downloaded determine the parent layout dimensions. All content size within the parent layout is defined as percentages of the parent layout, allowing the content size to scale with changes in screen resolution. This method is often preferred as it allows for flexibility from device to device without requiring additional interfaces or content alteration. However, this design method is not always feasible depending on app content. While text objects scale quite easily by enlarging in font size to fit the parent layout, many media objects, such as images, have a default height and width that inhibits proper rendering following scaling[15]. While coding methods, such as applying a max width property, exist to mitigate this failing, they are not always appropriate.

The second user interface design method to create interfaces that accommodate change in screen size is size-based design. Using size-based design, content for interfaces is manually scaled for the target screen solution within the interface code. In this design method, all content and media employed in that design have fully defined dimensions that do not change based on "parent layout" size. Using this method, sets of content are created for each device resolution and all layouts are created for only one screen size. While this requires separate interfaces to be developed for each different screen size the app will be viewed on, it eliminates any potential loss of resolution due to scaling.

All interfaces in this study were created using the size-based design method. All of the buttons within the interface for the various vital sign displays were created using the *ImageButton* function in Eclipse, which implements images imported into the program file to serve as icons for the button features. All images used for these icons were created in Microsoft Word. Because the image files used to create these buttons did not have flexible dimension, they could not be scaled between the smartphone and tablet screen size. In order to accommodate the image buttons, two sets of icon images were created, each manually sized for its intended target screen size. Two separate sets of interfaces (Health App 1, Health App 2, Health App 3 and Health App 1 Tab, Health App 2 Tab, and Health App 3 Tab) were created for the smartphone and tablet, respectively, applying the appropriate set of icon images as *ImageButton*s for each target device.

Another element of user interface design in this study was the creation of an interface that was relatively language-independent, a main consideration in the decision to use pictorial rather than textual vital sign indicators. By creating language-independent interfaces, only minor alterations  are required to accommodate a variety of intended end users. For this study, initial feedback was provided in the form of informal interviews with nurses at Muhimbili National Hospital in Dar es Salaam, Tanzania. Based on the preliminary feedback from the nurses at Muhimbili, the six interfaces described above were developed for testing on both tablet and smartphone devices. A major feature of developing “language-independent” interfaces was the creation of icons that were both universal and clear indicators of their intended function. In order to achieve these requirements, pictorial icons were selected to represent each of the three patient vital signs. The icons for each vital sign can be seen in the example interface shown in Figure 3.6. Effectiveness of this pictorial method will be analyzed and further discussed in Chapter 5.

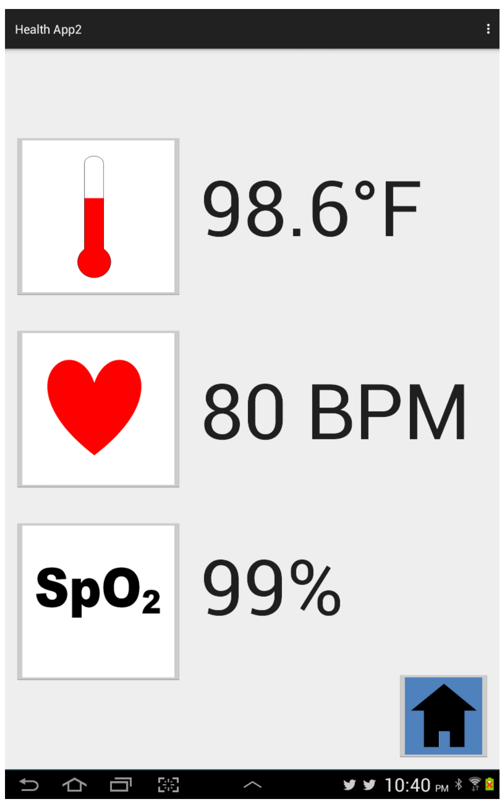


Figure 3.6: Example of Health App User Interface Demonstrating Pictorial Vital Sign Buttons

While all efforts were made to create language-independent interfaces, slight alterations in interface content were required to accommodate changes in intended end user. For this study, nurses at Hospital General Doctor Aurelio Valdivieso in Oaxaca, Oaxaca Mexico were invited to test the interfaces. Since the majority of nurses at Hospital General Doctor Aurelio Valdivieso only spoke Spanish, it was essential that the interfaces were appropriate for use by Spanish-speaking healthcare providers. User interface development for Mexico-based clinicians was easily accomplished with two alterations to each interface. The first alteration was translation of the pulse rate units of “BPM” in the English-based interface to “pulsos por minuto” in the Spanish-based interface. Since this was the only text included in the interface, no other language translations were required. In addition to translation of any text, the interfaces developed for the United States displayed patient temperature using the Fahrenheit scale. For the interfaces developed for Mexico, the interfaces were changed to display patient temperature using the Celsius scale, as this is the scale typically used for patient temperature measurement in Mexico. These alterations can be seen in the side-by-side comparison of U.S. and Mexico interfaces shown in Figure 3.7.

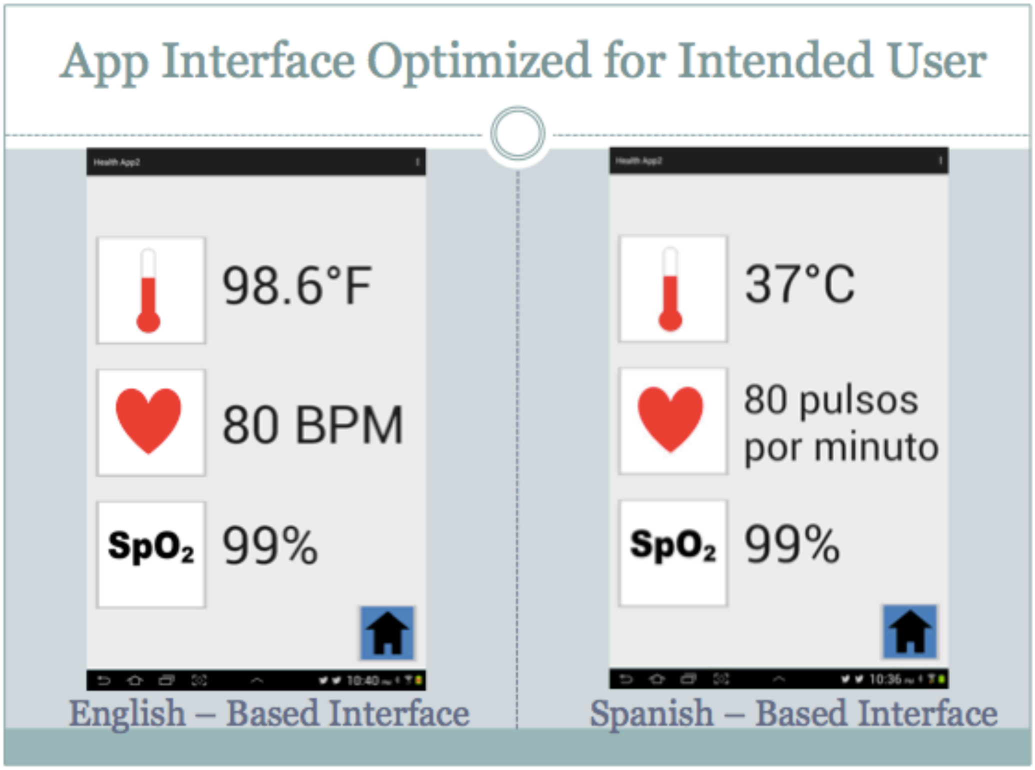


Figure 3.7: Side-by-side comparison of User Interfaces Created for End User Targeting in the United States and in Mexico.

Initial concern was expressed over the global ubiquity of "$SpO_2$" as a symbol for pulse oximetry, however a clinical contact that practices nursing in Mexico confirmed that the $SpO_2$ symbol is frequently used to indicate blood oximetery in Mexico as well. The use of $SpO_2$ as an indicator for oximetry in Mexico was further confirmed while examining available equipment in the surgical unit of Hospital General Doctor Aurelio Valdivieso.


Figure 3.8: Example of Pulse Oximetry Measuring Device in Oaxaca, Mexico

All user interfaces designed for this study and their accompanying features are summarized in Table 3.1.

| | Device Type | Number of Buttons | Horizontal Depth (number of "screens") |
|---|---|---|---|
| **Health App 1** | Cell Phone | 7 | 4 |
| **Health App 2** | Cell Phone | 4 | 3 |
| **Health App 3** | Cell Phone | 2 | 1 |
| **Health App 1 Tab** | Tablet | 7 | 4 |
| **Health App 2 Tab** | Tablet | 4 | 3 |
| **Health App 3 Tab** | Tablet | 2 | 1 |

Table 3.1: Summary of Mobile App Design Features

### 3.4 "User Interface Optimization Survey" Design

To ensure robust results, the survey developed for this study utilizes several components of previously established and verified usability testing methods. Common evaluation methods for usability, such as Computer User Satisfaction Inventory (CUSI)[,16], Questionnaire for User Interface Satisfaction (QUIS)[17], and Software Usability Metric Inventory (SUMI)[18], measure users' attitude towards software, such as mobile apps[19].

Significant portions of the usability surveys developed for this study were based on the System Usability Scale (SUS) and Questionnaire for User Interface Satisfaction (QUIS). A SUS type survey design was chosen for this study because it guides study participants through direct assessment of system usability. Additionally, its Likert scale assessment style has proven to be a robust and effective measurement tool in eliciting strong user response[20]. An example of a scored system usability scale is given in Figure 3.9. QUIS is slightly longer and includes both Likert scale open-ended questions, which provide an overall assessment of a product, and a set of detailed questions about interface components[12].

| | Strongly disagree | | | | Strongly agree | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | |
| 1. I think that I would like to use this system frequently | | | | | | 4 |
| 2. I found the system unnecessarily complex | | | | | | 1 |
| 3. I thought the system was easy to use | | | | | | 1 |
| 4. I think that I would need the support of a technical person to be able to use this system | | | | | | 4 |
| 5. I found the various functions in this system were well integrated | | | | | | 1 |
| 6. I thought there was too much inconsistency in this system | | | | | | 2 |
| 7. I would imagine that most people would learn to use this system very quickly | | | | | | 1 |
| 8. I found the system very cumbersome to use | | | | | | 1 |
| 9. I felt very confident using the system | | | | | | 4 |
| 10. I needed to learn a lot of things before I could get going with this system | | | | | | 3 |

**Total score = 22**

**SUS Score = 22 *22.5 = 55**

Figure 3.9: Example of a Score System Usability Scale Questionnaire[20]

The surveys created for this study also included Likert scale and open-ended questions. The main advantage of open-ended questions in usability testing is that open-ended questions allow the respondent to express an opinion without being influenced by the researcher[21]. Open-ended questions also allow the study participants to give spontaneous responses that the researcher may not have otherwise considered. For example, one question from the study survey is “Compared to the cell phone version, was the tablet app more or less suitable for your needs? Please explain.” This question guides the participant towards specific categories of responses (cell phone or tablet) but also allows for more detailed explanation of preference. While open-ended questions allow for more spontaneous responses, they have a higher reported rate of non-response compared to scaled questions and the results they produce are often more difficult to analyze[21].

One of the main advantages of the SUS survey design is its brevity, which helps prevent survey participants from becoming bored and disengaged during testing[15]. Though all three user interface workflows discussed earlier in this chapter were created into apps for both the cellphone and tablet, not all workflows were tested on both devices. However, all three workflows needed to be tested against one another on the same device to allow for accurate comparisons of the interfaces. Cellphones were selected as the device on which to have users test and compare all three mobile app interfaces. Cellphones were selected over tablets because they have greater global ubiquity which we hypothesize will increase the potential of the cellphone based mobile apps universal acceptance and implementation. Each survey also has users test one of the three workflows on the tablet. The specific workflow (Health App 1, Health App 2, or

Health App 3) tested on the tablet and the order of tablet and cellphone questions is varied across the surveys to eliminate potential bias.

The survey developed for this study, titled “User Interface Optimization Survey”, is comprised of 10 total questions: 5 Likert scale questions, 2 multiple-choice questions, 2 ranking questions, and 1 free response question. Additionally, one of the rank questions and one of the multiple-choice questions includes a free response component. Each survey prompts users to interface with and evaluate all three mobile app interfaces on the cellphone and one of the three mobile app interfaces on the tablet. A survey was created to for each mobile app interface on the tablet. The surveys were also designed so that on half of the surveys, users assess the cellphone-based mobile app interfaces followed by the tablet-based mobile app interface, while the other half of the surveys prompted users to first assess the tablet-based mobile app interface followed by cellphone-based mobile app interfaces. A summary of survey content randomization and design is shown in Figure 3.10.

| **Survey Design Number** | **Interface Viewed on Tablet** | **First Device used for Assessment** |
|---|---|---|
| 1 | Health App 1 | Cellphone |
| 2 | Health App 2 | Cellphone |
| 3 | Health App 3 | Cellphone |
| 4 | Health App 1 | Tablet |
| 5 | Health App 2 | Tablet |
| 6 | Health App 3 | Tablet |

Figure 3.10: Survey Design Summary

An example of the surveys is shown on the following pages. All surveys used in this study can be viewed in Appendix B.

**Mobile Application for Patient Vital Signs Measurement in Clinical Settings**
***User Interface Optimization Survey***

1. How would you rank your level of experience with mobile technology?

   a. No and/or Very Little Experience
   b. Some Experience
   c. A lot of Experience

2. Find the app icon on the **cell phone** labeled "*Health App 1*". Touch the icon to open the app and test the functions in the app. When you have finished exploring the three vital signs functions of the app, please press the blue home icon in the app (not the device) to reset back to the main screen. Based on your experience answer the following questions by encircling the number that most closely represents your opinion:

**Health App 1**

| | Strongly Disagree | Disagree | Slightly disagree | Slightly Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| The app was intuitive | 1 | 2 | 3 | 4 | 5 | 6 |
| The time to display vital signs was appropriate. | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons and texts are clearly displayed | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons used for the app buttons clearly indicate their function | 1 | 2 | 3 | 4 | 5 | 6 |
| The number of screen changes is appropriate to perform task | 1 | 2 | 3 | 4 | 5 | 6 |
| The app was easy to use | 1 | 2 | 3 | 4 | 5 | 6 |

3. Find the app icon on the cell phone labeled “Health App 2”. Touch the icon to open the app and test the functions in the app. When you have finished exploring the three vital signs functions of the app, please press the blue home icon in the app (not the device) to reset back to the main screen. Based on your experience answer the following questions by encircling the number that most closely represents your opinion:

**Health App 2**

| | Strongly Disagree | Disagree | Slightly disagree | Slightly Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| The app was intuitive | 1 | 2 | 3 | 4 | 5 | 6 |
| The time to display vital signs was appropriate. | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons and texts are clearly displayed | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons used for the app buttons clearly indicate their function | 1 | 2 | 3 | 4 | 5 | 6 |
| The number of screen changes is appropriate to perform task | 1 | 2 | 3 | 4 | 5 | 6 |
| The app was easy to use | 1 | 2 | 3 | 4 | 5 | 6 |

4. Find the app icon on the **cell phone** labeled "*Health App 3*". Touch the icon to open the app and test the functions in the app. When you have finished exploring the three vital signs functions of the app, please press the blue home icon in the app (not the device) to reset back to the main screen. Based on your experience answer the following questions by encircling the number that most closely represents your opinion:

**Health App 3**

| | Strongly Disagree | Disagree | Slightly disagree | Slightly Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| The app was intuitive | 1 | 2 | 3 | 4 | 5 | 6 |
| The time to display vital signs was appropriate. | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons and texts are clearly displayed | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons used for the app buttons clearly indicate their function | 1 | 2 | 3 | 4 | 5 | 6 |
| The number of screen changes is appropriate to perform task | 1 | 2 | 3 | 4 | 5 | 6 |
| The app was easy to use | 1 | 2 | 3 | 4 | 5 | 6 |

5. Please rank each of the three apps overall (1 = best, 3 = worst).

   Health App 1 = ________ Health App 2 = ________ Health App 3 = ________

6. Compared to your current instrumentation, is this mobile app based technology useful for your needs? Please rank 1-5: __________(1=not useful at all, 5=very useful) and then please explain.

7. How do you see this technology being utilized? Please check all that apply.

☐ Hospitals ☐ Physician Offices ☐ Mobile Clinics

☐ Resource-Poor countries ☐ Other

If other, please explain:

8. Find the app icon on the **tablet** labeled "*Health App 1*". Touch the icon to open the app and test the functions in the app. When you have finished exploring the three vital signs functions of the app, please press the blue home icon in the app (not the device) to reset back to the main screen. Based on your experience answer the following questions by encircling the number that most closely represents your opinion:

**Health App 1– Tablet**

| | Strongly Disagree | Disagree | Slightly disagree | Slightly Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| The app was intuitive | 1 | 2 | 3 | 4 | 5 | 6 |
| The time to display vital signs was appropriate. | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons and texts are clearly displayed | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons used for the app buttons clearly indicate their function | 1 | 2 | 3 | 4 | 5 | 6 |
| The number of screen changes is appropriate to perform task | 1 | 2 | 3 | 4 | 5 | 6 |
| The app was easy to use | 1 | 2 | 3 | 4 | 5 | 6 |

9. Compared to the cell phone version, was the tablet app more or less suitable for your needs? Please explain.

10. You have been provided examples of temperature and blood oxygen sensors that would accompany this app/device. The temperature sensor is intended for oral use and the blood oxygen sensor is intended for placement on the finger. Take a minute to examine them before answering the following questions.

**Sensors**

| | Strongly Disagree | Disagree | Slightly disagree | Slightly Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| The sensors are easy to understand | 1 | 2 | 3 | 4 | 5 | 6 |
| The sensors are portable | 1 | 2 | 3 | 4 | 5 | 6 |

### 3.5 Study Participant Selection and Test Procedure

Appropriate participant selection was vital to the study, particularly due to the need for interface evaluation by potential end users. As earlier discussed, medical mobile app technology is currently limited by a lack of healthcare professionals' involvement in app design and assessment[4]. For this study to provide evidence for the applicability of mobile app technology in clinical settings, it was essential for usability testing to be performed by clinicians that interface with patient vital sign measuring devices regularly. In most clinics and hospitals, the nursing staff performs all routine patient vital sign measurements. Based on the need to target the opinions of the true end user, nurses and nursing students were selected as the sole participants in the study.

Another aim of the study was to determine global applicability of the technology. In particular, the study aimed to compare acceptance of mobile app technology in resource-poor clinical settings with acceptance in clinical settings in developed countries.

In order to satisfy these aims the following populations were selected for the study:

- Nurses at Muhimbili National Hospital in Dar es Salaam, Tanzania

- Nurses at Hospital General Aurelio Valdivieso in Oaxaca, Mexico
- Nursing Student at Clemson University in Clemson, SC

It should be noted that the nurses' participation in Dar es Salaam, Tanzania on this particular trip was limited to informal interviews and that they have not yet participated in the study survey. These nurses were presented with one initial interface design and provided general feedback about the interface layout and app content. Input received in these interviews provided a framework for development of the interfaces used during all subsequent testing.

All interfaces and surveys were originally written in and designed for English-speaking clinicians based in the United States. These original interfaces and surveys were used during testing with the nursing students at Clemson University. The nurses at Hospital General Aurelio Valdivieso in Oaxaca primarily spoke Spanish. To ensure participant safety and understanding, Dr. Jorge Rodriguez, a native Spanish speaker, prior to testing in Oaxaca, translated all surveys and informational letters from English to Spanish. While all interfaces were designed to be as "language-independent" as possible, minor alterations in interface design were made to better target the nurses in Mexico compared to their U.S. counterparts. These changes were previously discussed in "**Mobile Application User Interface Design**".

All study participants, both in Mexico and the United States, were presented with the informational letter for the study, the study survey and a cellphone and tablet with all “Health Apps” pre-downloaded. The informational letter for this study, in both English and Spanish, and IRB Approved Application can be found in Appendix C and Appendix D, respectively. No identifying information, such as name or birthdate, was collected to ensure the privacy of all participants. Participation in this study was completely voluntary and no compensation, financial or otherwise, was provided. A total of 45 subjects were surveyed, 12 nurses in Oaxaca and 33 nursing students in Clemson. Results of these surveys will be presented in Chapter 4.

### 3.6 Vital Sign Sensor Integration

A major component of the functionality of the patient vital sign measurement apps developed for this study is the integration of wireless vital sign sensors. Though not the focus of this research, preliminary work on vital sign sensor integration was performed.

As previously discussed, patient temperature, pulse rate, and blood oxygen concentration were the vital signs selected for measurement and display by the mobile apps. These vital signs were selected based on a combination of traditional vital sign measures (temperature, respiratory rate, pulse rate, blood pressure)[22] and recommendations from informal interviews with nurses in Tanzania (pulse oximetry). Respiratory rate was not included in this study because it is measured using instrumentation that is both costly and complex to operate. Additionally, the value of monitoring respiratory rate has been previously investigated and findings suggest it may be of limited value[22]. Blood pressure was also excluded from the vital signs measured in this study due to the level of complexity associated with automated blood pressure measurement devices, such an automatic sphygmomanometer. The technical complexity of these devices would make it very difficult and costly to develop a device to interface with the Arduino that is used with all other devices in the study. In general, we did not believe that instrumentation developed to interface with mobile apps for these vital measurements could prove significant clinical benefit over currently available instrumentation.

All sensors included in this study were selected for their compatibility with Arduino. As defined on their website, Arduino is "open-source physical computing platform based on a simple microcontroller board, and a development environment for writing software for the board."[23] Arduino was chosen as the computing platform for the mobile app sensors because it provides a simple, open-source, streamlined programming language with the ability to readily interface with Android. Additionally, Arduino boards are cost effective and a variety of inexpensive, Arduino-compatible sensors are already commercially available. Many of the commercially available sensors also include "plug-and-play" source code that can be implemented for basic sensor function, a distinct advantage of Arduino and Android being open-source computing platforms.

For measurement of vital signs included in this study, two sensors were selected:

- DS18B20 Programmable Resolution 1-Wire® Digital Thermometer
- SI1143-based pulse rate/oximeter Pulse Sensor

Additionally, a Bluetooth serial link designed to interface with Arduino, the Bluefruit EZ-Link by Adafruit shown in Figure 3.11, was used to transmit data collected from all of the sensors wirelessly to the mobile Android apps. Adafruit also provided basic Arduino code for communication between the EZ-Link and the Arduino. Standard, open-source code that enables communicate data between Bluetooth serial links and Android devices is readily available online.

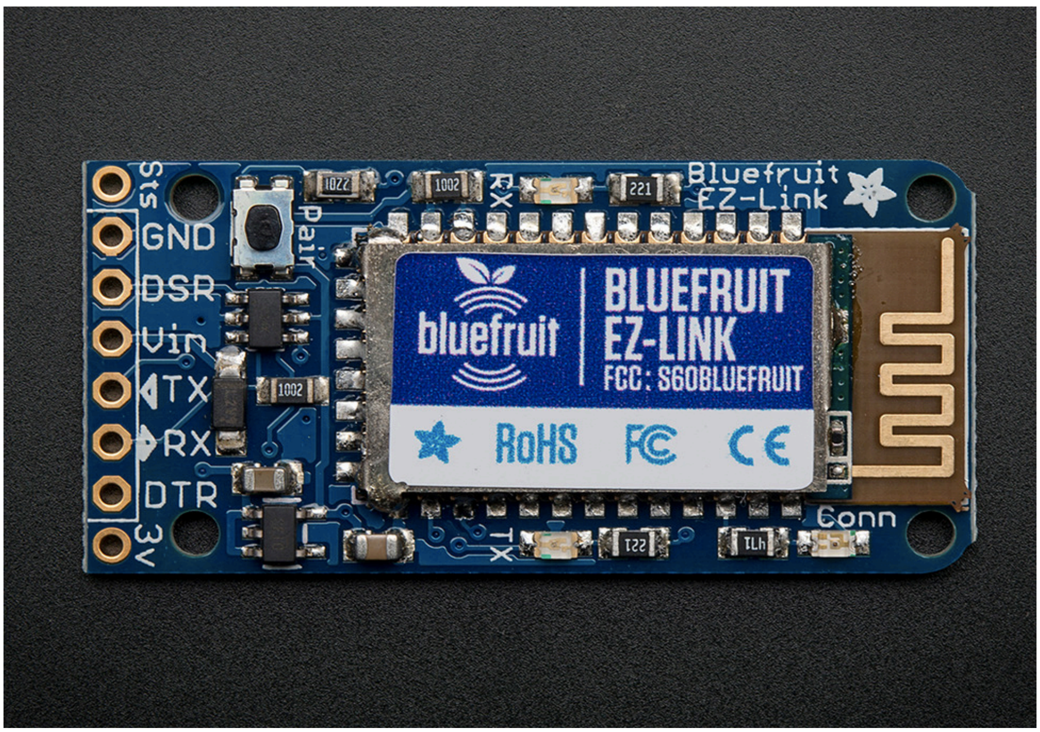


Figure 3.11: Bluefruit EZ-Link Bluetooth Serial Link[24]

The digital thermometer sensor, as shown in Figure 3.12, is used for obtaining oral patient temperature data. The sensor measures temperature by providing 9 to 12-

bit (configurable) temperature readings that indicate the temperature of the device[25]. It utilizes a 1-Wire port to perform all data line communication including reading, writing, and conversion of temperature data.

Figure 3.12: DS18B20 Programmable Resolution 1-Wire® Digital Thermometer[26]

The temperature sensor includes a thermistor that has the ability to measure temperatures from -55°C to +125°C with a ±0.5°C accuracy from -10°C to +85°C[25]. Thermistors, such as the one used in this sensor, measure temperature by measuring how resistance value across a resistor varies with temperature. This particular sensor utilizes a negative temperature coefficient thermistor, which exhibits decreasing resistance with increasing temperature. This change in resistance can then be correlated with the corresponding change in temperature.

The 1-Wire communication line also provides power to the sensor by storing energy on an internal capacitor during periods of time when the signal line is high and continuing to operate off this power source during the low times of the 1-Wire line until it returns high to replenish the parasite (capacitor) supply[25]. This is a particularly unique feature of this device as it reduces the need of external power, which can sometimes be difficult to supply in resource-poor settings. Additionally, it reduces the number of wires required for functionality from 3 wires (data line, ground, and power supply) to 2 wires (data line and ground). From a maintenance and repair perspective, this reduces the points for failure within the device and simplifies its repair, a feature particularly useful for resource-poor settings that may have limited repair equipment and personnel. Figure 3.13 shows a block diagram of the “parasitic” power supply circuitry that allows to sensor to run without an external power source.

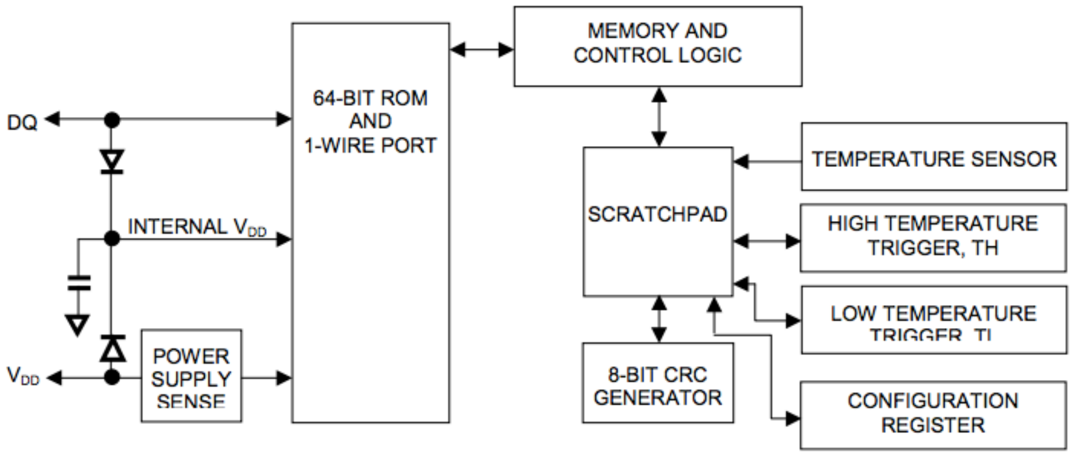


Figure 3.13: Block Diagram of DS18B20 Programmable Resolution 1-Wire® Digital

The temperature sensor measures and transmits temperature to the Arduino using two main steps: Conversion and Read Scratchpad. In the conversion step, a command (Convert T) is issued to the device to perform an internal conversion operation. After this command is issued, the data from the internal analog digital converter is read, converted to a digital output and copied onto the "Scratchpad" memory of the sensor[27]. Examples of conversion of specific measured temperature values to output data are shown in Figure 3.14. The Read Scratchpad command then reads the most recent converted temperature data copied to the sensor's scratchpad memory and that data is transferred to the Arduino over the device's 1-Wire bus[25]. This temperature data is then stored by Arduino until is called within the Android code through an *onClick* function and transferred to the host device using Bluetooth.

| TEMPERATURE | DIGITAL OUTPUT (Binary) | DIGITAL OUTPUT (Hex) |
|---|---|---|
| +125°C | 0000 0111 1101 0000 | 07D0h |
| +85°C | 0000 0101 0101 0000 | 0550h* |
| +25.0625°C | 0000 0001 1001 0001 | 0191h |
| +10.125°C | 0000 0000 1010 0010 | 00A2h |
| +0.5°C | 0000 0000 0000 1000 | 0008h |
| 0°C | 0000 0000 0000 0000 | 0000h |
| -0.5°C | 1111 1111 1111 1000 | FFF8h |
| -10.125°C | 1111 1111 0101 1110 | FF5Eh |
| -25.0625°C | 1111 1110 0110 1111 | FF6Fh |
| -55°C | 1111 1100 1001 0000 | FC90h |

*The power on reset register value is +85°C.

Figure 3.14: Relationship Between Measured Temperature and Data Output at 12-bit Resolution[25]

In general, pulse oximetry is performed using photoplethysmography, which is the non-invasive measurement of pulsatile blood flow by amplifying and filtering measured light absorption by the local tissue over time using LEDs and photodiodes, typically through the finger[28].

Arterial oxygen saturation, the parameter typically measured in pulse oximetry, is defined by the ratio of oxyhaemoglobin to the total concentration of haemoglobin in the blood. Under normal physiological conditions arterial blood is 97 - 99% saturated[29]. This ratio can be determined by comparing the difference in absorption spectra between deoxyhemoglobin and oxyhemoglobin, as seen in Figure 3.15 By measuring the light transmitted through the fingertip at two different wavelengths, one in the red and the other in the near infra−red part of the spectrum, the arterial oxygen saturation can be measured.

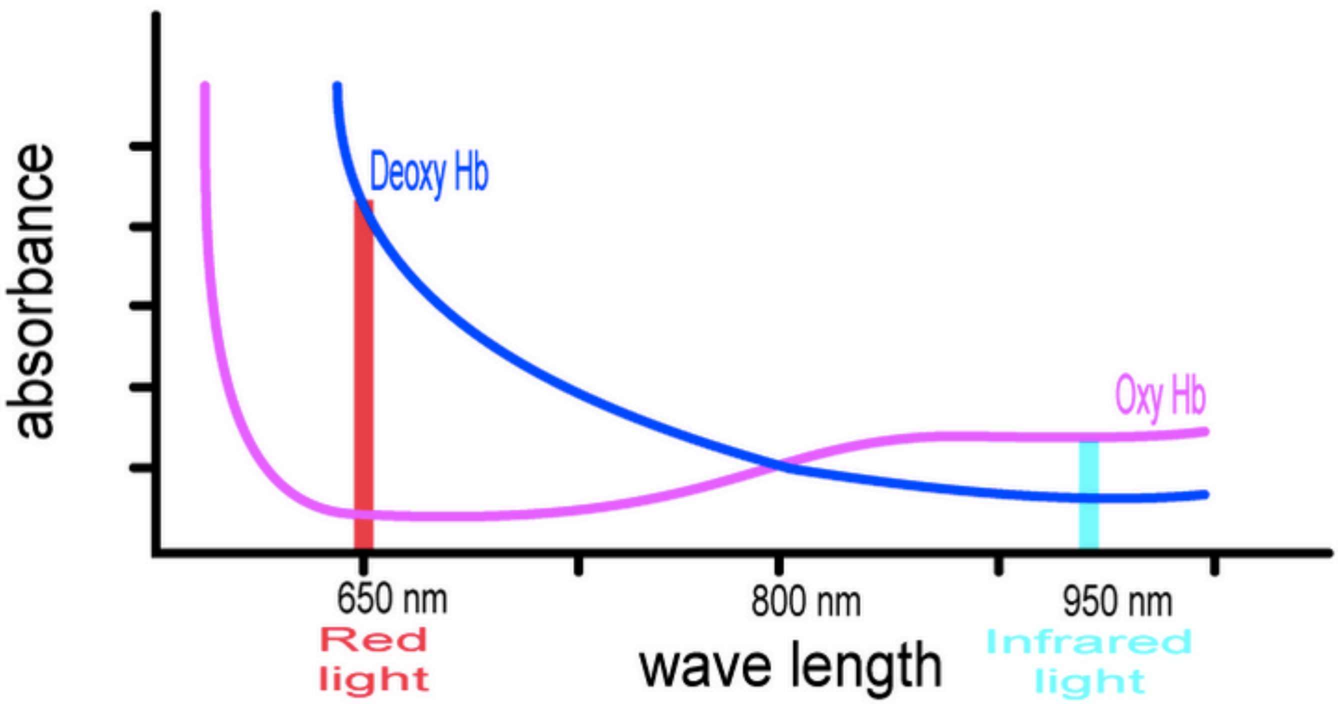


Figure 3.15: Comparison of Absorption Spectra for Oxyhemoglobin and Deoxyhemoglobin[31]

Assuming that transmission of light through the arterial bed is only influenced by relative concentrations of deoxyhemoglobin and oxyhemoglobin and their absorption coefficients at the two wavelengths used for measurement, then following the principles of Beer-Lambert law, as shown in Figure 3.16, the ratio of oxyhaemoglobin to total haemoglobin can be calculated from the measured light intensity absorbed at each wavelength.

At wavelength $\lambda_1$, $I_1 = I_{in1} 10^{-(\alpha_{o1} C_o + \alpha_{r1} C_r) l}$

At wavelength $\lambda_2$, $I_2 = I_{in2} 10^{-(\alpha_{o2} C_o + \alpha_{r2} C_r) l}$

where

- $C_o$ is the concentration of oxyhaemoglobin ($HbO_2$)
- $C_r$ is the concentration of reduced haemoglobin (Hb)
- $\alpha_{on}$ is the absorption coefficient of HbO2 at wavelength $\lambda_n$
- $\alpha_{rn}$ is the absorption coefficeint of Hb at wavelength $\lambda_n$

If we let

$$R = \frac{\log_{10}(I_1/I_{in1})}{\log_{10}(I_2/I_{in2})}$$

then it is simple enough to show:

$$SaO_2 = \frac{C_o}{C_o + C_r} = \frac{\alpha_{r2} R - \alpha_{r1}}{(\alpha_{r2} - \alpha_{o2}) R - (\alpha_{r1} - \alpha_{o1})}$$

Figure 3.16: Beer-Lambert Law calculation of Arterial Oxygen Saturation[29]

Pulse oximetry assumes that the attenuation of light by the body segment can be split into the three independent components: arterial blood, venous blood and tissues[29]. If it is assumed that the increase in attenuation of light is caused only by the inflow of arterial blood into the fingertip, the oxygen saturation of the arterial blood can be calculated by subtracting the DC component of the attenuation from the total attenuation, leaving only the cardiac−synchronous pulsatile component for the dual−wavelength determination of oxygen saturation[29].

The photoplethysmographic (PPG) waveform measured through light absorption can be converted to display information about blood oximetry by passing it through two filters. The first is a band-pass filter that eliminates areas of high variability in the waveform, essentially "auto-centering" the waveform by removing high frequency noise. This signal is then passed through a low-pass filter, creating an automatic gain control (AGC) circuit which adjusts the light intensity from the corresponding LED so that the DC level always remains at the same value regardless of thickness or skin characteristics of the patient's finger[29]. A simplified block diagram of a typical pulse oximeter can be seen in Figure 3.17.

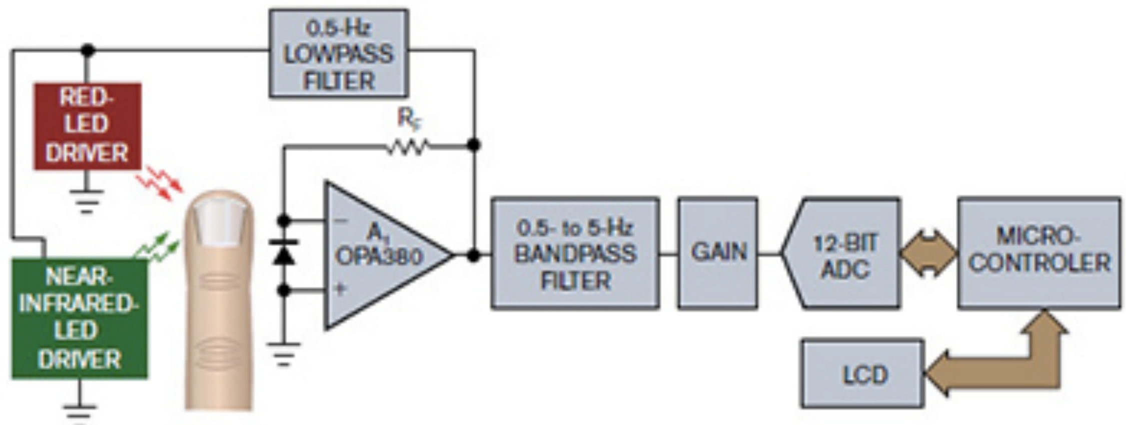


Figure 3.17: Pulse Oximeter Block Diagram[32]

Pulse rate can also be measured using the same instrumentation. As the heart beats, blood volume within the fingers changes. This change in volume correlates to a change in intensity of reflected light. By measuring the frequency of the change in light absorbed by the photodiode, which is a function of intensity of reflected light, the pulse rate can be determined.[30]

The SI1143-based pulse rate/oximeter Pulse Sensor from Silicon Labs, shown in Figure 3.18, simultaneously measures both patient pulse rate and pulse oximetry, or blood oxygen concentration. This sensor contains 2 LEDS, photodiode, band-pass filter, low-pass filter and analogue digital converter, which are all the components necessary to measure light absorbance and convert it into current for arterial oxygen saturation measurements.

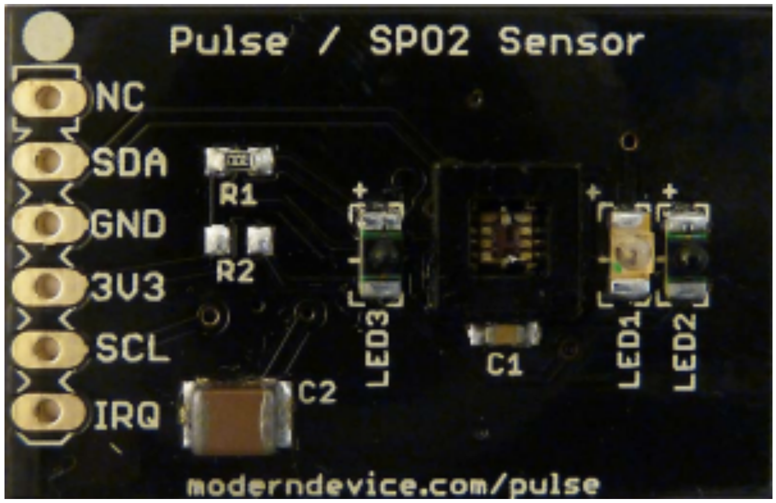


Figure 3.18: SI1143-based pulse rate/oximeter Pulse Sensor[33]

Like the temperature sensor, accompanying Arduino code to perform basic sensor function was also included. This code is complex and details about the code itself are out of the scope of this study. Generally, this code enables the digitized waveform data created by the sensor to be received by Arduino, which then performs the necessary Beer-Lambert calculations to determine the ration of oxyhemoglobin to total hemoglobin. The code also accounts for errors caused by ambient limit and attempts to mitigate these errors by subtracting the absorption of light with no LED usage from the absorption readings during use. Pulse rate and pulse oximetry data is stored within Arduino until it is called in the Android code through an *onClick* function and transferred to the host device using Bluetooth.

While the sensors discussed in this chapter were purchased for the study and initial viability testing was performed to ensure device function, implementation of the sensor data into the mobile app interfaces required a longer Institutional Board Review and was, therefore, not within the time constraints and scope of this study.

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# CHAPTER 4: RESULTS

## 4.1: Overview

Surveys to evaluate usability of the patient vital sign apps were conducted in Oaxaca, Mexico and Clemson, SC on 03/17/2015 and 04/03/2015, respectively. 12 nurses in Oaxaca and 33 nursing students from Clemson University participated in the survey, resulting in a total of 45 completed surveys. The survey content was the same at both locations with the exception of two minor alterations:

1. The surveys conducted in Oaxaca were translated from English to Spanish
2. In response to confusion during testing in Oaxaca, the final Likert scale question for all interfaces was changed from "The app was complex" to "The app was easy to use". The responses to this question were disregarded for all Oaxaca location participants and were not included in any statistical analysis.

## 4.2: Participants' Prior Experience Data

Initially, assessment was performed to identify the participants' level of experience with mobile device technology. This was accomplished through a self-assessment question that prompted participants to rate their level of experience with mobile device technology. Results of this self-assessment can be seen in Figure 4.1.

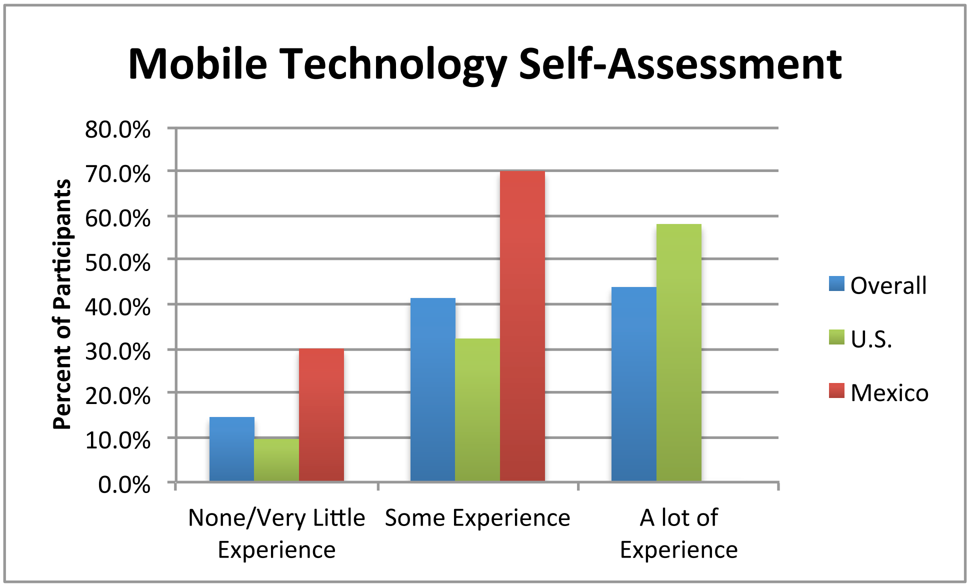


Figure 4.1: Participants' Self-Assessment of Level of Experience with Mobile Technology Displayed by Location

**4.3: User Interface Likert Scale Data**

Likert scales were used to assess a variety of attributes of each of the mobile app interfaces on both the cell phone and tablet. The scores given for each interface attribute were tabulated to provide an overall description of the response to the interface. Samples of the responses to the Likert scale questions are shown in Figures 4.2 – 4.3. Response summaries for all interfaces can be seen in Appendix E

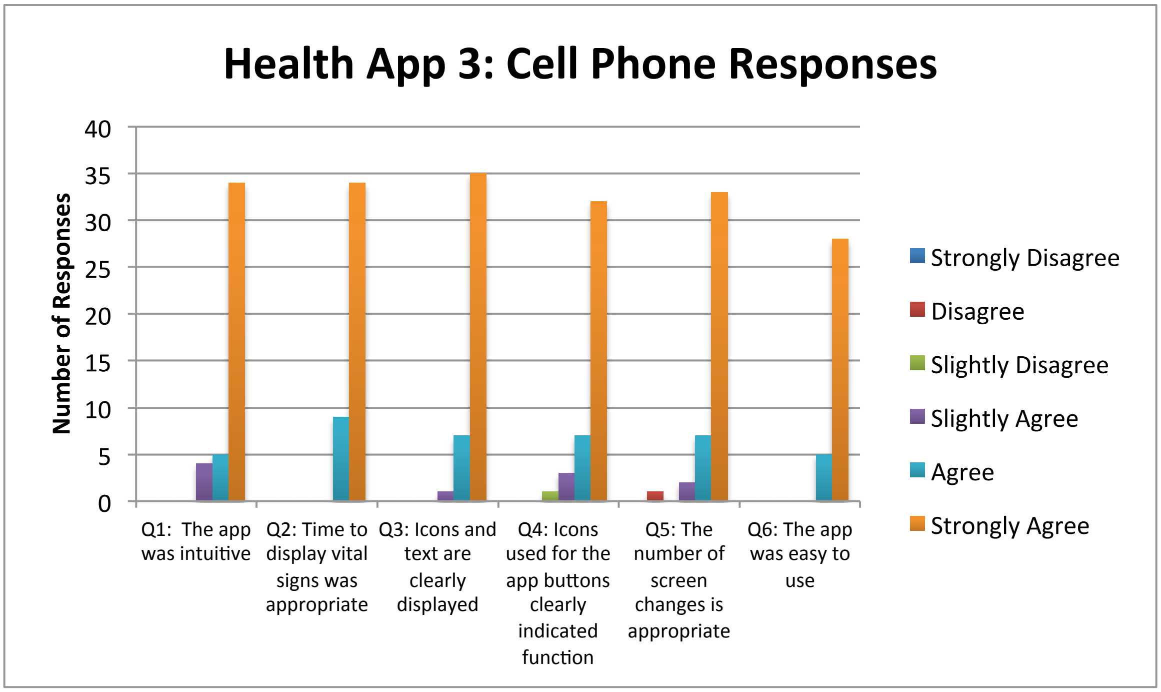


Figure 4.2: Participant Responses to Health App 3 on the Cell Phone

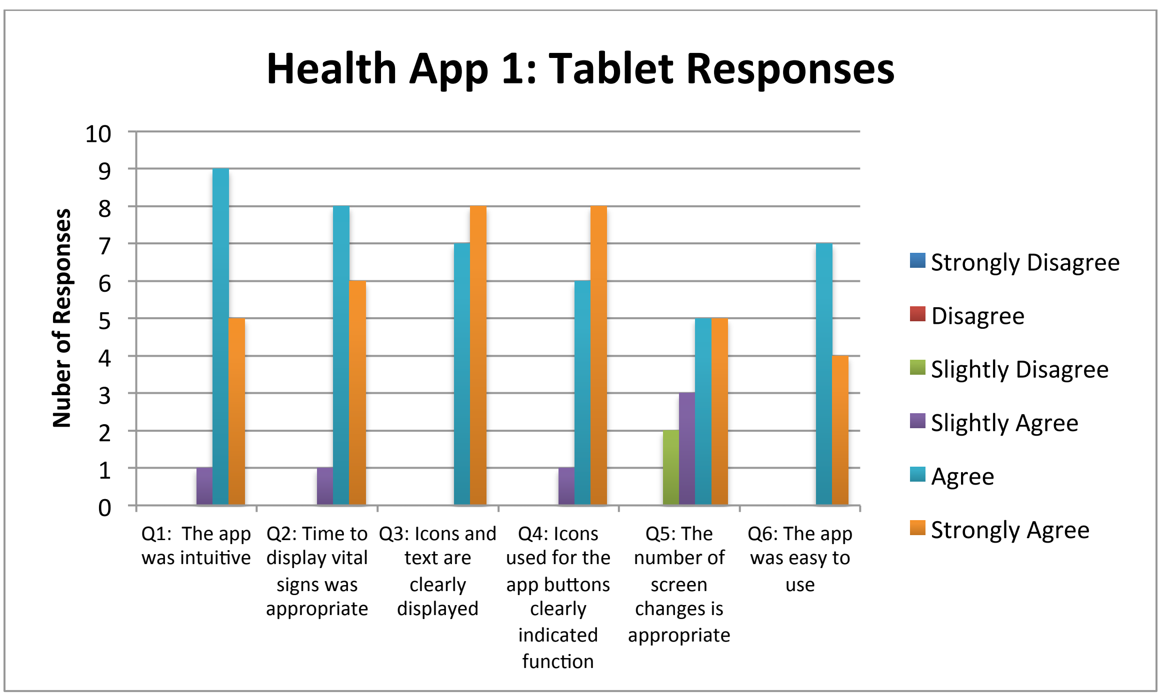


Figure 4.3: Participant Responses to Health App 1 on the Tablet

Following tabulation of all Likert scale responses, measures of central tendency were calculated for each interface and device combination. Due to the ordinal, non-parametric nature of the survey data, median and mode were used as the measures of central tendency for this study.  Median and mode for each question were calculated with the three population subsets: all participant responses, only Mexico participant responses, and only U.S. participant responses. These values have been summarized in Appendix E.  A sample graphical representation of the median Likert scale scores for Health App 1 developed for cell phones can be seen in Figure 4.4.

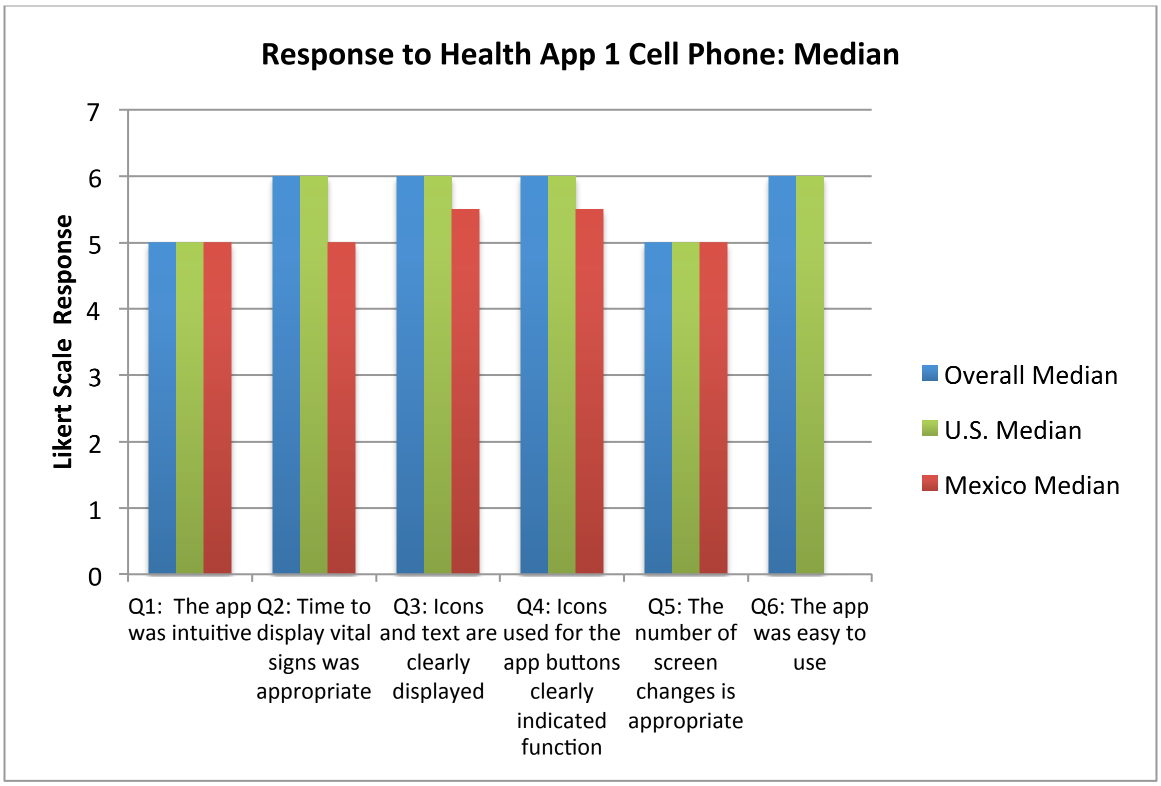


Figure 4.4: Median Scores for Health App 1 Likert Scale Questions

**4.4: Technology Utilization Data**

One survey question was designed to determine the clinical environments that participants felt the mobile device technology could be best utilized. The participant responses to "technology utilization" questions are summarized in Figure 4.5.

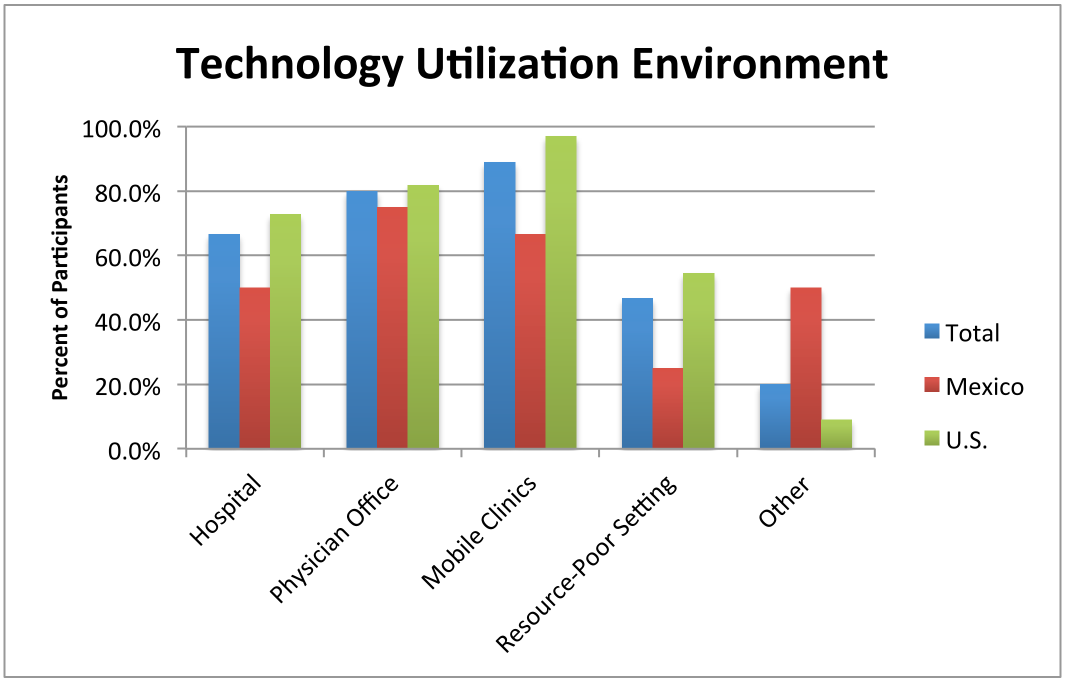


Figure 4.5: Participant Evaluation of Potential Technology Utilization Settings

Participants were also asked to rate (1= not useful at all to 5= very useful) how useful the mobile app technology was compared to the current instrumentation they used for measuring patient vital signs. Results are shown in Figure 4.6

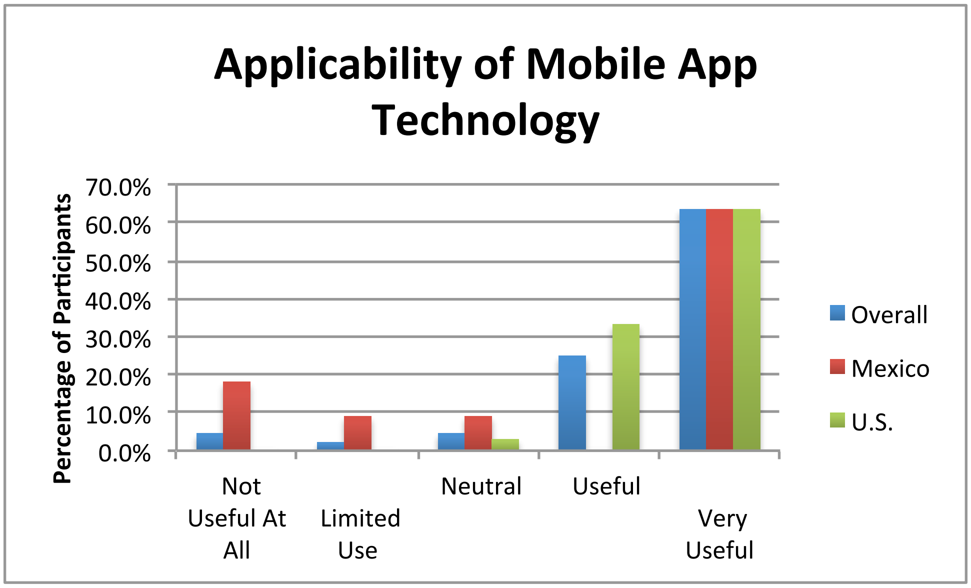


Figure 4.6: Participant Rating of Mobile App Technology Applicability to Their Workplace

### 4.5: Device Type Preference Data

Additionally, all participants were asked to indicate which device type, cell phone or tablet, best suited their own daily needs. The participant responses to device type preference questions are summarized in Figures 4.7 – 4.9.

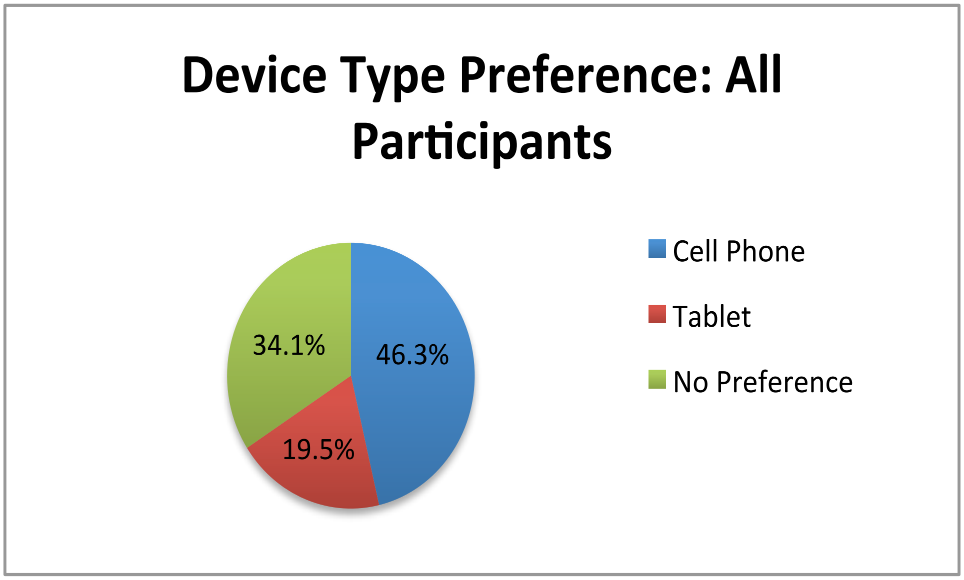


Figure 4.7: Device Preference Summary for All Study Participants

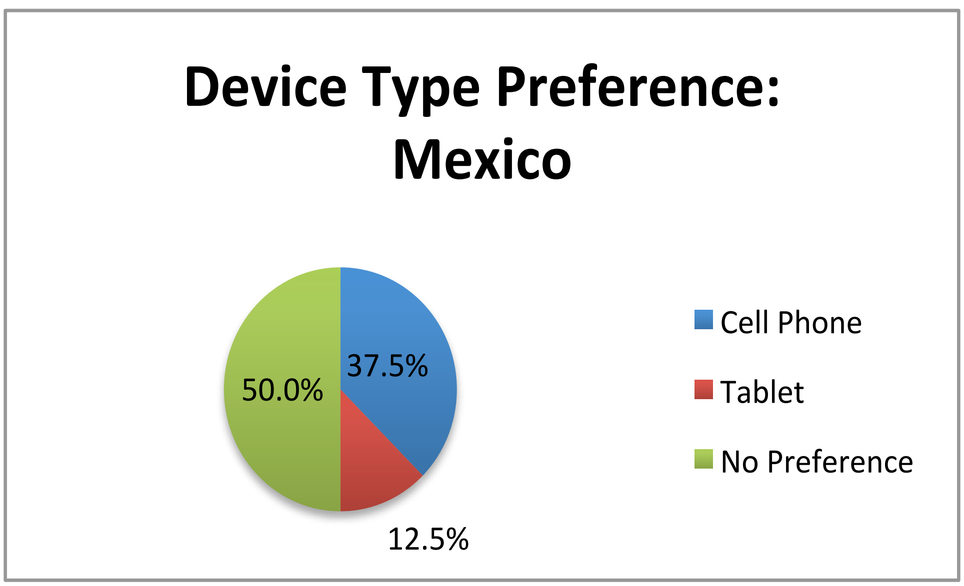


Figure 4.8: Device Preference Summary for Mexico Study Participants

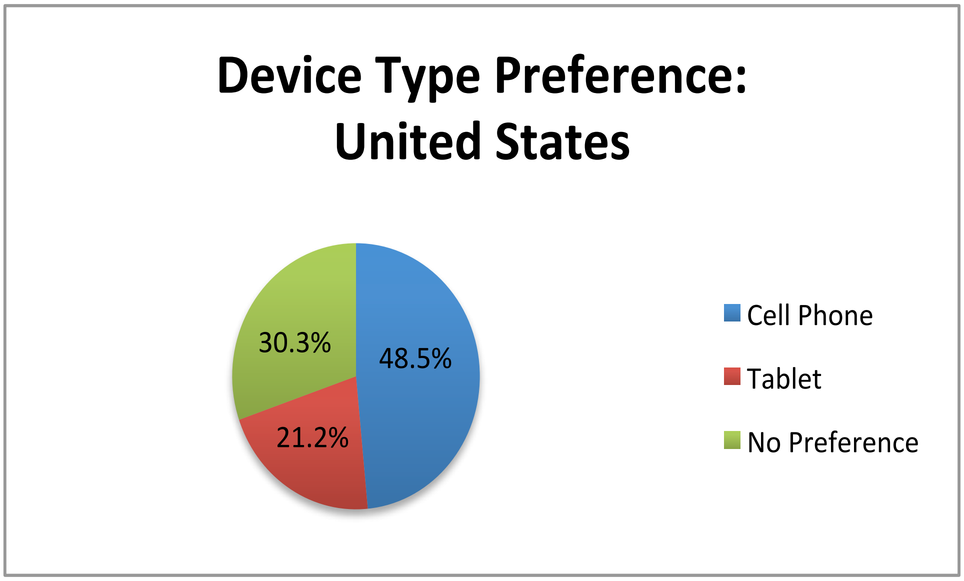


Figure 4.9: Device Preference Summary for U.S. Study Participants

**4.6: Sensor Data**

To allow for preliminary analysis of sensor usability, study participants were shown samples of the temperate and blood oximetry sensors and given a brief explanation of their function. They were then asked to answer two Likert scale questions concerning the ease to understand the function and portability of the sensors. The participant responses regarding sensors are summarized in Figures 4.10 – 4.11.

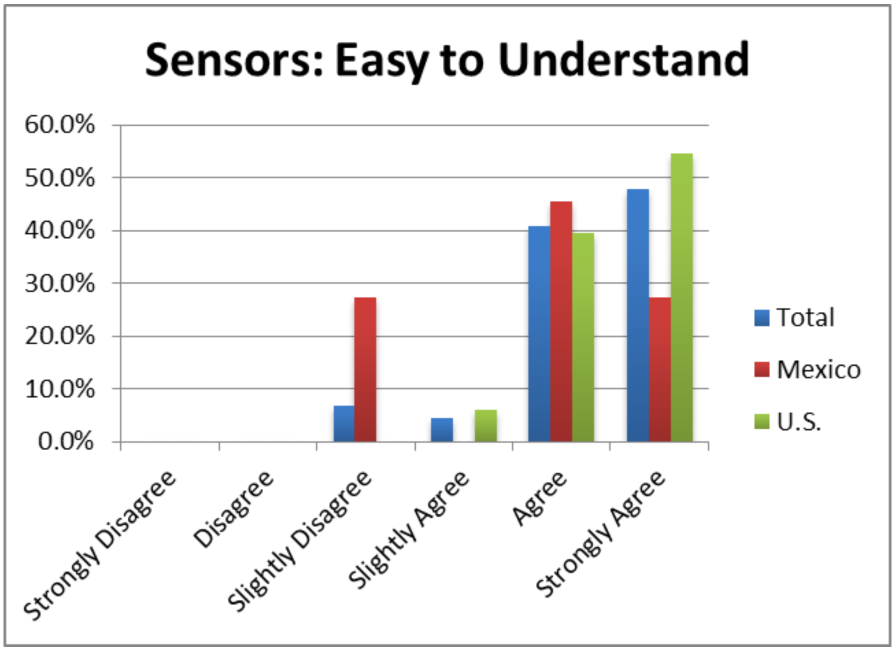


Figure 4.10: Participant Responses to “Sensors are easy to understand”

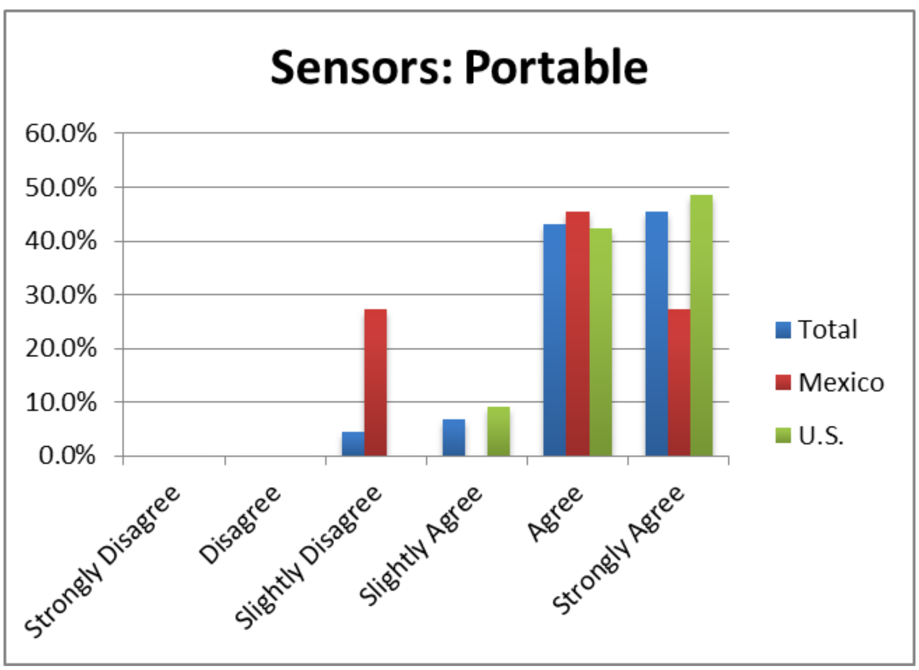


Figure 4.11: Participant Responses to “Sensors are portable”

## 4.7: Wilcoxon Signed Rank Test Data

To more explicitly analyze preferences for specific interface features, Wilcoxon Signed Rank tests were performed to compare each interface (Health App 1 vs. Health App 2 vs. Health App 3). The Wilcoxon Signed Rank test was selected as the statistical testing method because it provides information for non-parametric, ordinal, paired data, such as the data from Likert scales.

Each Likert scale question for each of the three apps was compared using a two-tailed Wilcoxon Signed Rank test. The results are shown in Tables 4.1 – 4.6, with all statistically significant results highlighted.

| Wilcoxon Signed Rank Test: Intuitive | | | |
|---|---|---|---|
| | HA1 v. HA2 | HA1 v. HA3 | HA2 v. HA3 |
| W | 9.5 | 25 | 24 |
| p-value | 0.074 | 0.002 | 0.014 |

Table 4.1: Results of Wilcoxon Signed Rank Test for Likert Scale Question #1 for all Interfaces

| Wilcoxon Signed Rank Test: Time to Display Vitals | | | |
|---|---|---|---|
| | HA1 v. HA2 | HA1 v. HA3 | HA2 v. HA3 |
| W | 16.5 | 11 | 12 |
| p-value | 0.285 | 0.031 | 0.236 |

Table 4.2: Results of Wilcoxon Signed Rank Test for Likert Scale Question #2 for all Interfaces

| Wilcoxon Signed Rank Test: Icons and Text Clearly Displayed | | | |
|---|---|---|---|
| | HA1 v. HA2 | HA1 v. HA3 | HA2 v. HA3 |
| W | 8 | 6.5 | 5 |
| p-value | 0.353 | 0.237 | 0.59 |

Table 4.3: Results of Wilcoxon Signed Rank Test for Likert Scale Question #3 for all Interfaces

| Wilcoxon Signed Rank Test: Icons Indicate Function | | | |
|---|---|---|---|
| | HA1 v. HA2 | HA1 v. HA3 | HA2 v. HA3 |
| W | 27 | 35 | 30 |
| p-value | 0.636 | 0.485 | 0.295 |

Table 4.4: Results of Wilcoxon Signed Rank Test for Likert Scale Question #4 for all Interfaces

| Wilcoxon Signed Rank Test: Appropriate Number of Screen Changes | | | |
|---|---|---|---|
| | HA1 v. HA2 | HA1 v. HA3 | HA2 v. HA3 |
| W | 48 | 30 | 93 |
| p-value | 0.006 | 0.001 | 0.444 |

Table 4.5: Results of Wilcoxon Signed Rank Test for Likert Scale Question #5 for all Interfaces

| Wilcoxon Signed Rank Test: Easy to Use | | | |
|---|---|---|---|
| | HA1 v. HA2 | HA1 v. HA3 | HA2 v. HA3 |
| W | 0 | 4.5 | 1.5 |
| p-value | 0.009 | 0.022 | 1 |

Table 4.6: Results of Wilcoxon Signed Rank Test for Likert Scale Question #6 for all Interfaces

Wilcoxon Signed Rank two-tail tests were also performed to compare each app developed for cell phones with the same app developed for tablets. The results are shown in Tables 4.7 – 4.9. It should be noted that no statistically significant differences were found between device types.

| Wilcoxon Signed Rank: Health App 1 Cell Phone vs. Tablet | | | | | | |
|---|---|---|---|---|---|---|
| | **Q1: The app was intuitive** | **Q2: Time to display vital signs was appropriate** | **Q3: Icons and text are clearly displayed** | **Q4: Icons used for the app buttons clearly indicated function** | **Q5: The number of screen changes is appropriate** | **Q6: The app was easy to use** |
| W | 16 | 4 | 3 | 20 | 21.5 | 22.5 |
| p-value | 0.477 | 0.855 | 1 | 0.834 | 0.953 | 0.575 |

Table 4.7: Results of Wilcoxon Signed Rank Test for Comparing Health App #1 on Cell Phones and Tablets

| Wilcoxon Signed Rank: Health App 2 Cell Phone vs. Tablet | | | | | | |
|---|---|---|---|---|---|---|
| | **Q1: The app was intuitive** | **Q2: Time to display vital signs was appropriate** | **Q3: Icons and text are clearly displayed** | **Q4: Icons used for the app buttons clearly indicated function** | **Q5: The number of screen changes is appropriate** | **Q6: The app was easy to use** |
| W | 1.5 | 1 | 1 | 3 | 1 | 6 |
| p-value | 1 | 1 | 1 | 0.371 | 1 | 0.181 |

Table 4.8: Results of Wilcoxon Signed Rank Test for Comparing Health App #2 on Cell Phones and Tablets

| Wilcoxon Signed Rank: Health App 3 Cell Phone vs. Tablet | | | | | | |
|---|---|---|---|---|---|---|
| | Q1: The app was intuitive | Q2: Time to display vital signs was appropriate | Q3: Icons and text are clearly displayed | Q4: Icons used for the app buttons clearly indicated function | Q5: The number of screen changes is appropriate | Q6: The app was easy to use |
| W | 32.5 | 6 | 2.5 | 6.5 | 4.5 | 8 |
| p-value | 0.05 | 0.181 | 1 | 0.715 | 0.593 | 0.361 |

Table 4.9: Results of Wilcoxon Signed Rank Test for Comparing Health App #3 on Cell Phones and Tablets

**4.8: Interface Feature Correlation Data**

Correlation tests were also performed to examine relationships between various aspects of the user interfaces and usability. All correlation statistics were performed using Spearman Rank Correlation tests, which is recommended for correlation studies of ordinal data. Likert question #1 (intuitive) was found to have a statistically significant correlation to Likert question #5 (appropriate number of screen changes) and question #6 (easy to use). Additionally, Likert question #5 (appropriate number of screen changes) was found to have a statistically significant correlation to Likert question #6 (easy to use).

Following these results a Spearman Rank Correlation test was performed to determine if participants' answer to Likert question #5 (appropriate # of screen changes) correlated with their ranking of the three interfaces. A statistically relevant correlation was identified between these two factors.

Spearman Rank Correlation tests were used to determine if participants' level of prior experience with mobile technology affected their response to Likert question #6 (easy to use) and to whether they felt the instrumentation met their needs. No statistically relevant correlation was found between level of prior experience and ease of use. A statistically relevant correlation was not identified between participants' prior experience and whether or not they felt the technology was applicable to their work.

Following this result, a Spearman Rank Correlation test was performed to determine if Likert question #6 (easy to use) correlated with whether or not participants felt the technology was applicable to their work. A significantly relevant correlation was identified between these to factors.

All Spearman Rank Correlation test results are summarized in Table 4.10.

| | R Value | p-value |
|---|---|---|
| **Intuitive vs. Number of Screen Changes** | 0.504 | 0.000 |
| **Intuitive vs. Easy To Use** | 0.556 | 0.000 |
| **Number of Screen Changes vs. Easy to Use** | 0.61 | 0.000 |
| **Number of Screen Changes vs. App Rank** | -0.475 | 0.000 |
| **Prior Experience vs. Easy to Use** | -0.07616 | 0.468 |
| **Prior Experience vs. Applicable Technology** | -0.24 | 0.131 |
| **Easy to Use vs. Applicable Technology** | 0.278 | 0.005 |

Table 4.10: Summary of Spearman Rank Correlation Tests

Finally, the median and mode of the participants' rank of the three mobile app interfaces was determined (1=best, 3=worst). The results are summarized in Figure 4.12.

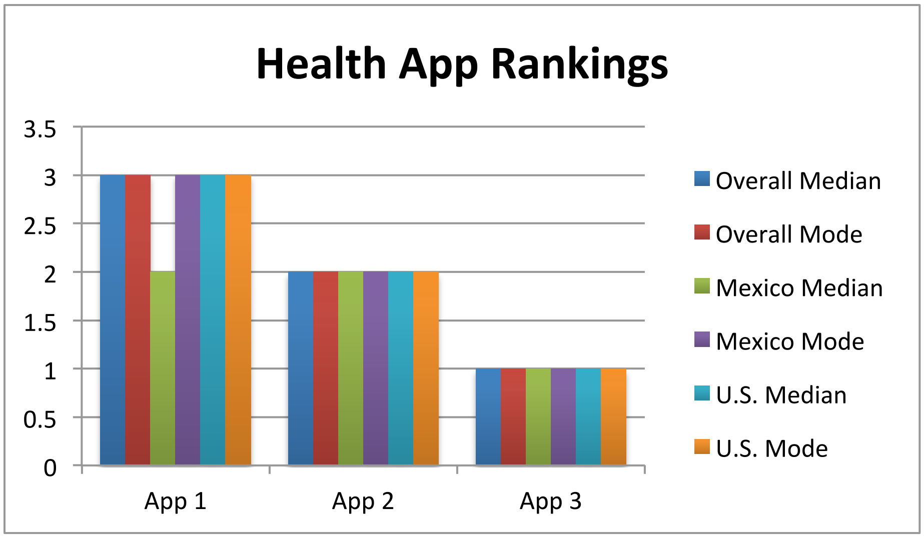


Figure 4.12: Summary of Health App Rankings

# CHAPTER 5: DISCUSSION

## 5.1 Interface Comparisons

Overall, responses to the Likert scale questions aimed at evaluating and comparing the features of each app developed for this study indicated that all of the apps were generally well received by the study participants. Responses to all Likert scale questions were tabulated for all interfaces, as shown in Figures 4.2 – 4.3 and Appendix E, and the mode and median for these responses for all population subsets were calculated, as seen in Figure 4.4 and Appendix E. Median scores for all population subsets studied (all participants, Mexico participants, and U.S. participants) for all Likert scale questions ranged from 4 -6, which correlates with "Slightly Agree" responses to "Strongly Agree" responses. No aspect of any of the interfaces received a median response categorized as "slightly disagree", "disagree", or "strongly disagree". Median and mode Likert scale scores were equal or higher among U.S. participants compared to Mexico participants, with the exception of Health App 1 developed for the tablet, which will be further explored in 5.4: Device Type Preference and 5.6: Location-Based Relevancy. This overwhelmingly positive response indicates that while preferences may exist between different populations, the technology is universally well accepted.

Acceptance of the mobile apps was further confirmed by responses received to the question "Compared to your current instrumentation, is this mobile technology useful for your needs?" Answers to this question resulted in 88.6% positive responses (scores 4-5). This indicates that not only do potential end users accept this technology, but also feel it would be advantageous over their currently available technology, which is a major barrier in introduction of technology in healthcare[1].

The effect of user interface design on participant response to Likert scale questions was further explored using Wilcoxon Signed Rank tests to compare responses for each Likert question comparing each of the three apps. The results to the Wilcoxon Sign Rank tests are shown in Tables 4.1 -4.6.

As can be seen from the results, responses to Likert scale question 3, “The icons used for the app buttons clearly indicated their function” (Table 4.3), did not demonstrate a statistically significant difference in median response scores between app interfaces. This demonstrates that increased amount of information displayed on the screen, which occurred with increasing “Health App” app number, did not negatively affect the users’ ability to view the icons and text. Responses to Likert question 4, “The icons used for the app buttons clearly indicate their function”(Table 4.4), also did not demonstrate statistically significant differences between the medians for each app interface. This result is as expected since the images used for to indicate button function were the same for all app interfaces.

A statistically significant difference in medians was identified between responses to question 2, “The time to display vital signs was appropriate” (Table 4.2), for Health App 1 and Health App 3. This difference in response is most likely a result of the change in number of required button presses and screen changes to complete the task, with preference toward fewer required buttons and screens.

A statistically significant difference in medians was identified between response scores to question 1, "The app was intuitive" (Table 4.1), for Health App 3 compared to median scores for both Health App 1 and Health App 2. This indicates that users felt that a reduction in the number of buttons allowed for an app that was more intuitive. It is hypothesized that the "one touch" design of Health App 3 more closely mimics the current interface design of patient vital sign measurement equipment, resulting in a more "natural" and intuitive workflow.

A statistically significant difference in medians was also identified between response scores to question 5, "The number of screen changes is appropriate to perform task" (Table 4.5), for Health App 1 compared to median scores for both Health App 2 and Health App 3. Health App 1 required the users to view separate screens for each vital sign before reaching a summary screen with simultaneous display of all vital signs. This result demonstrates that the "walk through" type of design used in Health App 1 was not preferred to designs that display all vitals within the same page/screen. Statistically significant difference in medians was also identified between response scores to question 6, "The app was easy to use" (Table 4.6), for Health App 1 compared to scores for both Health App 2 and Health App 3. This may indicate that the "walk through" type design also complicates the app for many users. The relationship between number of screens and ease of use will be further explored in 5.3: Effect of Horizontal Depth on Interface Perception.

In addition to Likert scale assessment of individual interface features, participants were asked to rank each of the app interfaces from 1 (best) to 3 (worst). The mode and median of each app's ranking scores is shown in Figure 4.12. From these results, the consistency of preference between population subsets allows us to make relatively definitive assumptions about interface preference, with Health App 3 being the most preferred interface and Health App 1 being the least preferred interface.

### 5.2 Effect of Level of Experience with Mobile App Technology

Participants were asked to complete self-evaluations of their prior experience and skill level with mobile technology, shown in Figure 4.1. We included this information in the study to determine if participants' pre-existing level of familiarity with mobile technology affected how they perceived the presented mobile app technology.

One initial observation was the difference in prior experience with mobile technology in resource-poor settings, as represented by the participants in Mexico, and those in more developed countries. One observation made when administering surveys in Oaxaca was that many of the nurses had smartphones for personal use, indicating that they had some baseline exposure to mobile technology. Majority of the participants from Mexico ranked their level of experience with mobile technology as "Some Experience" (70%) and none of the participants from Mexico ranked themselves as having "A Lot of Experience". Comparatively, 58% of participants from the U.S. ranked themselves as having "A Lot of Experience" with mobile technology and only 9.7%

claimed to have “No and/or Very Little Experience.” This shows a disparity between the levels of exposure to mobile app technology between the two environments.

Spearman Rank Correlation test was performed to determine if a users’ level of prior experience with mobile technology affected whether or not they felt the mobile apps presented in the study were easy to use. No statistically relevant or substantial correlation was found between prior experience and perceived ease of use. This result indicates that the user interfaces developed for this study were universal and did not require previous knowledge of mobile technology or apps to be effective. This is particularly important for broad, global implementation of the technology, particularly in resource-poor or rural settings where exposure to mobile technology may be more limited.

A Spearman Rank Correlation test was also performed to determine if participants’ level of prior experience correlated with how applicable they felt the technology was to meet their needs. As was the case for prior experience and ease of use, there was no statistically relevant or substantial correlation found between prior experience and perceived applicability. This result is also encouraging for broad implementation of the technology as it indicates that potential end users are not limited by their level of prior experience with mobile technology to potentially accept and integrate the new technology into their practices.

### 5.3 Effect of Horizontal Depth on Interface Perception

The largest difference between each of the three interface workflows created for this study is their horizontal depth. As previously discussed, horizontal depth is defined as the depth that exists between pages within a single level of the menu hierarchy[2]. In studies of mobile apps with non-medical indications, increases in horizontal depth have been shown to increase user errors[2] and reduce the amount of time prior discontinuing use of an app due to its perceived “lack of user friendliness.”[3]

In this study, we first assessed whether changing horizontal depth was consciously perceived by the user by asking participants if the felt “The number of screen changes was appropriate to perform the task” for each of the three interfaces. To compare results for each of the interfaces, a Wilcoxon Signed Rank test was performed comparing Likert scale responses for each of the interfaces. It was determined that the responses differed significantly for Health App 1 compared to Health App 2 and Health App 3. This demonstrates that users are aware of increases in horizontal depth (Health App 1 has a horizontal depth of 4 compared to horizontal depths of 3 and 1 for Health App 2 and Health App 3, respectively). Additionally, the median score for the responses regarding appropriate number of screen changes were lower for Health App 1 (median score=5) than Health App 2 and Health App 3 (median scores=6). This indicates that users are not only aware of increases in horizontal depth, but also respond negatively towards increases in horizontal depth.

To further investigate the effect of horizontal depth on perception of the mobile apps, Spearman Rank Correlation tests were performed to identify potential correlations between perceived horizontal depth, as measured by Likert question #5 (appropriate number of screen changes), and whether or not participants felt the app was intuitive and easy to use. Substantial, statistically significant correlations were identified between perceived horizontal depth and both whether or not the app was intuitive and whether or not the app was easy to use. Participants who scored an app highly for appropriate number or screen changes (horizontal depth) were more likely to also score the intuitiveness and ease of use for the app highly.

A substantial, statistically significant correlation was also identified between the perceived horizontal depth and the overall app rank. Participants who scored an app with a low horizontal depth score were more likely to rank the app lower compared to other apps with better horizontal depth scores. This is consistent with the overall rank of the apps, with Health App 1 (largest horizontal depth) ranked the worst and Health App 3 (smallest horizontal depth) ranked the best for all populations.

### 5.4: Device Type Preference

Very few mobile app usability previously performed assess the effect of device type on app usability. This study directly compared device types, cell phone and tablet, by having participants evaluate the same interface across both devices. Based on Wilcoxon Signed Rank tests comparing each of the Likert scale question responses across device types, shown in Tables 4.7 – 4.9, there was not a statistically significant difference in the perception of any feature of the apps between the two devices. This presents multiple implications. First, this result implies that the "mirroring" across the devices described in 3.3: Mobile Application User Interface Design was successfully performed and the change in screen size did not alter the appearance of the interfaces. Additionally, this result indicates that a change in screen size does not affect the usability of the mobile app.

While device type did not affect preferences for specific features of any of the apps, when asked whether the cell phone or tablet was more suitable for the participants' needs, 46.3% of participants claimed the cell phone as the preferred device medium, compared to 34.1% who preferred the tablet (19.5% claimed the did not have a device preference). The preference for cell phones was more pronounced in U.S. participants (48.5% of participants) compared to in Mexico participants (37.5% of participants). It is hypothesized that U.S. participants may have a stronger preference towards cell phones due to the increased ubiquity of cell phones in the United States compared to in Mexico. Many participants who preferred cell phones as the device medium indicated that they preferred the portability of the smaller device.

U.S. participants also showed a greater affinity towards tablets (19.5%) than Mexico participants (12.5%). This may be due to a negative perception of the use of cell phones in front of patients in the United States. A number of the U.S. participants that preferred the tablet indicated that they felt the tablet was the more professional medium and that using cell phones when interacting with patients may be perceived as inappropriate.

Overall, the differences or preferences identified between the device types were minimal. Based on these results, assuming the user interface for the app is designed appropriately, medical mobile apps have the potential to be effective across multiple types of mobile devices.

### 5.5: Assessment of Technology Utilization Environment

In order to assess end user perception of how and in which clinical setting this technology could potentially be utilized, the survey included a question where participants could select from a list (see surveys in Appendix B) of potential clinical setting where they felt the technology was applicable. The results of this poll are summarized in Figure 4.5.

The majority of participants (>50%) felt that the technology could be utilized in hospitals, physician offices, mobile clinics, and resource-poor settings. The positive responses received for all proposed clinical settings supports the potential for mobile medical app technology can be implemented in diverse applications.

Many of the participants who selected "Other" indicated that they felt the technology could be developed for home use. While there is strong support for personal fitness and home monitoring devices, the focus of this study was confined to clinical applications of mobile app diagnostic technology.

## 5.6: Location-Based Relevancy

As discussed in previous sections of this chapter, prior experience and specific device preferences differed between the U.S. participant population and the Mexico participant population. However, the overall rankings and generally positive response towards the mobile apps indicates that the technology is universal. The apps were designed with relatively little language-based text or instruction, which did not seem to affect the usability of the apps for either location, as shown by high response scores to “The app buttons clearly indicate function”, which resulted in a median score of 6 for all population subsets for all apps. Additionally, the overall rank of apps was not significantly affected by participant location. The level consensus between locations supports the goal of implementation of the same app globally without extensive changes to the interface design.

## 5.7: Sensors

While validation testing of the sensor function was not performed due to stricter IRB requirements and time constraints, participants were presented with examples of the Arduino-based sensors and explained the basic sensor functionality. Participants were then prompted to complete two Likert scale questions assessing the ability to understand the sensor function and the portability of the sensors. Results for the responses to sensor questions are summarized in Figures 4.10 - 4.11. As can be seen from the results, the majority of participants felt that the sensors were easy to understand and portable. The affirmative responses towards the sensors support the use of these mobile sensor types in concert with the mobile medical apps for both resource-poor and not resource-poor settings.

### 5.8: References


1. Bonnici, T. (2012). *IEEE Computer Society,* 9, 79-84.
2. Chae, Minhee, and Jinwoo Kim. "Do Size and Structure Matter to Mobile Users? An Empirical Study of the Effects of Screen Size, Information Structure, and Task Complexity on User Activities with Standard Web Phones." *Behaviour & Information Technology* 23.3 (2004): 165-81. Web. 27 Mar. 2015.
3. Smith, Dorothy. "Motivating Patients to Use Smartphone Health Apps."*PRWeb*. Consumer Health Information Corporation, 25 Apr. 2011. Web. 31 Mar. 2015.

# CHAPTER 6: CONCLUSIONS AND FUTURE WORK

With ever-increasing prevalence of smartphone and tablet use both in the United States and globally, there is a growing interest in the development and implementation of mobile apps for medical purposes. Despite rising popularity and use of medical mobile apps among physicians, there is little evidence on the usability, safety, and global applicability of medical mobile app technology, particularly for apps whose function is related to the diagnosis and treatment of disease.

In this study, we developed a series of patient vital sign measurement apps designed for both cell phones and tablets. Three distinct interface workflows were created and an accompanying survey was developed to compare the interfaces, device types, and location-based relevancy of the mobile apps. Following survey administration in Oaxaca, Mexico and Clemson, SC and statistical analysis of the participant survey responses, a variety of correlations were identified.

It was determined that specific interface features can directly impact the usability of a medical app. In particular, it was identified that increasing horizontal depth of the app reduced the intuitiveness and ease of use of the app. Participants preferred app interfaces that more closely mimicked the “one touch” interface design of currently used vital sign measurement equipment. Changes in device type, however, did not significantly affect the usability of the app or the participant’s response to the technology.

It was also determined that a user's level of prior experience does not affect their ability to understand the medical mobile app technology. Additionally, it was found that prior experience did not affect the user's opinion of the possible applicability of the technology in their practice. Participant location did not cause significant changes in the general response toward the technology or the ranking of the app interfaces. These results support the potential for global implementation of medical mobile app technology.

Based on participant responses, the technology was determined to be applicable in a variety of clinical settings including hospitals, physician offices, mobile clinics, and resource-poor settings.

Though validation and implementation of the accompanying mobile sensors was not performed in this study, preliminary survey responses from potential end users indicated positive reactions towards the sensors portability and ease to understand.

For future studies, integration of the Arduino sensors into the mobile application interface is essential for testing the app with full functionality. Additionally, validation studies of the Arduino-based sensors comparing their accuracy to that of commercially available vital sign measuring devices should be performed following the appropriate IRB approval. Surveying at other locations with more participants will also allow for increased validation of the global applicability of the patient vital sign app. Finally, repeated usability testing of medical mobile application interfaces will allow for continual improvement in end user specificity, increasing the likelihood of acceptance and continued use of the technology.

APPENDICES

## APPENDIX A: CODE FOR PATIENT VITAL SIGN MEASUREMENT MOBILE APPS

```
//HEALTH APP 1 CELL PHONE JAVA CODE

package com.example.mobilehealthapp1;

import com.example.mobilehealthapp1.R;

import android.support.v7.app.ActionBarActivity;
import android.os.Bundle;
import android.view.Menu;
import android.view.MenuItem;
import android.view.View;
import android.widget.ImageButton;
import android.widget.ImageView;
import android.widget.TextView;



public class MobileHealthApp1Activity extends ActionBarActivity {


	@Override
	protected void onCreate(Bundle savedInstanceState) {
		super.onCreate(savedInstanceState);
		setContentView(R.layout.activity_mobilehealthapp1);
		initTempButton();
		initPulseButton();
		initSpO2Button();

	}

	@Override
	public boolean onCreateOptionsMenu(Menu menu) {
		// Inflate the menu; this adds items to the action bar if it is
present.
		getMenuInflater().inflate(R.menu.mobile_health_app1, menu);
		return true;
	}

	@Override
	public boolean onOptionsItemSelected(MenuItem item) {
		// Handle action bar item clicks here. The action bar will
		// automatically handle clicks on the Home/Up button, so long
		// as you specify a parent activity in AndroidManifest.xml.
		int id = item.getItemId();
		if (id == R.id.action_settings) {
			return true;
		}
```

```
            return super.onOptionsItemSelected(item);}


private void initTempButton(){
ImageButton temp = (ImageButton) findViewById (R.id.imageButtonTemp);
temp.setOnClickListener(new View.OnClickListener() {
public void onClick (View v){
        TextView viewtemp=(TextView)findViewById(R.id.SampleTemp);
        viewtemp.setVisibility(View.VISIBLE);
        ImageButton next =(ImageButton)findViewById(R.id.imageButtonNext);
        next.setVisibility(View.VISIBLE);
        next.setOnClickListener(new View.OnClickListener(){
        public void onClick (View v){
                TextView viewtemp = (TextView)findViewById(R.id.SampleTemp);
                viewtemp.setVisibility(View.GONE);
                ImageButton temp
=(ImageButton)findViewById(R.id.imageButtonTemp);
                temp.setVisibility(View.GONE);
                ImageButton next
=(ImageButton)findViewById(R.id.imageButtonNext);
                next.setVisibility(View.GONE);
                ImageButton pulse
=(ImageButton)findViewById(R.id.imageButtonPulse);
                pulse.setVisibility(View.VISIBLE);
                }
                });
        }

        });
}

private void initPulseButton(){
        ImageButton pulse = (ImageButton)findViewById(R.id.imageButtonPulse);
        pulse.setOnClickListener(new View.OnClickListener(){
        public void onClick(View v){
                TextView viewpulse = (TextView)findViewById(R.id.SamplePulse);
                viewpulse.setVisibility(View.VISIBLE);
                ImageButton next
=(ImageButton)findViewById(R.id.imageButtonNext);
                next.setVisibility(View.VISIBLE);
                next.setOnClickListener(new View.OnClickListener(){
                public void onClick (View v){
                        TextView viewpulse =
(TextView)findViewById(R.id.SamplePulse);
                        viewpulse.setVisibility(View.GONE);
                        ImageButton
pulse=(ImageButton)findViewById(R.id.imageButtonPulse);
                        pulse.setVisibility(View.GONE);
                        ImageButton
next=(ImageButton)findViewById(R.id.imageButtonNext);
                        next.setVisibility(View.GONE);
```

```
                    ImageButton
spo2=(ImageButton)findViewById(R.id.imageButtonSpO2);
                    spo2.setVisibility(View.VISIBLE);
                    }
                    });
             }
             });
      }

private void initSpO2Button(){
      ImageButton spo2 = (ImageButton)findViewById(R.id.imageButtonSpO2);
      spo2.setOnClickListener(new View.OnClickListener(){
      public void onClick(View v){
             TextView viewspo2 =(TextView)findViewById(R.id.SampleSpO2);
             viewspo2.setVisibility(View.VISIBLE);
             ImageButton next
=(ImageButton)findViewById(R.id.imageButtonNext);
             next.setVisibility(View.VISIBLE);
             next.setOnClickListener(new View.OnClickListener(){
             public void onClick (View v){
                    TextView viewspo2 =
(TextView)findViewById(R.id.SampleSpO2);
                    viewspo2.setVisibility(View.GONE);
                    ImageButton
spo2=(ImageButton)findViewById(R.id.imageButtonSpO2);
                    spo2.setVisibility(View.GONE);
                    ImageButton
next=(ImageButton)findViewById(R.id.imageButtonNext);
                    next.setVisibility(View.GONE);
                    ImageView temp2
=(ImageView)findViewById(R.id.imageButtonTemp2);
                    temp2.setVisibility(View.VISIBLE);
                    ImageView
pulse2=(ImageView)findViewById(R.id.imageButtonPulse2);
                    pulse2.setVisibility(View.VISIBLE);
                    ImageView spo22
=(ImageView)findViewById(R.id.imageButtonSpO22);
                    spo22.setVisibility(View.VISIBLE);
                    TextView viewtemp2
=(TextView)findViewById(R.id.SampleTemp2);
                    viewtemp2.setVisibility(View.VISIBLE);
                    TextView viewpulse2
=(TextView)findViewById(R.id.SamplePulse2);
                    viewpulse2.setVisibility(View.VISIBLE);
                    TextView viewspo22
=(TextView)findViewById(R.id.SampleSpO22);
                    viewspo22.setVisibility(View.VISIBLE);
                    ImageButton
home=(ImageButton)findViewById(R.id.imageButtonHome);
                    home.setVisibility(View.VISIBLE);
                    home.setOnClickListener(new View.OnClickListener(){
                    public void onClick (View v){
```

```
                                ImageView
temp2=(ImageView)findViewById(R.id.imageButtonTemp2);
                                temp2.setVisibility(View.GONE);
                                ImageView
pulse2=(ImageView)findViewById(R.id.imageButtonPulse2);
                                pulse2.setVisibility(View.GONE);
                                ImageView
spo22=(ImageView)findViewById(R.id.imageButtonSpO22);
                                spo22.setVisibility(View.GONE);
                                TextView
viewtemp2=(TextView)findViewById(R.id.SampleTemp2);
                                viewtemp2.setVisibility(View.GONE);
                                TextView
viewpulse2=(TextView)findViewById(R.id.SamplePulse2);
                                viewpulse2.setVisibility(View.GONE);
                                TextView viewspo22
=(TextView)findViewById(R.id.SampleSpO22);
                                viewspo22.setVisibility(View.GONE);
                                ImageButton
home=(ImageButton)findViewById(R.id.imageButtonHome);
                                home.setVisibility(View.GONE);
                                ImageButton
temp=(ImageButton)findViewById(R.id.imageButtonTemp);
                                temp.setVisibility(View.VISIBLE);
                                }
                                });

                        }
                        });
                }
                });


        }
}
```

```
//HEALTH APP 1 TABLET JAVA CODE

package com.example.mobilehealthapp1tab;

import com.example.mobilehealthapp1tab.R;

import android.support.v7.app.ActionBarActivity;
import android.os.Bundle;
import android.view.Menu;
import android.view.MenuItem;
import android.view.View;
import android.widget.ImageButton;
import android.widget.ImageView;
import android.widget.TextView;

import android.support.v7.app.ActionBarActivity;
```

```java
import android.os.Bundle;
import android.view.Menu;
import android.view.MenuItem;

public class MobileHealthApp1TABActivity extends ActionBarActivity {


	@Override
	protected void onCreate(Bundle savedInstanceState) {
		super.onCreate(savedInstanceState);
		setContentView(R.layout.activity_mobilehealthapp1tab);
		initTempButton();
		initPulseButton();
		initSpO2Button();

	}

	@Override
	public boolean onCreateOptionsMenu(Menu menu) {
		// Inflate the menu; this adds items to the action bar if it is
present.
		getMenuInflater().inflate(R.menu.mobile_health_app1_tab, menu);
		return true;
	}

	@Override
	public boolean onOptionsItemSelected(MenuItem item) {
		// Handle action bar item clicks here. The action bar will
		// automatically handle clicks on the Home/Up button, so long
		// as you specify a parent activity in AndroidManifest.xml.
		int id = item.getItemId();
		if (id == R.id.action_settings) {
			return true;
		}
		return super.onOptionsItemSelected(item);}


private void initTempButton(){
ImageButton temp = (ImageButton) findViewById (R.id.imageButtonTemp);
temp.setOnClickListener(new View.OnClickListener() {
public void onClick (View v){
	TextView viewtemp = (TextView)findViewById(R.id.SampleTemp);
	viewtemp.setVisibility(View.VISIBLE);
	ImageButton next =(ImageButton)findViewById(R.id.imageButtonNext);
	next.setVisibility(View.VISIBLE);
	next.setOnClickListener(new View.OnClickListener(){
	public void onClick (View v){
		TextView viewtemp = (TextView)findViewById(R.id.SampleTemp);
		viewtemp.setVisibility(View.GONE);
		ImageButton temp
=(ImageButton)findViewById(R.id.imageButtonTemp);
		temp.setVisibility(View.GONE);
```

```
              ImageButton next
=(ImageButton)findViewById(R.id.imageButtonNext);
              next.setVisibility(View.GONE);
              ImageButton pulse
=(ImageButton)findViewById(R.id.imageButtonPulse);
              pulse.setVisibility(View.VISIBLE);
              }
              });
       }

       });
}

private void initPulseButton(){
ImageButton pulse = (ImageButton)findViewById(R.id.imageButtonPulse);
pulse.setOnClickListener(new View.OnClickListener(){
public void onClick(View v){
       TextView viewpulse = (TextView)findViewById(R.id.SamplePulse);
       viewpulse.setVisibility(View.VISIBLE);
       ImageButton next =(ImageButton)findViewById(R.id.imageButtonNext);
       next.setVisibility(View.VISIBLE);
       next.setOnClickListener(new View.OnClickListener(){
       public void onClick (View v){
              TextView viewpulse = (TextView)findViewById(R.id.SamplePulse);
              viewpulse.setVisibility(View.GONE);
              ImageButton pulse
=(ImageButton)findViewById(R.id.imageButtonPulse);
              pulse.setVisibility(View.GONE);
              ImageButton next
=(ImageButton)findViewById(R.id.imageButtonNext);
              next.setVisibility(View.GONE);
              ImageButton spo2
=(ImageButton)findViewById(R.id.imageButtonSpO2);
              spo2.setVisibility(View.VISIBLE);
              }
              });
       }
       });
}

private void initSpO2Button(){
ImageButton spo2 = (ImageButton)findViewById(R.id.imageButtonSpO2);
spo2.setOnClickListener(new View.OnClickListener(){
public void onClick(View v){
       TextView viewspo2 =(TextView)findViewById(R.id.SampleSpO2);
       viewspo2.setVisibility(View.VISIBLE);
       ImageButton next =(ImageButton)findViewById(R.id.imageButtonNext);
       next.setVisibility(View.VISIBLE);
       next.setOnClickListener(new View.OnClickListener(){
       public void onClick (View v){
              TextView viewspo2 = (TextView)findViewById(R.id.SampleSpO2);
              viewspo2.setVisibility(View.GONE);
```

```
            ImageButton spo2
=(ImageButton)findViewById(R.id.imageButtonSpO2);
            spo2.setVisibility(View.GONE);
            ImageButton next
=(ImageButton)findViewById(R.id.imageButtonNext);
            next.setVisibility(View.GONE);
            ImageView temp2 =(ImageView)findViewById(R.id.imageButtonTemp2);
            temp2.setVisibility(View.VISIBLE);
            ImageView pulse2
=(ImageView)findViewById(R.id.imageButtonPulse2);
            pulse2.setVisibility(View.VISIBLE);
            ImageView spo22 =(ImageView)findViewById(R.id.imageButtonSpO22);
            spo22.setVisibility(View.VISIBLE);
            TextView viewtemp2 =(TextView)findViewById(R.id.SampleTemp2);
            viewtemp2.setVisibility(View.VISIBLE);
            TextView viewpulse2 =(TextView)findViewById(R.id.SamplePulse2);
            viewpulse2.setVisibility(View.VISIBLE);
            TextView viewspo22 =(TextView)findViewById(R.id.SampleSpO22);
            viewspo22.setVisibility(View.VISIBLE);
            ImageButton home =
(ImageButton)findViewById(R.id.imageButtonHome);
            home.setVisibility(View.VISIBLE);
            home.setOnClickListener(new View.OnClickListener(){
            public void onClick (View v){
                    ImageView temp2
=(ImageView)findViewById(R.id.imageButtonTemp2);
                    temp2.setVisibility(View.GONE);
                    ImageView
pulse2=(ImageView)findViewById(R.id.imageButtonPulse2);
                    pulse2.setVisibility(View.GONE);
                    ImageView spo22
=(ImageView)findViewById(R.id.imageButtonSpO22);
                    spo22.setVisibility(View.GONE);
                    TextView viewtemp2
=(TextView)findViewById(R.id.SampleTemp2);
                    viewtemp2.setVisibility(View.GONE);
                    TextView viewpulse2
=(TextView)findViewById(R.id.SamplePulse2);
                    viewpulse2.setVisibility(View.GONE);
                    TextView viewspo22
=(TextView)findViewById(R.id.SampleSpO22);
                    viewspo22.setVisibility(View.GONE);
                    ImageButton
home=(ImageButton)findViewById(R.id.imageButtonHome);
                    home.setVisibility(View.GONE);
                    ImageButton
temp=(ImageButton)findViewById(R.id.imageButtonTemp);
                    temp.setVisibility(View.VISIBLE);
                    }
                    });

            }
```

```
            });
        }
        });


}
}
```

```
//HEALTH APP 1 CELL PHONE XML CODE FOR U.S.A.

<RelativeLayout xmlns:android="http://schemas.android.com/apk/res/android"
    xmlns:tools="http://schemas.android.com/tools"
    android:layout_width="match_parent"
    android:layout_height="match_parent"
    android:paddingBottom="@dimen/activity_vertical_margin"
    android:paddingLeft="@dimen/activity_horizontal_margin"
    android:paddingRight="@dimen/activity_horizontal_margin"
    android:paddingTop="@dimen/activity_vertical_margin"
    tools:context="com.example.mobilehealthapp1.MobileHealthApp1Activity" >


    <ImageButton
        android:id="@+id/imageButtonTemp"
        android:layout_width="150dp"
        android:layout_height="150dp"
        android:layout_alignParentTop="true"
        android:layout_centerHorizontal="true"
        android:layout_marginTop="25dp"
        android:src="@drawable/tempbutton" />


    <ImageButton
        android:id="@+id/imageButtonPulse"
        android:layout_width="150dp"
        android:layout_height="150dp"
        android:layout_centerHorizontal="true"
        android:layout_marginTop="25dp"
        android:src="@drawable/pulsebutton"
        android:visibility="gone"  />

    <ImageButton
        android:id="@+id/imageButtonSpO2"
        android:layout_width="150dp"
        android:layout_height="150dp"
        android:layout_centerHorizontal="true"
        android:layout_marginTop="25dp"
        android:src="@drawable/spo2button"
        android:visibility="gone" />
```

```xml
 <ImageButton
    android:id="@+id/imageButtonNext"
    android:layout_width="85dp"
    android:layout_height="65dp"
    android:layout_alignParentBottom="true"
    android:layout_alignParentRight="true"
    android:src="@drawable/arrow"
    android:visibility="gone" />

<TextView
    android:id="@+id/SampleTemp"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_above="@+id/imageButtonNext"
    android:layout_below="@+id/imageButtonTemp"
    android:layout_marginTop="50dp"
    android:layout_centerHorizontal="true"
    android:text="98.6°F"
    android:textAppearance="?android:attr/textAppearanceLarge"
    android:textSize="100dp"
    android:visibility="gone" />

<TextView
    android:id="@+id/SamplePulse"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_above="@+id/imageButtonNext"
    android:layout_below="@+id/imageButtonPulse"
    android:layout_marginTop="50dp"
    android:layout_centerHorizontal="true"
    android:text="80 BPM"
    android:textSize="85dp"
    android:textAppearance="?android:attr/textAppearanceLarge"
    android:visibility="gone" />

<TextView
    android:id="@+id/SampleSpO2"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_above="@+id/imageButtonNext"
    android:layout_below="@+id/imageButtonSpO2"
    android:layout_marginTop="50dp"
    android:layout_centerHorizontal="true"
    android:text="99%"
    android:textAppearance="?android:attr/textAppearanceLarge"
    android:textSize="100dp"
    android:visibility="gone"  />

<ImageView
    android:id="@+id/imageButtonPulse2"
    android:layout_width="100dp"
    android:layout_height="100dp"
```

```
        android:layout_centerVertical="true"
        android:layout_alignParentLeft="true"
        android:src="@drawable/pulseicon"
        android:visibility="gone"  />

    <ImageView
        android:id="@+id/imageButtonSpO22"
        android:layout_width="100dp"
        android:layout_height="100dp"
        android:layout_alignParentBottom="true"
        android:layout_alignParentLeft="true"
        android:layout_marginBottom="50dp"
        android:src="@drawable/so2"
        android:visibility="gone"  />

       <ImageView
           android:id="@+id/imageButtonTemp2"
           android:layout_width="100dp"
           android:layout_height="100dp"
           android:layout_alignParentLeft="true"
           android:layout_alignParentTop="true"
           android:layout_marginTop="50dp"
           android:src="@drawable/thermometericon"
           android:visibility="gone"  />

       <TextView
           android:id="@+id/SampleSpO22"
           android:layout_width="wrap_content"
           android:layout_height="wrap_content"
           android:layout_alignParentLeft="true"
           android:layout_marginLeft="125dp"
           android:layout_alignTop="@+id/imageButtonSpO22"
           android:text="99%"
           android:textAppearance="?android:attr/textAppearanceLarge"
           android:textSize="60dp"
           android:visibility="gone"  />

       <TextView
           android:id="@+id/SampleTemp2"
           android:layout_width="wrap_content"
           android:layout_height="wrap_content"
           android:layout_alignParentLeft="true"
           android:layout_marginLeft="125dp"
           android:layout_alignTop="@+id/imageButtonTemp2"
           android:text="98.6°F"
           android:textAppearance="?android:attr/textAppearanceLarge"
           android:textSize="60dp"
           android:visibility="gone" />

       <TextView
           android:id="@+id/SamplePulse2"
           android:layout_width="wrap_content"
```

```
            android:layout_height="wrap_content"
            android:layout_alignTop="@+id/imageButtonPulse2"
            android:layout_alignParentLeft="true"
            android:layout_marginLeft="125dp"
            android:text="80 BPM"
            android:textAppearance="?android:attr/textAppearanceLarge"
            android:textSize="55dp"
            android:visibility="gone" />

        <ImageButton
            android:id="@+id/imageButtonHome"
            android:layout_width="70dp"
            android:layout_height="70dp"
            android:layout_alignParentBottom="true"
            android:layout_alignParentRight="true"
            android:src="@drawable/homeicon"
            android:visibility="gone" />

</RelativeLayout>


//HEALTH APP 1 TABLET CELL PHONE XML CODE FOR MEXICO

<RelativeLayout xmlns:android="http://schemas.android.com/apk/res/android"
    xmlns:tools="http://schemas.android.com/tools"
    android:layout_width="match_parent"
    android:layout_height="match_parent"
    android:paddingBottom="@dimen/activity_vertical_margin"
    android:paddingLeft="@dimen/activity_horizontal_margin"
    android:paddingRight="@dimen/activity_horizontal_margin"
    android:paddingTop="@dimen/activity_vertical_margin"
    tools:context="com.example.mobilehealthapp1.MobileHealthApp1Activity" >


    <ImageButton
        android:id="@+id/imageButtonTemp"
        android:layout_width="150dp"
        android:layout_height="150dp"
        android:layout_alignParentTop="true"
        android:layout_centerHorizontal="true"
        android:layout_marginTop="25dp"
        android:src="@drawable/tempbutton" />


    <ImageButton
        android:id="@+id/imageButtonPulse"
        android:layout_width="150dp"
        android:layout_height="150dp"
        android:layout_centerHorizontal="true"
        android:layout_marginTop="25dp"
        android:src="@drawable/pulsebutton"
        android:visibility="gone"  />
```

```
<ImageButton
    android:id="@+id/imageButtonSpO2"
    android:layout_width="150dp"
    android:layout_height="150dp"
    android:layout_centerHorizontal="true"
    android:layout_marginTop="25dp"
    android:src="@drawable/spo2button"
    android:visibility="gone" />

 <ImageButton
    android:id="@+id/imageButtonNext"
    android:layout_width="85dp"
    android:layout_height="65dp"
    android:layout_alignParentBottom="true"
    android:layout_alignParentRight="true"
    android:src="@drawable/arrow"
    android:visibility="gone" />

<TextView
    android:id="@+id/SampleTemp"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_above="@+id/imageButtonNext"
    android:layout_below="@+id/imageButtonTemp"
    android:layout_marginTop="50dp"
    android:layout_centerHorizontal="true"
    android:text="37°C"
    android:textAppearance="?android:attr/textAppearanceLarge"
    android:textSize="100dp"
    android:visibility="gone" />

<TextView
    android:id="@+id/SamplePulse"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_above="@+id/imageButtonNext"
    android:layout_below="@+id/imageButtonPulse"
    android:layout_marginTop="50dp"
    android:layout_centerHorizontal="true"
    android:text="80 pulsos por minuto"
    android:textSize="65dp"
    android:textAppearance="?android:attr/textAppearanceLarge"
    android:visibility="gone" />

<TextView
    android:id="@+id/SampleSpO2"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_above="@+id/imageButtonNext"
    android:layout_below="@+id/imageButtonSpO2"
    android:layout_marginTop="50dp"
```

```
        android:layout_centerHorizontal="true"
        android:text="99%"
        android:textAppearance="?android:attr/textAppearanceLarge"
        android:textSize="100dp"
        android:visibility="gone"  />

    <ImageView
        android:id="@+id/imageButtonPulse2"
        android:layout_width="100dp"
        android:layout_height="100dp"
        android:layout_centerVertical="true"
        android:layout_alignParentLeft="true"
        android:src="@drawable/pulseicon"
        android:visibility="gone"  />

    <ImageView
        android:id="@+id/imageButtonSpO22"
        android:layout_width="100dp"
        android:layout_height="100dp"
        android:layout_alignParentBottom="true"
        android:layout_alignParentLeft="true"
        android:layout_marginBottom="50dp"
        android:src="@drawable/so2"
        android:visibility="gone"  />

       <ImageView
           android:id="@+id/imageButtonTemp2"
           android:layout_width="100dp"
           android:layout_height="100dp"
           android:layout_alignParentLeft="true"
           android:layout_alignParentTop="true"
           android:layout_marginTop="50dp"
           android:src="@drawable/thermometericon"
           android:visibility="gone"  />

       <TextView
           android:id="@+id/SampleSpO22"
           android:layout_width="wrap_content"
           android:layout_height="wrap_content"
           android:layout_alignParentLeft="true"
           android:layout_marginLeft="125dp"
           android:layout_alignTop="@+id/imageButtonSpO22"
           android:text="99%"
           android:textAppearance="?android:attr/textAppearanceLarge"
           android:textSize="60dp"
           android:visibility="gone"  />

       <TextView
           android:id="@+id/SampleTemp2"
           android:layout_width="wrap_content"
           android:layout_height="wrap_content"
           android:layout_alignParentLeft="true"
```

```
            android:layout_marginLeft="125dp"
            android:layout_alignTop="@+id/imageButtonTemp2"
            android:text="37°C"
            android:textAppearance="?android:attr/textAppearanceLarge"
            android:textSize="60dp"
            android:visibility="gone" />

        <TextView
            android:id="@+id/SamplePulse2"
            android:layout_width="wrap_content"
            android:layout_height="wrap_content"
            android:layout_alignTop="@+id/imageButtonPulse2"
            android:layout_alignParentLeft="true"
            android:layout_marginLeft="125dp"
            android:text="80 pulsos por minuto"
            android:textAppearance="?android:attr/textAppearanceLarge"
            android:textSize="40dp"
            android:visibility="gone" />

        <ImageButton
            android:id="@+id/imageButtonHome"
            android:layout_width="70dp"
            android:layout_height="70dp"
            android:layout_alignParentBottom="true"
            android:layout_alignParentRight="true"
            android:src="@drawable/homeicon"
            android:visibility="gone" />

</RelativeLayout>



//HEALTH APP 1 TABLET XML CODE OF U.S.A.

<RelativeLayout xmlns:android="http://schemas.android.com/apk/res/android"
    xmlns:tools="http://schemas.android.com/tools"
    android:layout_width="match_parent"
    android:layout_height="match_parent"
    android:paddingBottom="@dimen/activity_vertical_margin"
    android:paddingLeft="@dimen/activity_horizontal_margin"
    android:paddingRight="@dimen/activity_horizontal_margin"
    android:paddingTop="@dimen/activity_vertical_margin"

tools:context="com.example.mobilehealthapp1tab.MobileHealthApp1TABActivity" >

 <ImageButton
        android:id="@+id/imageButtonTemp"
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:layout_alignParentTop="true"
        android:layout_centerHorizontal="true"
```

```
    android:layout_marginTop="50dp"
    android:src="@drawable/tempbuttontab" />


<ImageButton
    android:id="@+id/imageButtonPulse"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_centerHorizontal="true"
    android:layout_marginTop="50dp"
    android:src="@drawable/pulsebuttontab"
    android:visibility="gone"  />

<ImageButton
    android:id="@+id/imageButtonSpO2"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_centerHorizontal="true"
    android:layout_marginTop="50dp"
    android:src="@drawable/spo2buttontab"
    android:visibility="gone" />

 <ImageButton
    android:id="@+id/imageButtonNext"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_alignParentBottom="true"
    android:layout_alignParentRight="true"
    android:src="@drawable/nextbuttontab"
    android:visibility="gone" />

<TextView
    android:id="@+id/SampleTemp"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_above="@+id/imageButtonNext"
    android:layout_below="@+id/imageButtonTemp"
    android:layout_marginTop="100dp"
    android:layout_centerHorizontal="true"
    android:text="98.6°F"
    android:textAppearance="?android:attr/textAppearanceLarge"
    android:textSize="225dp"
    android:visibility="gone" />

<TextView
    android:id="@+id/SamplePulse"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_above="@+id/imageButtonNext"
    android:layout_below="@+id/imageButtonPulse"
    android:layout_marginTop="100dp"
    android:layout_centerHorizontal="true"
```

```
        android:text="80 BPM"
        android:textAppearance="?android:attr/textAppearanceLarge"
        android:textSize="200dp"
        android:visibility="gone" />

    <TextView
        android:id="@+id/SampleSpO2"
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:layout_above="@+id/imageButtonNext"
        android:layout_below="@+id/imageButtonSpO2"
        android:layout_marginTop="100dp"
        android:layout_centerHorizontal="true"
        android:text="99%"
        android:textAppearance="?android:attr/textAppearanceLarge"
        android:textSize="225dp"
        android:visibility="gone"  />

    <ImageView
        android:id="@+id/imageButtonPulse2"
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:layout_centerVertical="true"
        android:layout_alignParentLeft="true"
        android:src="@drawable/pulseicontab"
        android:visibility="gone"  />

    <ImageView
        android:id="@+id/imageButtonSpO22"
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:layout_alignParentBottom="true"
        android:layout_alignParentLeft="true"
        android:src="@drawable/spo2icontab"
        android:visibility="gone"  />

       <TextView
           android:id="@+id/SampleSpO22"
           android:layout_width="wrap_content"
           android:layout_height="wrap_content"
           android:layout_alignParentLeft="true"
           android:layout_marginLeft="274dp"
           android:layout_alignTop="@+id/imageButtonSpO22"
           android:text="99%"
           android:textAppearance="?android:attr/textAppearanceLarge"
           android:textSize="110dp"
           android:visibility="gone"  />

       <TextView
           android:id="@+id/SampleTemp2"
           android:layout_width="wrap_content"
           android:layout_height="wrap_content"
```

```xml
            android:layout_alignParentLeft="true"
            android:layout_marginLeft="275dp"
            android:layout_alignTop="@+id/imageButtonTemp"
            android:text="98.6°F"
            android:textAppearance="?android:attr/textAppearanceLarge"
            android:textSize="125dp"
            android:visibility="gone" />

        <ImageButton
            android:id="@+id/imageButtonHome"
            android:layout_width="wrap_content"
            android:layout_height="wrap_content"
            android:layout_alignParentBottom="true"
            android:layout_alignParentRight="true"
            android:src="@drawable/homebuttontab"
            android:visibility="gone" />

        <TextView
            android:id="@+id/SamplePulse2"
            android:layout_width="wrap_content"
            android:layout_height="wrap_content"
            android:layout_centerVertical="true"
            android:layout_alignParentLeft="true"
            android:layout_marginLeft="275dp"
            android:text="80 BPM"
            android:textAppearance="?android:attr/textAppearanceLarge"
            android:textSize="110dp"
            android:visibility="gone" />

        <ImageView
            android:id="@+id/imageButtonTemp2"
            android:layout_width="wrap_content"
            android:layout_height="wrap_content"
            android:layout_alignBottom="@+id/imageButtonTemp"
            android:layout_alignParentLeft="true"
            android:src="@drawable/tempicontab"
            android:visibility="gone" />

</RelativeLayout>



//HEALTH APP 1 TABLET XML CODE FOR MEXICO

<RelativeLayout xmlns:android="http://schemas.android.com/apk/res/android"
    xmlns:tools="http://schemas.android.com/tools"
    android:layout_width="match_parent"
    android:layout_height="match_parent"
    android:paddingBottom="@dimen/activity_vertical_margin"
    android:paddingLeft="@dimen/activity_horizontal_margin"
    android:paddingRight="@dimen/activity_horizontal_margin"
    android:paddingTop="@dimen/activity_vertical_margin"
```

```
tools:context="com.example.mobilehealthapp1tab.MobileHealthApp1TABActivity" >

 <ImageButton
        android:id="@+id/imageButtonTemp"
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:layout_alignParentTop="true"
        android:layout_centerHorizontal="true"
        android:layout_marginTop="50dp"
        android:src="@drawable/tempbuttontab" />


    <ImageButton
        android:id="@+id/imageButtonPulse"
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:layout_centerHorizontal="true"
        android:layout_marginTop="50dp"
        android:src="@drawable/pulsebuttontab"
        android:visibility="gone"  />

    <ImageButton
        android:id="@+id/imageButtonSpO2"
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:layout_centerHorizontal="true"
        android:layout_marginTop="50dp"
        android:src="@drawable/spo2buttontab"
        android:visibility="gone" />

     <ImageButton
        android:id="@+id/imageButtonNext"
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:layout_alignParentBottom="true"
        android:layout_alignParentRight="true"
        android:src="@drawable/nextbuttontab"
        android:visibility="gone" />

    <TextView
        android:id="@+id/SampleTemp"
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:layout_above="@+id/imageButtonNext"
        android:layout_below="@+id/imageButtonTemp"
        android:layout_marginTop="100dp"
        android:layout_centerHorizontal="true"
        android:text="37°C"
        android:textAppearance="?android:attr/textAppearanceLarge"
        android:textSize="225dp"
        android:visibility="gone" />
```

```
<TextView
    android:id="@+id/SamplePulse"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_above="@+id/imageButtonNext"
    android:layout_below="@+id/imageButtonPulse"
    android:layout_marginTop="100dp"
    android:layout_centerHorizontal="true"
    android:text="80 pulsos por minutos"
    android:textAppearance="?android:attr/textAppearanceLarge"
    android:textSize="135dp"
    android:visibility="gone" />

<TextView
    android:id="@+id/SampleSpO2"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_above="@+id/imageButtonNext"
    android:layout_below="@+id/imageButtonSpO2"
    android:layout_marginTop="100dp"
    android:layout_centerHorizontal="true"
    android:text="99%"
    android:textAppearance="?android:attr/textAppearanceLarge"
    android:textSize="225dp"
    android:visibility="gone"  />

<ImageView
    android:id="@+id/imageButtonPulse2"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_centerVertical="true"
    android:layout_alignParentLeft="true"
    android:src="@drawable/pulseicontab"
    android:visibility="gone"  />

<ImageView
    android:id="@+id/imageButtonSpO22"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_alignParentBottom="true"
    android:layout_alignParentLeft="true"
    android:src="@drawable/spo2icontab"
    android:visibility="gone"  />

   <TextView
       android:id="@+id/SampleSpO22"
       android:layout_width="wrap_content"
       android:layout_height="wrap_content"
       android:layout_alignParentLeft="true"
       android:layout_marginLeft="274dp"
       android:layout_alignTop="@+id/imageButtonSpO22"
```

```
        android:text="99%"
        android:textAppearance="?android:attr/textAppearanceLarge"
        android:textSize="110dp"
        android:visibility="gone"  />

    <TextView
        android:id="@+id/SampleTemp2"
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:layout_alignParentLeft="true"
        android:layout_marginLeft="275dp"
        android:layout_alignTop="@+id/imageButtonTemp"
        android:text="37°C"
        android:textAppearance="?android:attr/textAppearanceLarge"
        android:textSize="125dp"
        android:visibility="gone" />

    <ImageButton
        android:id="@+id/imageButtonHome"
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:layout_alignParentBottom="true"
        android:layout_alignParentRight="true"
        android:src="@drawable/homebuttontab"
        android:visibility="gone" />

    <TextView
        android:id="@+id/SamplePulse2"
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:layout_centerVertical="true"
        android:layout_alignParentLeft="true"
        android:layout_marginLeft="275dp"
        android:text="80 pulsos por minutos"
        android:textAppearance="?android:attr/textAppearanceLarge"
        android:textSize="90dp"
        android:visibility="gone" />

    <ImageView
        android:id="@+id/imageButtonTemp2"
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:layout_alignBottom="@+id/imageButtonTemp"
        android:layout_alignParentLeft="true"
        android:src="@drawable/tempicontab"
        android:visibility="gone" />

</RelativeLayout>

//HEALTH APP 2 CELL PHONE JAVA CODE

package com.example.mobilehealthapp2;
```

```java
import com.example.mobilehealthapp2.R;
import android.os.Bundle;
import android.support.v7.app.ActionBarActivity;
import android.view.Menu;
import android.view.MenuItem;
import android.view.View;
import android.widget.ImageButton;
import android.widget.TextView;


public class MobileHealthApp2TABActivity extends ActionBarActivity {

	@Override
	protected void onCreate(Bundle savedInstanceState) {
		super.onCreate(savedInstanceState);
		setContentView(R.layout.activity_mobilehealthapp2);
		initHomeButton();
		initTempButton();
		initPulseButton();
		initSpO2Button();
	}

	@Override
	public boolean onCreateOptionsMenu(Menu menu) {
		// Inflate the menu; this adds items to the action bar if it is
present.
		getMenuInflater().inflate(R.menu.mobile_health_app2, menu);
		return true;
	}

	@Override
	public boolean onOptionsItemSelected(MenuItem item) {
		// Handle action bar item clicks here. The action bar will
		// automatically handle clicks on the Home/Up button, so long
		// as you specify a parent activity in AndroidManifest.xml.
		int id = item.getItemId();
		if (id == R.id.action_settings) {
			return true;
		}
		return super.onOptionsItemSelected(item);
	}

private void initTempButton(){
	ImageButton temp = (ImageButton) findViewById (R.id.imageButtonTemp);
	temp.setOnClickListener(new View.OnClickListener() {
	public void onClick (View v){
		TextView viewtemp = (TextView)findViewById(R.id.sampleTemp);
		viewtemp.setVisibility(View.VISIBLE);

		};
```

```
});
}

private void initPulseButton(){
	ImageButton pulse = (ImageButton) findViewById (R.id.imageButtonPulse);
	pulse.setOnClickListener(new View.OnClickListener() {
	public void onClick (View v){
		TextView viewpulse = (TextView)findViewById(R.id.samplePulse);
		viewpulse.setVisibility(View.VISIBLE);

		};
});
}


private void initSpO2Button(){
	ImageButton spo2 = (ImageButton) findViewById (R.id.imageButtonSpO2);
	spo2.setOnClickListener(new View.OnClickListener() {
	public void onClick (View v){
		TextView viewspo2 = (TextView)findViewById(R.id.sampleSpO2);
		viewspo2.setVisibility(View.VISIBLE);

		};
});
}
private void initHomeButton(){
	ImageButton home = (ImageButton) findViewById (R.id.imageButtonHome);
	home.setOnClickListener(new View.OnClickListener() {
	public void onClick (View v){
		TextView viewpulse = (TextView)findViewById(R.id.samplePulse);
		viewpulse.setVisibility(View.GONE);
		TextView viewspo2 = (TextView)findViewById(R.id.sampleSpO2);
		viewspo2.setVisibility(View.GONE);
		TextView viewtemp = (TextView)findViewById(R.id.sampleTemp);
		viewtemp.setVisibility(View.GONE);

		};
		});
	}
}



//HEALTH APP 2 TABLET JAVA CODE

package com.example.mobilehealthapp2tab;


import com.example.mobilehealthapp2tab.R;
import android.os.Bundle;
import android.support.v7.app.ActionBarActivity;
import android.view.Menu;
```

```java
import android.view.MenuItem;
import android.view.View;
import android.widget.ImageButton;
import android.widget.TextView;


public class MobileHealthApp2TABActivity extends ActionBarActivity {

	@Override
	protected void onCreate(Bundle savedInstanceState) {
		super.onCreate(savedInstanceState);
		setContentView(R.layout.activity_mobilehealthapp2tab);
		initHomeButton();
		initTempButton();
		initPulseButton();
		initSpO2Button();
	}

	@Override
	public boolean onCreateOptionsMenu(Menu menu) {
		// Inflate the menu; this adds items to the action bar if it is
present.
		getMenuInflater().inflate(R.menu.mobile_health_app2_tab, menu);
		return true;
	}

	@Override
	public boolean onOptionsItemSelected(MenuItem item) {
		// Handle action bar item clicks here. The action bar will
		// automatically handle clicks on the Home/Up button, so long
		// as you specify a parent activity in AndroidManifest.xml.
		int id = item.getItemId();
		if (id == R.id.action_settings) {
			return true;
		}
		return super.onOptionsItemSelected(item);
	}

private void initTempButton(){
	ImageButton temp = (ImageButton) findViewById (R.id.imageButtonTemp);
	temp.setOnClickListener(new View.OnClickListener() {
	public void onClick (View v){
		TextView viewtemp = (TextView)findViewById(R.id.sampleTemp);
		viewtemp.setVisibility(View.VISIBLE);

		};
});
}

private void initPulseButton(){
	ImageButton pulse = (ImageButton) findViewById (R.id.imageButtonPulse);
	pulse.setOnClickListener(new View.OnClickListener() {
```

```java
        public void onClick (View v){
                TextView viewpulse = (TextView)findViewById(R.id.samplePulse);
                viewpulse.setVisibility(View.VISIBLE);

                };
});
}


private void initSpO2Button(){
        ImageButton spo2 = (ImageButton) findViewById (R.id.imageButtonSpO2);
        spo2.setOnClickListener(new View.OnClickListener() {
        public void onClick (View v){
                TextView viewspo2 = (TextView)findViewById(R.id.sampleSpO2);
                viewspo2.setVisibility(View.VISIBLE);

                };
});
}
private void initHomeButton(){
        ImageButton home = (ImageButton) findViewById (R.id.imageButtonHome);
        home.setOnClickListener(new View.OnClickListener() {
        public void onClick (View v){
                TextView viewpulse = (TextView)findViewById(R.id.samplePulse);
                viewpulse.setVisibility(View.GONE);
                TextView viewspo2 = (TextView)findViewById(R.id.sampleSpO2);
                viewspo2.setVisibility(View.GONE);
                TextView viewtemp = (TextView)findViewById(R.id.sampleTemp);
                viewtemp.setVisibility(View.GONE);

                };
                });
        }
}



//HEALTH APP 2 CELL PHONE XML CODE FOR U.S.A.

<RelativeLayout xmlns:android="http://schemas.android.com/apk/res/android"
    xmlns:tools="http://schemas.android.com/tools"
    android:layout_width="match_parent"
    android:layout_height="match_parent"
    android:paddingBottom="@dimen/activity_vertical_margin"
    android:paddingLeft="@dimen/activity_horizontal_margin"
    android:paddingRight="@dimen/activity_horizontal_margin"
    android:paddingTop="@dimen/activity_vertical_margin"
    tools:context="com.example.mobilehealthapp2.MobileHealthApp2Activity" >


        <ImageButton
         android:id="@+id/imageButtonTemp"
```

```
 android:layout_width="wrap_content"
 android:layout_height="wrap_content"
 android:layout_alignParentTop="true"
 android:layout_alignParentLeft="true"
 android:layout_marginTop="50dp"
 android:src="@drawable/thermometericon" />

<ImageButton
    android:id="@+id/imageButtonPulse"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_alignLeft="@+id/imageButtonTemp"
    android:layout_centerVertical="true"
    android:src="@drawable/pulseicon" />

<TextView
    android:id="@+id/samplePulse"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_alignParentLeft="true"
    android:layout_marginLeft="145dp"
    android:layout_centerVertical="true"
    android:text="80 BPM"
    android:textAppearance="?android:attr/textAppearanceLarge"
    android:textSize="50dp"
    android:visibility="gone"/>


<TextView
    android:id="@+id/sampleTemp"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_marginTop="60dp"
         android:layout_alignParentLeft="true"
    android:layout_marginLeft="145dp"
    android:text="98.6°F"
    android:textAppearance="?android:attr/textAppearanceLarge"
    android:textSize="50dp"
    android:visibility="gone"/>

<ImageButton
    android:id="@+id/imageButtonSpO2"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_alignParentBottom="true"
    android:layout_alignRight="@+id/imagePulse"
    android:layout_marginBottom="50dp"
    android:src="@drawable/spo2icon" />

       <ImageButton
           android:id="@+id/imageButtonHome"
           android:layout_width="70dp"
```

```
                android:layout_height="70dp"
                android:layout_alignParentBottom="true"
                android:layout_alignParentRight="true"
                android:src="@drawable/homeicon" />

            <TextView
                android:id="@+id/sampleSpO2"
                android:layout_width="wrap_content"
                android:layout_height="wrap_content"
                android:layout_marginBottom="70dp"
                android:layout_alignParentLeft="true"
                android:layout_marginLeft="145dp"
                android:layout_alignParentBottom="true"
                android:text="99%"
                android:textAppearance="?android:attr/textAppearanceLarge"
                android:textSize="50dp"
                android:visibility="gone"/>

</RelativeLayout>
```

**//HEALTH APP 2 CELL PHONE XML CODE FOR MEXICO**

```
<RelativeLayout xmlns:android="http://schemas.android.com/apk/res/android"
    xmlns:tools="http://schemas.android.com/tools"
    android:layout_width="match_parent"
    android:layout_height="match_parent"
    android:paddingBottom="@dimen/activity_vertical_margin"
    android:paddingLeft="@dimen/activity_horizontal_margin"
    android:paddingRight="@dimen/activity_horizontal_margin"
    android:paddingTop="@dimen/activity_vertical_margin"
    tools:context="com.example.mobilehealthapp2.MobileHealthApp2Activity" >


       <ImageButton
        android:id="@+id/imageButtonTemp"
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:layout_alignParentTop="true"
        android:layout_alignParentLeft="true"
        android:layout_marginTop="50dp"
        android:src="@drawable/thermometericon" />

       <ImageButton
           android:id="@+id/imageButtonPulse"
           android:layout_width="wrap_content"
           android:layout_height="wrap_content"
           android:layout_alignLeft="@+id/imageButtonTemp"
           android:layout_centerVertical="true"
           android:src="@drawable/pulseicon" />
```

```
<TextView
    android:id="@+id/samplePulse"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_alignParentLeft="true"
    android:layout_marginLeft="145dp"
    android:layout_centerVertical="true"
    android:text="80 pulsos por minuto"
    android:textAppearance="?android:attr/textAppearanceLarge"
    android:textSize="37dp"
    android:visibility="gone"/>


<TextView
    android:id="@+id/sampleTemp"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_marginTop="60dp"
         android:layout_alignParentLeft="true"
    android:layout_marginLeft="145dp"
    android:text="37°C"
    android:textAppearance="?android:attr/textAppearanceLarge"
    android:textSize="50dp"
    android:visibility="gone"/>

<ImageButton
    android:id="@+id/imageButtonSpO2"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_alignParentBottom="true"
    android:layout_alignRight="@+id/imagePulse"
    android:layout_marginBottom="50dp"
    android:src="@drawable/spo2icon" />

       <ImageButton
           android:id="@+id/imageButtonHome"
           android:layout_width="70dp"
           android:layout_height="70dp"
           android:layout_alignParentBottom="true"
           android:layout_alignParentRight="true"
           android:src="@drawable/homeicon" />

       <TextView
           android:id="@+id/sampleSpO2"
           android:layout_width="wrap_content"
           android:layout_height="wrap_content"
           android:layout_marginBottom="70dp"
           android:layout_alignParentLeft="true"
           android:layout_marginLeft="145dp"
           android:layout_alignParentBottom="true"
           android:text="99%"
```

```
                    android:textAppearance="?android:attr/textAppearanceLarge"
                    android:textSize="50dp"
                    android:visibility="gone"/>

</RelativeLayout>
```

**//HEALTH APP 2 TABLET XML CODE FOR U.S.A.**

```
<RelativeLayout xmlns:android="http://schemas.android.com/apk/res/android"
    xmlns:tools="http://schemas.android.com/tools"
    android:layout_width="match_parent"
    android:layout_height="match_parent"
    android:paddingBottom="@dimen/activity_vertical_margin"
    android:paddingLeft="@dimen/activity_horizontal_margin"
    android:paddingRight="@dimen/activity_horizontal_margin"
    android:paddingTop="@dimen/activity_vertical_margin"

tools:context="com.example.mobilehealthapp2tab.MobileHealthApp2TABActivity" >

<ImageButton
        android:id="@+id/imageButtonTemp"
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:layout_alignParentTop="true"
        android:layout_alignParentLeft="true"
        android:layout_marginTop="125dp"
        android:src="@drawable/tempbuttontab" />

       <ImageButton
           android:id="@+id/imageButtonPulse"
           android:layout_width="wrap_content"
           android:layout_height="wrap_content"
           android:layout_alignLeft="@+id/imageButtonTemp"
           android:layout_centerVertical="true"
           android:src="@drawable/pulsebuttontab" />

       <TextView
           android:id="@+id/samplePulse"
           android:layout_width="wrap_content"
           android:layout_height="wrap_content"
           android:layout_alignParentLeft="true"
           android:layout_marginLeft="300dp"
           android:layout_centerVertical="true"
           android:text="80 BPM"
           android:textAppearance="?android:attr/textAppearanceLarge"
           android:textSize="125dp"
           android:visibility="gone"/>
```

```
        <TextView
            android:id="@+id/sampleTemp"
            android:layout_width="wrap_content"
            android:layout_height="wrap_content"
            android:layout_marginTop="155dp"
                 android:layout_alignParentLeft="true"
            android:layout_marginLeft="300dp"
            android:text="98.6°F"
            android:textAppearance="?android:attr/textAppearanceLarge"
            android:textSize="125dp"
            android:visibility="gone"/>

        <ImageButton
            android:id="@+id/imageButtonSpO2"
            android:layout_width="wrap_content"
            android:layout_height="wrap_content"
            android:layout_alignParentBottom="true"
            android:layout_alignRight="@+id/imagePulse"
            android:layout_marginBottom="125dp"
            android:src="@drawable/spo2buttontab" />

               <ImageButton
                   android:id="@+id/imageButtonHome"
                   android:layout_width="wrap_content"
                   android:layout_height="wrap_content"
                   android:layout_alignParentBottom="true"
                   android:layout_alignParentRight="true"
                   android:src="@drawable/homebuttontab" />

               <TextView
                   android:id="@+id/sampleSpO2"
                   android:layout_width="wrap_content"
                   android:layout_height="wrap_content"
                   android:layout_marginBottom="200dp"
                   android:layout_alignParentLeft="true"
                   android:layout_marginLeft="300dp"
                   android:layout_alignParentBottom="true"
                   android:text="99%"
                   android:textAppearance="?android:attr/textAppearanceLarge"
                   android:textSize="125dp"
                   android:visibility="gone"/>

</RelativeLayout>




//HEALTH APP 2 TABLET XML CODE FOR MEXICO

<RelativeLayout xmlns:android="http://schemas.android.com/apk/res/android"
```

```
    xmlns:tools="http://schemas.android.com/tools"
    android:layout_width="match_parent"
    android:layout_height="match_parent"
    android:paddingBottom="@dimen/activity_vertical_margin"
    android:paddingLeft="@dimen/activity_horizontal_margin"
    android:paddingRight="@dimen/activity_horizontal_margin"
    android:paddingTop="@dimen/activity_vertical_margin"

tools:context="com.example.mobilehealthapp2tab.MobileHealthApp2TABActivity" >

<ImageButton
        android:id="@+id/imageButtonTemp"
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:layout_alignParentTop="true"
        android:layout_alignParentLeft="true"
        android:layout_marginTop="125dp"
        android:src="@drawable/tempbuttontab" />

       <ImageButton
           android:id="@+id/imageButtonPulse"
           android:layout_width="wrap_content"
           android:layout_height="wrap_content"
           android:layout_alignLeft="@+id/imageButtonTemp"
           android:layout_centerVertical="true"
           android:src="@drawable/pulsebuttontab" />

       <TextView
           android:id="@+id/samplePulse"
           android:layout_width="wrap_content"
           android:layout_height="wrap_content"
           android:layout_alignParentLeft="true"
           android:layout_marginLeft="300dp"
           android:layout_centerVertical="true"
           android:text="80 pulsos por minuto"
           android:textAppearance="?android:attr/textAppearanceLarge"
           android:textSize="95dp"
           android:visibility="gone"/>


       <TextView
           android:id="@+id/sampleTemp"
           android:layout_width="wrap_content"
           android:layout_height="wrap_content"
           android:layout_marginTop="155dp"
                android:layout_alignParentLeft="true"
           android:layout_marginLeft="300dp"
           android:text="37°C"
           android:textAppearance="?android:attr/textAppearanceLarge"
           android:textSize="125dp"
           android:visibility="gone"/>
```

```
<ImageButton
    android:id="@+id/imageButtonSpO2"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_alignParentBottom="true"
    android:layout_alignRight="@+id/imagePulse"
    android:layout_marginBottom="125dp"
    android:src="@drawable/spo2buttontab" />

        <ImageButton
            android:id="@+id/imageButtonHome"
            android:layout_width="wrap_content"
            android:layout_height="wrap_content"
            android:layout_alignParentBottom="true"
            android:layout_alignParentRight="true"
            android:src="@drawable/homebuttontab" />

        <TextView
            android:id="@+id/sampleSpO2"
            android:layout_width="wrap_content"
            android:layout_height="wrap_content"
            android:layout_marginBottom="200dp"
            android:layout_alignParentLeft="true"
            android:layout_marginLeft="300dp"
            android:layout_alignParentBottom="true"
            android:text="99%"
            android:textAppearance="?android:attr/textAppearanceLarge"
            android:textSize="125dp"
            android:visibility="gone"/>

</RelativeLayout>
```

```
//HEALTH APP 3 CELL PHONE JAVA CODE

package com.example.mobilehealthapp3;
import com.example.mobilehealthapp3.R;
import android.support.v7.app.ActionBarActivity;
import android.os.Bundle;
import android.view.Menu;
import android.view.MenuItem;
import android.view.View;
import android.widget.Button;
import android.widget.ImageButton;
import android.widget.TextView;

public class MobileHealthApp3Activity extends ActionBarActivity {

      @Override
      protected void onCreate(Bundle savedInstanceState) {
```

```
		super.onCreate(savedInstanceState);
		setContentView(R.layout.activity_mobilehealthapp3);
		initStartButton();
		initHomeButton();

	}

	@Override
	public boolean onCreateOptionsMenu(Menu menu) {
		// Inflate the menu; this adds items to the action bar if it is
present.
		getMenuInflater().inflate(R.menu.mobile_health_app3, menu);
		return true;
	}

	@Override
	public boolean onOptionsItemSelected(MenuItem item) {
		// Handle action bar item clicks here. The action bar will
		// automatically handle clicks on the Home/Up button, so long
		// as you specify a parent activity in AndroidManifest.xml.
		int id = item.getItemId();
		if (id == R.id.action_settings) {
			return true;
		}
		return super.onOptionsItemSelected(item);
	}
private void initStartButton(){
	Button start = (Button) findViewById (R.id.buttonSTART);
	start.setOnClickListener(new View.OnClickListener() {
		public void onClick (View v){
			TextView viewtemp =
(TextView)findViewById(R.id.sampleTemp);
			viewtemp.setVisibility(View.VISIBLE);
			TextView viewpulse =
(TextView)findViewById(R.id.samplePulse);
			viewpulse.setVisibility(View.VISIBLE);
			TextView viewspo2 =
(TextView)findViewById(R.id.sampleSpO2);
			viewspo2.setVisibility(View.VISIBLE);


		};
	});
	}
private void initHomeButton(){
ImageButton home = (ImageButton) findViewById (R.id.imageButtonHome);
home.setOnClickListener(new View.OnClickListener() {
public void onClick (View v){
	TextView viewpulse = (TextView)findViewById(R.id.samplePulse);
	viewpulse.setVisibility(View.GONE);
	TextView viewspo2 = (TextView)findViewById(R.id.sampleSpO2);
	viewspo2.setVisibility(View.GONE);
```

```
        TextView viewtemp = (TextView)findViewById(R.id.sampleTemp);
        viewtemp.setVisibility(View.GONE);
        };
});
}


}
```

**//HEALTH APP 3 TABLET JAVA CODE**

```
package com.example.mobilehealthapp3tab;

import com.example.mobilehealthapp3tab.R;



import android.support.v7.app.ActionBarActivity;
import android.os.Bundle;
import android.view.Menu;
import android.view.MenuItem;
import android.view.View;
import android.widget.Button;
import android.widget.ImageButton;
import android.widget.TextView;

import android.support.v7.app.ActionBarActivity;
import android.os.Bundle;
import android.view.Menu;
import android.view.MenuItem;

public class MobileHealthApp3TABActivity extends ActionBarActivity {

        @Override
        protected void onCreate(Bundle savedInstanceState) {
                super.onCreate(savedInstanceState);
                setContentView(R.layout.activity_mobilehealthapp3tab);
                initStartButton();
                initHomeButton();
        }

        @Override
        public boolean onCreateOptionsMenu(Menu menu) {
                // Inflate the menu; this adds items to the action bar if it is
present.
                getMenuInflater().inflate(R.menu.mobile_health_app3_tab, menu);
                return true;
        }

        @Override
```

```java
	public boolean onOptionsItemSelected(MenuItem item) {
		// Handle action bar item clicks here. The action bar will
		// automatically handle clicks on the Home/Up button, so long
		// as you specify a parent activity in AndroidManifest.xml.
		int id = item.getItemId();
		if (id == R.id.action_settings) {
			return true;
		}
		return super.onOptionsItemSelected(item);
	}
	private void initStartButton(){
		Button start = (Button) findViewById (R.id.buttonSTART);
		start.setOnClickListener(new View.OnClickListener() {
		public void onClick (View v){
			TextView viewtemp =
(TextView)findViewById(R.id.sampleTemp);
			viewtemp.setVisibility(View.VISIBLE);
			TextView viewpulse =
(TextView)findViewById(R.id.samplePulse);
			viewpulse.setVisibility(View.VISIBLE);
			TextView viewspo2 =
(TextView)findViewById(R.id.sampleSpO2);
			viewspo2.setVisibility(View.VISIBLE);

			};
		});
	}
	private void initHomeButton(){
		ImageButton home = (ImageButton) findViewById
(R.id.imageButtonHome);
		home.setOnClickListener(new View.OnClickListener() {
		public void onClick (View v){
			TextView viewpulse =
(TextView)findViewById(R.id.samplePulse);
			viewpulse.setVisibility(View.GONE);
			TextView viewspo2 =
(TextView)findViewById(R.id.sampleSpO2);
			viewspo2.setVisibility(View.GONE);
			TextView viewtemp =
(TextView)findViewById(R.id.sampleTemp);
			viewtemp.setVisibility(View.GONE);

			};
	});
}


}


//HEALTH APP 3 CELL PHONE XML FOR U.S.A.
```

```xml
<RelativeLayout xmlns:android="http://schemas.android.com/apk/res/android"
    xmlns:tools="http://schemas.android.com/tools"
    android:layout_width="match_parent"
    android:layout_height="match_parent"
    android:paddingBottom="@dimen/activity_vertical_margin"
    android:paddingLeft="@dimen/activity_horizontal_margin"
    android:paddingRight="@dimen/activity_horizontal_margin"
    android:paddingTop="@dimen/activity_vertical_margin"
    tools:context="com.example.mobilehealthapp3.MobileHealthApp3Activity" >

 <ImageView
        android:id="@+id/imageViewTemp"
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:layout_alignParentTop="true"
        android:layout_alignParentLeft="true"
        android:layout_marginTop="75dp"
        android:src="@drawable/thermometericon" />

      <ImageView
          android:id="@+id/imageViewPulse"
          android:layout_width="wrap_content"
          android:layout_height="wrap_content"
          android:layout_alignLeft="@+id/imageButtonTemp"
          android:layout_centerVertical="true"
          android:src="@drawable/pulseicon" />

      <TextView
          android:id="@+id/samplePulse"
          android:layout_width="wrap_content"
          android:layout_height="wrap_content"
          android:layout_alignParentLeft="true"
          android:layout_marginLeft="125dp"
          android:layout_centerVertical="true"
          android:text="80 BPM"
          android:textAppearance="?android:attr/textAppearanceLarge"
          android:textSize="55dp"
          android:visibility="gone"/>


      <TextView
          android:id="@+id/sampleTemp"
          android:layout_width="wrap_content"
          android:layout_height="wrap_content"
          android:layout_marginTop="85dp"
               android:layout_alignParentLeft="true"
          android:layout_marginLeft="125dp"
          android:text="98.6°F"
          android:textAppearance="?android:attr/textAppearanceLarge"
          android:textSize="55dp"
          android:visibility="gone"/>
```

```xml
    <ImageView
        android:id="@+id/imageViewSpO2"
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:layout_alignParentBottom="true"
        android:layout_alignRight="@+id/imagePulse"
        android:layout_marginBottom="75dp"
        android:src="@drawable/spo2icon" />

        <ImageButton
            android:id="@+id/imageButtonHome"
            android:layout_width="70dp"
            android:layout_height="70dp"
            android:layout_alignParentBottom="true"
            android:layout_alignParentRight="true"
            android:src="@drawable/homeicon" />

        <TextView
            android:id="@+id/sampleSpO2"
            android:layout_width="wrap_content"
            android:layout_height="wrap_content"
            android:layout_marginBottom="85dp"
            android:layout_alignParentLeft="true"
            android:layout_marginLeft="125dp"
            android:layout_alignParentBottom="true"
            android:text="99%"
            android:textAppearance="?android:attr/textAppearanceLarge"
            android:textSize="55dp"
            android:visibility="gone"/>

        <Button
            android:id="@+id/buttonSTART"
            android:layout_width="wrap_content"
            android:layout_height="wrap_content"
            android:layout_alignParentTop="true"
            android:layout_centerHorizontal="true"
            android:textSize="40dp"
            android:text="START" />

</RelativeLayout>
```

**//HEALTH APP 3 CELL PHONE XML FOR MEXICO**

```xml
<RelativeLayout xmlns:android="http://schemas.android.com/apk/res/android"
    xmlns:tools="http://schemas.android.com/tools"
    android:layout_width="match_parent"
    android:layout_height="match_parent"
```

```
    android:paddingBottom="@dimen/activity_vertical_margin"
    android:paddingLeft="@dimen/activity_horizontal_margin"
    android:paddingRight="@dimen/activity_horizontal_margin"
    android:paddingTop="@dimen/activity_vertical_margin"
    tools:context="com.example.mobilehealthapp3.MobileHealthApp3Activity" >

 <ImageView
        android:id="@+id/imageViewTemp"
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:layout_alignParentTop="true"
        android:layout_alignParentLeft="true"
        android:layout_marginTop="75dp"
        android:src="@drawable/thermometericon" />

       <ImageView
           android:id="@+id/imageViewPulse"
           android:layout_width="wrap_content"
           android:layout_height="wrap_content"
           android:layout_alignLeft="@+id/imageButtonTemp"
           android:layout_centerVertical="true"
           android:src="@drawable/pulseicon" />

       <TextView
           android:id="@+id/samplePulse"
           android:layout_width="wrap_content"
           android:layout_height="wrap_content"
           android:layout_alignParentLeft="true"
           android:layout_marginLeft="125dp"
           android:layout_centerVertical="true"
           android:text="80 pulsos por minuto"
           android:textAppearance="?android:attr/textAppearanceLarge"
           android:textSize="38dp"
           android:visibility="gone"/>


       <TextView
           android:id="@+id/sampleTemp"
           android:layout_width="wrap_content"
           android:layout_height="wrap_content"
           android:layout_marginTop="85dp"
                android:layout_alignParentLeft="true"
           android:layout_marginLeft="125dp"
           android:text="37°C"
           android:textAppearance="?android:attr/textAppearanceLarge"
           android:textSize="55dp"
           android:visibility="gone"/>


       <ImageView
           android:id="@+id/imageViewSpO2"
           android:layout_width="wrap_content"
```

```xml
        android:layout_height="wrap_content"
        android:layout_alignParentBottom="true"
        android:layout_alignRight="@+id/imagePulse"
        android:layout_marginBottom="75dp"
        android:src="@drawable/spo2icon" />

    <ImageButton
        android:id="@+id/imageButtonHome"
        android:layout_width="70dp"
        android:layout_height="70dp"
        android:layout_alignParentBottom="true"
        android:layout_alignParentRight="true"
        android:src="@drawable/homeicon" />

    <TextView
        android:id="@+id/sampleSpO2"
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:layout_marginBottom="85dp"
        android:layout_alignParentLeft="true"
        android:layout_marginLeft="125dp"
        android:layout_alignParentBottom="true"
        android:text="99%"
        android:textAppearance="?android:attr/textAppearanceLarge"
        android:textSize="55dp"
        android:visibility="gone"/>

    <Button
        android:id="@+id/buttonSTART"
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:layout_alignParentTop="true"
        android:layout_centerHorizontal="true"
        android:textSize="40dp"
        android:text="INICIO" />

</RelativeLayout>
```

**//HEALTH APP 3 TABLET XML CODE FOR U.S.A.**

```xml
<RelativeLayout xmlns:android="http://schemas.android.com/apk/res/android"
    xmlns:tools="http://schemas.android.com/tools"
    android:layout_width="match_parent"
    android:layout_height="match_parent"
    android:paddingBottom="@dimen/activity_vertical_margin"
    android:paddingLeft="@dimen/activity_horizontal_margin"
    android:paddingRight="@dimen/activity_horizontal_margin"
    android:paddingTop="@dimen/activity_vertical_margin"
```

```
tools:context="com.example.mobilehealthapp3tab.MobileHealthApp3TABActivity" >

 <ImageView
        android:id="@+id/imageViewTemp"
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:layout_alignParentTop="true"
        android:layout_alignParentLeft="true"
        android:layout_marginTop="150dp"
        android:src="@drawable/tempicontab" />

    <ImageView
        android:id="@+id/imageViewPulse"
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:layout_alignLeft="@+id/imageButtonTemp"
        android:layout_centerVertical="true"
        android:src="@drawable/pulseicontab" />

    <TextView
        android:id="@+id/samplePulse"
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:layout_alignParentLeft="true"
        android:layout_marginLeft="300dp"
        android:layout_centerVertical="true"
        android:text="80 BPM"
        android:textAppearance="?android:attr/textAppearanceLarge"
        android:textSize="125dp"
        android:visibility="gone"/>


    <TextView
        android:id="@+id/sampleTemp"
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:layout_marginTop="160dp"
             android:layout_alignParentLeft="true"
        android:layout_marginLeft="300dp"
        android:text="98.6°F"
        android:textAppearance="?android:attr/textAppearanceLarge"
        android:textSize="125dp"
        android:visibility="gone"/>


    <ImageView
        android:id="@+id/imageViewSpO2"
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:layout_alignParentBottom="true"
        android:layout_alignRight="@+id/imagePulse"
```

```
            android:layout_marginBottom="150dp"
            android:src="@drawable/spo2icontab" />

               <ImageButton
                   android:id="@+id/imageButtonHome"
                   android:layout_width="wrap_content"
                   android:layout_height="wrap_content"
                   android:layout_alignParentBottom="true"
                   android:layout_alignParentRight="true"
                   android:src="@drawable/homebuttontab" />

               <TextView
                   android:id="@+id/sampleSpO2"
                   android:layout_width="wrap_content"
                   android:layout_height="wrap_content"
                   android:layout_alignParentBottom="true"
                   android:layout_marginBottom="210dp"
                   android:layout_alignParentLeft="true"
                   android:layout_marginLeft="300dp"
                   android:text="99%"
                   android:textAppearance="?android:attr/textAppearanceLarge"
                   android:textSize="125dp"
                   android:visibility="gone"/>

               <Button
                   android:id="@+id/buttonSTART"
                   android:layout_width="wrap_content"
                   android:layout_height="wrap_content"
                   android:layout_alignParentTop="true"
                   android:layout_centerHorizontal="true"
                   android:textSize="90dp"
                   android:text="START" />
</RelativeLayout>
```

**//HEALTH APP 3 TABLET XML CODE FOR MEXICO**

```
<RelativeLayout xmlns:android="http://schemas.android.com/apk/res/android"
    xmlns:tools="http://schemas.android.com/tools"
    android:layout_width="match_parent"
    android:layout_height="match_parent"
    android:paddingBottom="@dimen/activity_vertical_margin"
    android:paddingLeft="@dimen/activity_horizontal_margin"
    android:paddingRight="@dimen/activity_horizontal_margin"
    android:paddingTop="@dimen/activity_vertical_margin"

tools:context="com.example.mobilehealthapp3tab.MobileHealthApp3TABActivity" >

 <ImageView
```

```
 android:id="@+id/imageViewTemp"
 android:layout_width="wrap_content"
 android:layout_height="wrap_content"
 android:layout_alignParentTop="true"
 android:layout_alignParentLeft="true"
 android:layout_marginTop="150dp"
 android:src="@drawable/tempicontab" />

<ImageView
    android:id="@+id/imageViewPulse"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_alignLeft="@+id/imageButtonTemp"
    android:layout_centerVertical="true"
    android:src="@drawable/pulseicontab" />

<TextView
    android:id="@+id/samplePulse"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_alignParentLeft="true"
    android:layout_marginLeft="300dp"
    android:layout_centerVertical="true"
    android:text="80 pulsos por minutos"
    android:textAppearance="?android:attr/textAppearanceLarge"
    android:textSize="86dp"
    android:visibility="gone"/>


<TextView
    android:id="@+id/sampleTemp"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_marginTop="160dp"
         android:layout_alignParentLeft="true"
    android:layout_marginLeft="300dp"
    android:text="37°C"
    android:textAppearance="?android:attr/textAppearanceLarge"
    android:textSize="125dp"
    android:visibility="gone"/>


<ImageView
    android:id="@+id/imageViewSpO2"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_alignParentBottom="true"
    android:layout_alignRight="@+id/imagePulse"
    android:layout_marginBottom="150dp"
    android:src="@drawable/spo2icontab" />

       <ImageButton
```

```xml
            android:id="@+id/imageButtonHome"
            android:layout_width="wrap_content"
            android:layout_height="wrap_content"
            android:layout_alignParentBottom="true"
            android:layout_alignParentRight="true"
            android:src="@drawable/homebuttontab" />

        <TextView
            android:id="@+id/sampleSpO2"
            android:layout_width="wrap_content"
            android:layout_height="wrap_content"
            android:layout_alignParentBottom="true"
            android:layout_marginBottom="210dp"
            android:layout_alignParentLeft="true"
            android:layout_marginLeft="300dp"
            android:text="99%"
            android:textAppearance="?android:attr/textAppearanceLarge"
            android:textSize="125dp"
            android:visibility="gone"/>

        <Button
            android:id="@+id/buttonSTART"
            android:layout_width="wrap_content"
            android:layout_height="wrap_content"
            android:layout_alignParentTop="true"
            android:layout_centerHorizontal="true"
            android:textSize="90dp"
            android:text="INICIO" />
</RelativeLayout>
```

## APPENDIX B: STUDY SURVEY DOCUMENTS

**Mobile Application for Patient Vital Signs Measurement in Clinical Settings**

***User Interface Optimization Survey : Version 1***

1. How would you rank your level of experience with mobile technology?

   a. No and/or Very Little Experience
   b. Some Experience
   c. A lot of Experience

2. Find the app icon on the **cell phone** labeled "*Health App 1*". Touch the icon to open the app and test the functions in the app. When you have finished exploring the three vital signs functions of the app, please press the blue home icon in the app (not the device) to reset back to the main screen. Based on your experience answer the following questions by encircling the number that most closely represents your opinion:

**Health App 1**

| | Strongly Disagree | Disagree | Slightly disagree | Slightly Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| The app was intuitive | 1 | 2 | 3 | 4 | 5 | 6 |
| The time to display vital signs was appropriate. | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons and texts are clearly displayed | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons used for the app buttons clearly indicate their function | 1 | 2 | 3 | 4 | 5 | 6 |
| The number of screen changes is appropriate to perform task | 1 | 2 | 3 | 4 | 5 | 6 |
| The app was easy to use | 1 | 2 | 3 | 4 | 5 | 6 |

3. Find the app icon on the cell phone labeled “Health App 2”. Touch the icon to open the app and test the functions in the app. When you have finished exploring the three vital signs functions of the app, please press the blue home icon in the app (not the device) to reset back to the main screen. Based on your experience answer the following questions by encircling the number that most closely represents your opinion:

**Health App 2**

| | Strongly Disagree | Disagree | Slightly disagree | Slightly Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| The app was intuitive | 1 | 2 | 3 | 4 | 5 | 6 |
| The time to display vital signs was appropriate. | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons and texts are clearly displayed | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons used for the app buttons clearly indicate their function | 1 | 2 | 3 | 4 | 5 | 6 |
| The number of screen changes is appropriate to perform task | 1 | 2 | 3 | 4 | 5 | 6 |
| The app was easy to use | 1 | 2 | 3 | 4 | 5 | 6 |

4. Find the app icon on the **cell phone** labeled "*Health App 3*". Touch the icon to open the app and test the functions in the app. When you have finished exploring the three vital signs functions of the app, please press the blue home icon in the app (not the device) to reset back to the main screen. Based on your experience answer the following questions by encircling the number that most closely represents your opinion:

**Health App 3**

| | Strongly Disagree | Disagree | Slightly disagree | Slightly Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| The app was intuitive | 1 | 2 | 3 | 4 | 5 | 6 |
| The time to display vital signs was appropriate. | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons and texts are clearly displayed | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons used for the app buttons clearly indicate their function | 1 | 2 | 3 | 4 | 5 | 6 |
| The number of screen changes is appropriate to perform task | 1 | 2 | 3 | 4 | 5 | 6 |
| The app was easy to use | 1 | 2 | 3 | 4 | 5 | 6 |

5. Please rank each of the three apps overall (1 = best, 3 = worst).

   Health App 1 = ________ Health App 2 = ________ Health App 3 = ________

6. Compared to your current instrumentation, is this mobile app based technology useful for your needs?
   Please rank 1-5: __________(1=not useful at all, 5=very useful) and then please explain.

7. How do you see this technology being utilized? Please check all that apply.

- ☐ Hospitals
- ☐ Physician Offices
- ☐ Mobile Clinics
- ☐ Resource-Poor countries
- ☐ Other

If other, please explain:

8. Find the app icon on the **tablet** labeled "*Health App 1*". Touch the icon to open the app and test the functions in the app. When you have finished exploring the three vital signs functions of the app, please press the blue home icon in the app (not the device) to reset back to the main screen. Based on your experience answer the following questions by encircling the number that most closely represents your opinion:

**Health App 1– Tablet**

| | Strongly Disagree | Disagree | Slightly disagree | Slightly Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| The app was intuitive | 1 | 2 | 3 | 4 | 5 | 6 |
| The time to display vital signs was appropriate. | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons and texts are clearly displayed | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons used for the app buttons clearly indicate their function | 1 | 2 | 3 | 4 | 5 | 6 |
| The number of screen changes is appropriate to perform task | 1 | 2 | 3 | 4 | 5 | 6 |
| The app was easy to use | 1 | 2 | 3 | 4 | 5 | 6 |

9. Compared to the cell phone version, was the tablet app more or less suitable for your needs? Please explain.

10. You have been provided examples of temperature and blood oxygen sensors that would accompany this app/device. The temperature sensor is intended for oral use and the blood oxygen sensor is intended for placement on the finger. Take a minute to examine them before answering the following questions.

**Sensors**

| | Strongly Disagree | Disagree | Slightly disagree | Slightly Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| The sensors are easy to understand | 1 | 2 | 3 | 4 | 5 | 6 |
| The sensors are portable | 1 | 2 | 3 | 4 | 5 | 6 |

**Mobile Application for Patient Vital Signs Measurement in Clinical Settings**

***User Interface Optimization Survey : Version 2***

1. How would you rank your level of experience with mobile technology?

   a. No and/or Very Little Experience
   b. Some Experience
   c. A lot of Experience

2. Find the app icon on the **cell phone** labeled "*Health App 1*". Touch the icon to open the app and test the functions in the app. When you have finished exploring the three vital signs functions of the app, please press the blue home icon in the app (not the device) to reset back to the main screen. Based on your experience answer the following questions by encircling the number that most closely represents your opinion:

**Health App 1**

| | Strongly Disagree | Disagree | Slightly disagree | Slightly Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| The app was intuitive | 1 | 2 | 3 | 4 | 5 | 6 |
| The time to display vital signs was appropriate. | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons and texts are clearly displayed | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons used for the app buttons clearly indicate their function | 1 | 2 | 3 | 4 | 5 | 6 |
| The number of screen changes is appropriate to perform task | 1 | 2 | 3 | 4 | 5 | 6 |
| The app was easy to use | 1 | 2 | 3 | 4 | 5 | 6 |

3. Find the app icon on the cell phone labeled “Health App 2”. Touch the icon to open the app and test the functions in the app. When you have finished exploring the three vital signs functions of the app, please press the blue home icon in the app (not the device) to reset back to the main screen. Based on your experience answer the following questions by encircling the number that most closely represents your opinion:

**Health App 2**

| | Strongly Disagree | Disagree | Slightly disagree | Slightly Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| The app was intuitive | 1 | 2 | 3 | 4 | 5 | 6 |
| The time to display vital signs was appropriate. | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons and texts are clearly displayed | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons used for the app buttons clearly indicate their function | 1 | 2 | 3 | 4 | 5 | 6 |
| The number of screen changes is appropriate to perform task | 1 | 2 | 3 | 4 | 5 | 6 |
| The app was easy to use | 1 | 2 | 3 | 4 | 5 | 6 |

4. Find the app icon on the **cell phone** labeled “*Health App 3*”. Touch the icon to open the app and test the functions in the app. When you have finished exploring the three vital signs functions of the app, please press the blue home icon in the app (not the device) to reset back to the main screen. Based on your experience answer the following questions by encircling the number that most closely represents your opinion:

**Health App 3**

| | Strongly Disagree | Disagree | Slightly disagree | Slightly Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| The app was intuitive | 1 | 2 | 3 | 4 | 5 | 6 |
| The time to display vital signs was appropriate. | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons and texts are clearly displayed | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons used for the app buttons clearly indicate their function | 1 | 2 | 3 | 4 | 5 | 6 |
| The number of screen changes is appropriate to perform task | 1 | 2 | 3 | 4 | 5 | 6 |
| The app was easy to use | 1 | 2 | 3 | 4 | 5 | 6 |

5. Please rank each of the three apps overall (1 = best, 3 = worst).

   Health App 1 = ________ Health App 2 = ________ Health App 3 = ________

6. Compared to your current instrumentation, is this mobile app based technology useful for your needs?
   Please rank 1-5: __________(1=not useful at all, 5=very useful) and then please explain.

7. How do you see this technology being utilized? Please check all that apply.

- [ ] Hospitals
- [ ] Physician Offices
- [ ] Mobile Clinics
- [ ] Resource-Poor countries
- [ ] Other

If other, please explain:

8. Find the app icon on the **tablet** labeled “*Health App 2*. Touch the icon to open the app and test the functions in the app. When you have finished exploring the three vital signs functions of the app, please press the blue home icon in the app (not the device) to reset back to the main screen. Based on your experience answer the following questions by encircling the number that most closely represents your opinion:

**Health App 2– Tablet**

| | Strongly Disagree | Disagree | Slightly disagree | Slightly Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| The app was intuitive | 1 | 2 | 3 | 4 | 5 | 6 |
| The time to display vital signs was appropriate. | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons and texts are clearly displayed | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons used for the app buttons clearly indicate their function | 1 | 2 | 3 | 4 | 5 | 6 |
| The number of screen changes is appropriate to perform task | 1 | 2 | 3 | 4 | 5 | 6 |
| The app was easy to use | 1 | 2 | 3 | 4 | 5 | 6 |

9. Compared to the cell phone version, was the tablet app more or less suitable for your needs? Please explain.

10. You have been provided examples of temperature and blood oxygen sensors that would accompany this app/device. The temperature sensor is intended for oral use and the blood oxygen sensor is intended for placement on the finger. Take a minute to examine them before answering the following questions.

**Sensors**

| | Strongly Disagree | Disagree | Slightly disagree | Slightly Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| The sensors are easy to understand | 1 | 2 | 3 | 4 | 5 | 6 |
| The sensors are portable | 1 | 2 | 3 | 4 | 5 | 6 |

**Mobile Application for Patient Vital Signs Measurement in Clinical Settings**

***User Interface Optimization Survey : Version 3***

1. How would you rank your level of experience with mobile technology?

    a. No and/or Very Little Experience
    b. Some Experience
    c. A lot of Experience

2. Find the app icon on the **cell phone** labeled "*Health App 1*". Touch the icon to open the app and test the functions in the app. When you have finished exploring the three vital signs functions of the app, please press the blue home icon in the app (not the device) to reset back to the main screen. Based on your experience answer the following questions by encircling the number that most closely represents your opinion:

**Health App 1**

| | Strongly Disagree | Disagree | Slightly disagree | Slightly Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| The app was intuitive | 1 | 2 | 3 | 4 | 5 | 6 |
| The time to display vital signs was appropriate. | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons and texts are clearly displayed | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons used for the app buttons clearly indicate their function | 1 | 2 | 3 | 4 | 5 | 6 |
| The number of screen changes is appropriate to perform task | 1 | 2 | 3 | 4 | 5 | 6 |
| The app was easy to use | 1 | 2 | 3 | 4 | 5 | 6 |

3. Find the app icon on the cell phone labeled “Health App 2”. Touch the icon to open the app and test the functions in the app. When you have finished exploring the three vital signs functions of the app, please press the blue home icon in the app (not the device) to reset back to the main screen. Based on your experience answer the following questions by encircling the number that most closely represents your opinion:

**Health App 2**

| | Strongly Disagree | Disagree | Slightly disagree | Slightly Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| The app was intuitive | 1 | 2 | 3 | 4 | 5 | 6 |
| The time to display vital signs was appropriate. | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons and texts are clearly displayed | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons used for the app buttons clearly indicate their function | 1 | 2 | 3 | 4 | 5 | 6 |
| The number of screen changes is appropriate to perform task | 1 | 2 | 3 | 4 | 5 | 6 |
| The app was easy to use | 1 | 2 | 3 | 4 | 5 | 6 |

4. Find the app icon on the **cell phone** labeled "*Health App 3*". Touch the icon to open the app and test the functions in the app. When you have finished exploring the three vital signs functions of the app, please press the blue home icon in the app (not the device) to reset back to the main screen. Based on your experience answer the following questions by encircling the number that most closely represents your opinion:

**Health App 3**

| | Strongly Disagree | Disagree | Slightly disagree | Slightly Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| The app was intuitive | 1 | 2 | 3 | 4 | 5 | 6 |
| The time to display vital signs was appropriate. | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons and texts are clearly displayed | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons used for the app buttons clearly indicate their function | 1 | 2 | 3 | 4 | 5 | 6 |
| The number of screen changes is appropriate to perform task | 1 | 2 | 3 | 4 | 5 | 6 |
| The app was easy to use | 1 | 2 | 3 | 4 | 5 | 6 |

5. Please rank each of the three apps overall (1 = best, 3 = worst).

   Health App 1 = ________ Health App 2 = ________ Health App 3 = ________

6. Compared to your current instrumentation, is this mobile app based technology useful for your needs?
   Please rank 1-5: __________(1=not useful at all, 5=very useful) and then please explain.

7. How do you see this technology being utilized? Please check all that apply.

- ☐ Hospitals
- ☐ Physician Offices
- ☐ Mobile Clinics
- ☐ Resource-Poor countries
- ☐ Other

If other, please explain:

8. Find the app icon on the **tablet** labeled "*Health App 3*". Touch the icon to open the app and test the functions in the app. When you have finished exploring the three vital signs functions of the app, please press the blue home icon in the app (not the device) to reset back to the main screen. Based on your experience answer the following questions by encircling the number that most closely represents your opinion:

**Health App 3– Tablet**

| | Strongly Disagree | Disagree | Slightly disagree | Slightly Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| The app was intuitive | 1 | 2 | 3 | 4 | 5 | 6 |
| The time to display vital signs was appropriate. | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons and texts are clearly displayed | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons used for the app buttons clearly indicate their function | 1 | 2 | 3 | 4 | 5 | 6 |
| The number of screen changes is appropriate to perform task | 1 | 2 | 3 | 4 | 5 | 6 |
| The app was easy to use | 1 | 2 | 3 | 4 | 5 | 6 |

9. Compared to the cell phone version, was the tablet app more or less suitable for your needs? Please explain.

10. You have been provided examples of temperature and blood oxygen sensors that would accompany this app/device. The temperature sensor is intended for oral use and the blood oxygen sensor is intended for placement on the finger. Take a minute to examine them before answering the following questions.

**Sensors**

| | Strongly Disagree | Disagree | Slightly disagree | Slightly Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| The sensors are easy to understand | 1 | 2 | 3 | 4 | 5 | 6 |
| The sensors are portable | 1 | 2 | 3 | 4 | 5 | 6 |

**Mobile Application for Patient Vital Signs Measurement in Clinical Settings**

***User Interface Optimization Survey: Version 4***

1. How would you rank your level of experience with mobile technology?

   a. No and/or Very Little Experience
   b. Some Experience
   c. A lot of Experience

2. Find the app icon on the **tablet** labeled "*Health App 1*". Touch the icon to open the app and test the functions in the app. When you have finished exploring the three vital signs functions of the app, please press the blue home icon in the app (not the device) to reset back to the main screen. Based on your experience answer the following questions by encircling the number that most closely represents your opinion:

**Health App 1 – Tablet**

| | Strongly Disagree | Disagree | Slightly disagree | Slightly Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| The app was intuitive | 1 | 2 | 3 | 4 | 5 | 6 |
| The time to display vital signs was appropriate. | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons and texts are clearly displayed | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons used for the app buttons clearly indicate their function | 1 | 2 | 3 | 4 | 5 | 6 |
| The number of screen changes is appropriate to perform task | 1 | 2 | 3 | 4 | 5 | 6 |
| The app was easy to use | 1 | 2 | 3 | 4 | 5 | 6 |

3. Find the app icon on the **cell phone** labeled "*Health App 1*". Touch the icon to open the app and test the functions in the app. When you have finished exploring the three vital signs functions of the app, please press the blue home icon in the app (not the device) to reset back to the main screen. Based on your experience answer the following questions by encircling the number that most closely represents your opinion:

**Health App 1**

| | Strongly Disagree | Disagree | Slightly disagree | Slightly Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| The app was intuitive | 1 | 2 | 3 | 4 | 5 | 6 |
| The time to display vital signs was appropriate. | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons and texts are clearly displayed | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons used for the app buttons clearly indicate their function | 1 | 2 | 3 | 4 | 5 | 6 |
| The number of screen changes is appropriate to perform task | 1 | 2 | 3 | 4 | 5 | 6 |
| The app was easy to use | 1 | 2 | 3 | 4 | 5 | 6 |

4. Find the app icon on the **cell phone** labeled “Health App 2”. Touch the icon to open the app and test the functions in the app. When you have finished exploring the three vital signs functions of the app, please press the blue home icon in the app (not the device) to reset back to the main screen. Based on your experience answer the following questions by encircling the number that most closely represents your opinion:

**Health App 2**

| | Strongly Disagree | Disagree | Slightly disagree | Slightly Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| The app was intuitive | 1 | 2 | 3 | 4 | 5 | 6 |
| The time to display vital signs was appropriate. | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons and texts are clearly displayed | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons used for the app buttons clearly indicate their function | 1 | 2 | 3 | 4 | 5 | 6 |
| The number of screen changes is appropriate to perform task | 1 | 2 | 3 | 4 | 5 | 6 |
| The app was easy to use | 1 | 2 | 3 | 4 | 5 | 6 |

5. Find the app icon on the **cell phone** labeled "*Health App 3*". Touch the icon to open the app and test the functions in the app. When you have finished exploring the three vital signs functions of the app, please press the blue home icon in the app (not the device) to reset back to the main screen. Based on your experience answer the following questions by encircling the number that most closely represents your opinion:

**Health App 3**

| | Strongly Disagree | Disagree | Slightly disagree | Slightly Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| The app was intuitive | 1 | 2 | 3 | 4 | 5 | 6 |
| The time to display vital signs was appropriate. | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons and texts are clearly displayed | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons used for the app buttons clearly indicate their function | 1 | 2 | 3 | 4 | 5 | 6 |
| The number of screen changes is appropriate to perform task | 1 | 2 | 3 | 4 | 5 | 6 |
| The app was easy to use | 1 | 2 | 3 | 4 | 5 | 6 |

6. Please rank each of the three apps overall (1 = best, 3 = worst).

   Health App 1 = ________ Health App 2 = ________ Health App 3 = ________

7. Compared to your current instrumentation, is this mobile app based technology useful for your needs?
   Please rank 1-5: __________(1=not useful at all, 5=very useful) and then please explain.

8. How do you see this technology being utilized? Please check all that apply.

- ☐ Hospitals
- ☐ Physician Offices
- ☐ Mobile Clinics
- ☐ Resource-Poor countries
- ☐ Other

If other, please explain:

9. Compared to the cell phone version, was the tablet app more or less suitable for your needs? Please explain.

10. You have been provided examples of temperature and blood oxygen sensors that would accompany this app/device. The temperature sensor is intended for oral use and the blood oxygen sensor is intended for placement on the finger. Take a minute to examine them before answering the following questions.

**Sensors**

| | Strongly Disagree | Disagree | Slightly disagree | Slightly Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| The sensors are easy to understand | 1 | 2 | 3 | 4 | 5 | 6 |
| The sensors are portable | 1 | 2 | 3 | 4 | 5 | 6 |

**Mobile Application for Patient Vital Signs Measurement in Clinical Settings**

***User Interface Optimization Survey: Version 5***

1. How would you rank your level of experience with mobile technology?

    a. No and/or Very Little Experience
    b. Some Experience
    c. A lot of Experience

2. Find the app icon on the **tablet** labeled "*Health App 2*". Touch the icon to open the app and test the functions in the app. When you have finished exploring the three vital signs functions of the app, please press the blue home icon in the app (not the device) to reset back to the main screen. Based on your experience answer the following questions by encircling the number that most closely represents your opinion:

**Health App 2 – Tablet**

| | Strongly Disagree | Disagree | Slightly disagree | Slightly Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| The app was intuitive | 1 | 2 | 3 | 4 | 5 | 6 |
| The time to display vital signs was appropriate. | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons and texts are clearly displayed | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons used for the app buttons clearly indicate their function | 1 | 2 | 3 | 4 | 5 | 6 |
| The number of screen changes is appropriate to perform task | 1 | 2 | 3 | 4 | 5 | 6 |
| The app was easy to use | 1 | 2 | 3 | 4 | 5 | 6 |

3. Find the app icon on the **cell phone** labeled "*Health App 1*". Touch the icon to open the app and test the functions in the app. When you have finished exploring the three vital signs functions of the app, please press the blue home icon in the app (not the device) to reset back to the main screen. Based on your experience answer the following questions by encircling the number that most closely represents your opinion:

**Health App 1**

| | Strongly Disagree | Disagree | Slightly disagree | Slightly Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| The app was intuitive | 1 | 2 | 3 | 4 | 5 | 6 |
| The time to display vital signs was appropriate. | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons and texts are clearly displayed | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons used for the app buttons clearly indicate their function | 1 | 2 | 3 | 4 | 5 | 6 |
| The number of screen changes is appropriate to perform task | 1 | 2 | 3 | 4 | 5 | 6 |
| The app was easy to use | 1 | 2 | 3 | 4 | 5 | 6 |

4. Find the app icon on the **cell phone** labeled "Health App 2". Touch the icon to open the app and test the functions in the app. When you have finished exploring the three vital signs functions of the app, please press the blue home icon in the app (not the device) to reset back to the main screen. Based on your experience answer the following questions by encircling the number that most closely represents your opinion:

**Health App 2**

| | Strongly Disagree | Disagree | Slightly disagree | Slightly Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| The app was intuitive | 1 | 2 | 3 | 4 | 5 | 6 |
| The time to display vital signs was appropriate. | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons and texts are clearly displayed | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons used for the app buttons clearly indicate their function | 1 | 2 | 3 | 4 | 5 | 6 |
| The number of screen changes is appropriate to perform task | 1 | 2 | 3 | 4 | 5 | 6 |
| The app was easy to use | 1 | 2 | 3 | 4 | 5 | 6 |

5. Find the app icon on the **cell phone** labeled "*Health App 3*". Touch the icon to open the app and test the functions in the app. When you have finished exploring the three vital signs functions of the app, please press the blue home icon in the app (not the device) to reset back to the main screen. Based on your experience answer the following questions by encircling the number that most closely represents your opinion:

**Health App 3**

| | Strongly Disagree | Disagree | Slightly disagree | Slightly Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| The app was intuitive | 1 | 2 | 3 | 4 | 5 | 6 |
| The time to display vital signs was appropriate. | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons and texts are clearly displayed | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons used for the app buttons clearly indicate their function | 1 | 2 | 3 | 4 | 5 | 6 |
| The number of screen changes is appropriate to perform task | 1 | 2 | 3 | 4 | 5 | 6 |
| The app was easy to use | 1 | 2 | 3 | 4 | 5 | 6 |

6. Please rank each of the three apps overall (1 = best, 3 = worst).

   Health App 1 = ________ Health App 2 = ________ Health App 3 = ________

7. Compared to your current instrumentation, is this mobile app based technology useful for your needs?
   Please rank 1-5: __________(1=not useful at all, 5=very useful) and then please explain.

8. How do you see this technology being utilized? Please check all that apply.

☐ Hospitals

☐ Physician Offices

☐ Mobile Clinics

☐ Resource-Poor countries

☐ Other

If other, please explain:

9. Compared to the cell phone version, was the tablet app more or less suitable for your needs? Please explain.

10. You have been provided examples of temperature and blood oxygen sensors that would accompany this app/device. The temperature sensor is intended for oral use and the blood oxygen sensor is intended for placement on the finger. Take a minute to examine them before answering the following questions.

**Sensors**

| | Strongly Disagree | Disagree | Slightly disagree | Slightly Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| The sensors are easy to understand | 1 | 2 | 3 | 4 | 5 | 6 |
| The sensors are portable | 1 | 2 | 3 | 4 | 5 | 6 |

**Mobile Application for Patient Vital Signs Measurement in Clinical Settings**

***User Interface Optimization Survey: Version 6***

1. How would you rank your level of experience with mobile technology?

    a. No and/or Very Little Experience
    b. Some Experience
    c. A lot of Experience

2. Find the app icon on the **tablet** labeled "*Health App 3*". Touch the icon to open the app and test the functions in the app. When you have finished exploring the three vital signs functions of the app, please press the blue home icon in the app (not the device) to reset back to the main screen. Based on your experience answer the following questions by encircling the number that most closely represents your opinion:

**Health App 3 – Tablet**

| | Strongly Disagree | Disagree | Slightly disagree | Slightly Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| The app was intuitive | 1 | 2 | 3 | 4 | 5 | 6 |
| The time to display vital signs was appropriate. | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons and texts are clearly displayed | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons used for the app buttons clearly indicate their function | 1 | 2 | 3 | 4 | 5 | 6 |
| The number of screen changes is appropriate to perform task | 1 | 2 | 3 | 4 | 5 | 6 |
| The app was easy to use | 1 | 2 | 3 | 4 | 5 | 6 |

3. Find the app icon on the **cell phone** labeled "*Health App 1*". Touch the icon to open the app and test the functions in the app. When you have finished exploring the three vital signs functions of the app, please press the blue home icon in the app (not the device) to reset back to the main screen. Based on your experience answer the following questions by encircling the number that most closely represents your opinion:

**Health App 1**

| | Strongly Disagree | Disagree | Slightly disagree | Slightly Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| The app was intuitive | 1 | 2 | 3 | 4 | 5 | 6 |
| The time to display vital signs was appropriate. | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons and texts are clearly displayed | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons used for the app buttons clearly indicate their function | 1 | 2 | 3 | 4 | 5 | 6 |
| The number of screen changes is appropriate to perform task | 1 | 2 | 3 | 4 | 5 | 6 |
| The app was easy to use | 1 | 2 | 3 | 4 | 5 | 6 |

4. Find the app icon on the **cell phone** labeled "Health App 2". Touch the icon to open the app and test the functions in the app. When you have finished exploring the three vital signs functions of the app, please press the blue home icon in the app (not the device) to reset back to the main screen. Based on your experience answer the following questions by encircling the number that most closely represents your opinion:

**Health App 2**

| | Strongly Disagree | Disagree | Slightly disagree | Slightly Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| The app was intuitive | 1 | 2 | 3 | 4 | 5 | 6 |
| The time to display vital signs was appropriate. | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons and texts are clearly displayed | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons used for the app buttons clearly indicate their function | 1 | 2 | 3 | 4 | 5 | 6 |
| The number of screen changes is appropriate to perform task | 1 | 2 | 3 | 4 | 5 | 6 |
| The app was easy to use | 1 | 2 | 3 | 4 | 5 | 6 |

5. Find the app icon on the **<u>cell phone</u>** labeled "*Health App 3*". Touch the icon to open the app and test the functions in the app. When you have finished exploring the three vital signs functions of the app, please press the blue home icon in the app (not the device) to reset back to the main screen. Based on your experience answer the following questions by encircling the number that most closely represents your opinion:

**Health App 3**

| | Strongly Disagree | Disagree | Slightly disagree | Slightly Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| The app was intuitive | 1 | 2 | 3 | 4 | 5 | 6 |
| The time to display vital signs was appropriate. | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons and texts are clearly displayed | 1 | 2 | 3 | 4 | 5 | 6 |
| The icons used for the app buttons clearly indicate their function | 1 | 2 | 3 | 4 | 5 | 6 |
| The number of screen changes is appropriate to perform task | 1 | 2 | 3 | 4 | 5 | 6 |
| The app was easy to use | 1 | 2 | 3 | 4 | 5 | 6 |

6. Please rank each of the three apps overall (1 = best, 3 = worst).

   Health App 1 = ________ Health App 2 = ________ Health App 3 = ________

7. Compared to your current instrumentation, is this mobile app based technology useful for your needs?
   Please rank 1-5: __________(1=not useful at all, 5=very useful) and then please explain.

8. How do you see this technology being utilized? Please check all that apply.

- ☐ Hospitals
- ☐ Physician Offices
- ☐ Mobile Clinics
- ☐ Resource-Poor countries
- ☐ Other

If other, please explain:

9. Compared to the cell phone version, was the tablet app more or less suitable for your needs? Please explain.

10. You have been provided examples of temperature and blood oxygen sensors that would accompany this app/device. The temperature sensor is intended for oral use and the blood oxygen sensor is intended for placement on the finger. Take a minute to examine them before answering the following questions.

**Sensors**

| | Strongly Disagree | Disagree | Slightly disagree | Slightly Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| The sensors are easy to understand | 1 | 2 | 3 | 4 | 5 | 6 |
| The sensors are portable | 1 | 2 | 3 | 4 | 5 | 6 |

## APPENDIX C: INFORMATIONAL LETTER

**Information for Participation in a Research Study**
**Clemson University**

**Usability Study for Acceptance of Mobile Application based Technology in Clinical Settings**


**Principal Investigator:**
Dr. Delphine Dean
Gregg-Graniteville Associate Professor, Bioengineering
305 Rhodes Annex
finou@clemson.edu
864-656-2611


**Description of the research and your participation**
You are being asked to participate in a research study that will examine the relevance and acceptance of mobile, "smart device" technology in a clinical setting. Most of the evidence supporting the use of mobile application in clinical setting is anecdotal, with little empirical research to guide development of these application. Anecdotal evidence suggests that medical professionals have a desire for and acceptance of mobile applications to be used in the clinical setting; however, little evidence exists to support the optimum user interface features for widespread use. Your participation will involve viewing 3 examples of vital signs measurement mobile interfaces and their accompanying mobile sensors and then completing a survey (approximately 8 minutes).

**Risks and discomforts**
There are no known risks associated with this research.

**Potential benefits**
You will likely receive no direct benefit from taking part in this research study. Results from this project will increase the knowledge base concerning how medical professions interact with mobile devices and how to optimize "smart device" technology in the clinical setting.

**Protection of confidentiality**
We will do everything we can to protect your privacy. Your name will not be recorded in any way in the compiled surveys. Your responses will be marked with a code. Your identity will not be revealed in any publication that might result from this study.

**Voluntary participation**
You may choose not to participate and you may withdraw your consent to participate at any time. The results of the study will in no way affect your grades, standing, nor relations with the University or your Department. You do have the right to withdraw from the experiment at any time. Your decision to withdraw will not negatively affect your status as a student in your Department or at the University. Should you decide to withdraw from the study the data collected will be removed from any data analysis and reporting.

**Exclusion Requirements**
Participants must be at least eighteen years of age to be eligible to participate.

**Contact information**
If you have any questions or concerns about this study or if any problems arise, please contact Dr.Delphine Dean at Clemson University at 864.656.2611 or finou@clemson.edu. If you have any questions or concerns

about your rights as a research participant, please contact the Clemson University Office of Research Compliance at 864.656.6460 or irb@clemson.edu.

A copy of this form will be given to you.

**Información para su Participación en un Studio de Investigación**
**Para la Universidad de Clemson**

**Estudio de utilidad para la aceptacion de interfaces moviles**
**basados en tecnologias para el uso en hospitales**

## Investigador Principal:

Doc. Delphine Dean
Profesor Asociado Gregg-Graniteville
Bioingenieria
finou@clemson.edu
864-656-2611

**Descripción de la investigación y su participación**

Se le pide a participar en un estudio de investigación que examinará la pertinencia y la aceptación de la tecnología móvil, " dispositivos inteligentes " en un entorno clínico. La mayor parte de la evidencia que apoya el uso de aplicaciones móviles en el entorno clínico es anecdótico, con poca investigación empírica para guiar el desarrollo de estas aplicaciones. La evidencia anecdótica sugiere que los doctores tienen el deseo y la aceptación de aplicaciones móviles para ser utilizados en la práctica clínica. Sin embargo, existe poca evidencia para apoyar las características óptimas de la interface de usuario para su uso generalizado. Su participación es necesaria para evaluar 3 ejemplos de la medición de signos vitales con la ayuda de un dispositivo móvil y sus respectivos sensores portátiles, para finalmente completar una encuesta (aproximadamente 8 minutos).

**Riesgos**

No existen riesgos asociados con este estudio.

**Beneficios Potenciales**

El participante no recibira beneficio directo alguno por su participación en este estudio de investigación. Los resultados de este proyecto serán aumentar la base de conocimientos sobre cómo profesiones médicos interactúan con los dispositivos móviles y la forma de optimizar la tecnología de " dispositivos inteligentes " en el ámbito clínico

**Protección de la confidencialidad**

Haremos todo lo posible por proteger su privacidad. Su nombre no se grabará en modo alguno en las encuestas compilados. Sus respuestas serán marcados con un código. Su identidad no será revelada en cualquier publicación que pueda resultar de este estudio.

**La participación voluntaria**

Usted puede optar por no participar y usted puede retirar su consentimiento en cualquier momento. Los resultados del estudio no afectaran sus calificaciones, ni las relaciones con la Universidad, Hospital o Departamento. Usted tiene el derecho de retirarse del experimento en cualquier momento. Su decisión de retirarse no afectará negativamente a su condición de estudiante en su departamento o en la Universidad. Si usted decide retirarse del estudio de los datos recogidos serán apartados de todos los análisis y presentación de datos.

**Requisitos de exclusión**
Los participantes deben tener al menos dieciocho años de edad para ser elegibles para participar.

**Información del contacto**
Si usted tiene alguna pregunta o inquietud acerca de este estudio o si surge algún problema, por favor póngase en contacto con la Doctora Delphine Dean de la Universidad de Clemson en el numero de EU 864.656.2611 o pro correo electronico a finou@clemson.edu. Si usted tiene alguna pregunta o inquietud acerca de sus derechos como participante de la investigación, por favor comuníquese con la Oficina de Cumplimiento de Investigación de la Universidad de Clemson en 864.656.6460 o irb@clemson.edu.

Una copia de esta forma se le dará a usted.

## APPENDIX D: IRB APPROVED APPLICATION

Exempt Review Application

Clemson University (CU) Institutional Review Board (IRB) **(Version 6.1.2013)**

Clemson University IRB Website

| | |
|---|---|
| Office use only | Protocol Number: |
| ☐ Approved Exemption Category ________ ______________________________ | Expiration date: |
| __________________________________________ ___________ | __________________________________ |
| Signature of IRB Chair / Designee | Date |

| | |
|---|---|
| **1.** | **Developmental Approval:** If you already have developmental approval for this research study (you should know if you do), please give the IRB protocol number assigned to the study. More information available here. |

| | | |
|---|---|---|
| **2.** | **Research Title:** | Usability Study for Acceptance of Mobile Application based Technology in Clinical Settings |
| | If different, title used on consent document(s) | |

| | | |
|---|---|---|
| | If class project, include course number and title | |

| | | |
|---|---|---|
| **3.** | **Principal Investigator (PI):** The PI must be a member of the Clemson faculty or staff. You cannot be the PI if this is your thesis or dissertation. The PI must have completed IRB-approved human research protections training. Training will be verified by IRB staff before approval is granted. Training instructions available here. CITI training site available here. | |
| | Name: Dr. Delphine Dean | ☒ Faculty<br>☐ Staff |
| | Department: Bioengineering | E-mail: finou@clemson.edu |
| | Campus address:<br>301 Rhodes Research Hall<br>Clemson, SC 29634 | Phone: (864) 656-2611<br>Fax: |

| | | | |
|---|---|---|---|
| **4.** | **Co-Investigator(s):** Co-Investigators must have completed IRB-approved human research protections training. Training will be verified by IRB staff before approval is granted. Training instructions available here. CITI training site available here. | | |
| | Name: Leanne Loper | | E-mail: lloper@g.clemson.edu |
| | Department: Bioengineering | | Phone: |
| | ☐ Faculty<br>☐ Staff | ☒ Graduate student<br>☐ Undergraduate student | ☐ Other. Please specify. |
| | Name: | | E-mail: |
| | Department: | | Phone: |
| | ☐ Faculty | ☐ Graduate student<br>☐ Undergraduate | ☐ Other. Please specify. |

| | |
|---|---|
| | ☐ Staff student |

| | |
|---|---|
| **5.** | **Additional Research Team Members:** All research team members must have completed IRB-approved human research protections training. Training will be verified by IRB staff before approval is granted. Training instructions available here. CITI training site available here. |
| | ☐ List of additional research team members included. Form available here. |

6. **Research Team Roles:** Describe the role of each member of the research team (everyone included in Items 3, 4 and 5), indicating which research activities will be carried out by each particular member. Team members may be grouped into categories.

   **Description:** Dr. Dean will supervise and evaluate the implentation of the set research procedures as well as determine the budget for the research project. Leanne Loper will coordinate the study the nursing department in Edwards Hall. Leanne Loper will implement the research procedures, analyze collected data, and synthesize research findings for publication.

7. **Email Communications:** If you would like one or two of your team members (in addition to the PI) to be copied on all email communications, please list these individuals in the box below.

| | |
|---|---|
| Name: Leanne Loper | E-mail: lloper@g.clemson.edu |
| Name: | E-mail: |

8. **Study Purpose:** Provide a brief description of the purpose of the study. Use lay language and avoid technical terms. IRB members not familiar with the area of research must understand

the nature of the research. Upon conclusion of the study, how will you share your results (e.g., academic publication, evaluation report to funder, conference presentation)?

**Description:** The purpose of this study is to evaluate the acceptance of mobile, "smart device" technology in clinical settings. An additional function of the study is to determine how to better optimize mobile application user interfaces for improved clinical implementation. This will be studied by presenting clinicians and nursing students with multiple example mobile app interfaces and using a survey to systematically compare aspects of each interface, as well as the partner mobile sensors.

9. **Anticipated Dates of Research:**

Anticipated start date (may not be prior to IRB approval; may be "upon IRB approval"): upon IRB approval

Anticipated completion date (Expiration date will be determined by the date entered, maximum three years for initial approval with optional extensions. Please include time needed for analysis of individually identifiable data.): April 2015

10. **Funding Source:** Please check all that apply.

☐ Submitted for internal funding

☒ Internally funded

☐ Submitted for external funding

Funding source, if applicable (Do not use initials): ______

Proposal number (PPN) for the Office of Sponsored Programs: ______

Name of PI on Funding Proposal: ______

☐ Externally funded

Funding source, if applicable (Do not use initials): ______

Proposal number (PPN) for the Office of Sponsored Programs: ______

Name of PI on Funding Proposal: ______

☐ Intend to seek funding   From whom? ______

☐ Not funded

11. **Support provided by Creative Inquiry Initiative:** ☐ Yes ☒ No

If yes, all Creative Inquiry students will be members of the research team, please see item # 5.

12. **Other IRB Approvals:**

Has this research study been presented to any other IRB? ☐ Yes ☒ No

Where? ______   When? ______

If yes, what was their decision? ☐ Approved ☐ Disapproved ☐ Pending

Please attach a copy of any submissions, approvals, or disapprovals from other IRBs.

13. **Exempt Review Checklist:** To determine whether this study meets the federal requirements for exemption [45 CFR 46.101], please complete the following checklist. This will indicate if your study can be exempted from IRB continuing review.

The Federal Code [45 CFR 46.101] permits research activities in the following six categories to be exempted. Please check the relevant exemption category / categories.
**The Federal Office of Human Research Protections has made Decision Charts available here to help in determining whether a particular study falls within a particular Exemption Category.**

| Categories of Research Activities Exempt from Continuing Review | |
|---|---|
| ☐ | **B1**. Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as:<br>a. research on regular and special education instructional strategies, OR<br>b. research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.<br><br>NOTE: Survey and interview procedures with minors are exemptible if the activities fall within this category. |
| ☒ | **B2**. Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, UNLESS:<br>a. the information obtained is recorded in such a manner that human participants can be identified, directly or through identifiers linked to the participants; AND<br>b. any disclosure of the human participants' responses outside the research could reasonably place the participants at risk of criminal or civil liability or be damaging to the participants' financial standing, employability, or reputation.<br><br>NOTE: Survey and interview techniques which include minors are not exempt. Observation of the public behavior of minors, if the researcher is not a participant, is exempt. |
| | |

| | |
|---|---|
| ☐ | **B3**. Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior **that is not exempt under Category B2**, if:<br><br>a. the human participants are elected or appointed public officials or candidates for public office, or<br><br>b. federal statute(s) require(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter. |
| ☐ | **B4**. Research, involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available or if the information is recorded by the investigator in such a manner that participants cannot be identified directly or through identifiers linked to the participants. |
| ☐ | **B5**. **NOTE: Please contact the IRB office before selecting this category since use of this exemption must be initiated by the agency head of the federal funder.**<br><br>Research and demonstration projects which are conducted by or subject to the approval of appropriate Federal Department or Agency heads, and which are designed to study, evaluate, or otherwise examine:<br><br>a. public benefit or service programs; or<br><br>b. procedures for obtaining benefits or services under those programs; or<br><br>c. possible changes in or alternatives to those programs or procedures; or<br><br>d. possible changes in methods or levels of payment for benefits or services under those programs. |
| ☐ | **B6**. Taste and food quality evaluation and consumer acceptance studies,<br><br>a. if wholesome foods without additives are consumed, OR<br><br>b. if a food is consumed that contains a food ingredient at or below the level and |

| | |
|---|---|
| | for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the Food and Drug Administration or approved by the Environmental Protection Agency or the Food Safety and Inspection Service of the U.S. Department of Agriculture. |

**14. If you selected Exemption Category B4, please complete questions a through g below:**

a. Provide a detailed description of the data or specimens and what information will be used. ______

b. What is the source of the data or specimens? ______

c. Are the data or specimens publicly available without restriction or password? (That is, can the general public obtain the data or specimens? Data are not considered publicly available if access is limited to researchers.)

Yes ☐ No ☐

*If yes, please contact the IRB staff for consultation. You may not be conducting research involving human subjects as defined in the federal regulations governing research involving human subjects (45 CFR 46.102).*

d. If the data or specimens are not publicly available, how are you obtaining permission to access these or to use them for research purposes? ______

*Please attach a copy of the correspondence or agreement granting you permission.*

e. How will you receive the data or specimens (e.g., electronic file, access to hard copy records at record-holder's institution, test tube)? ______

f. How are the data or specimens identified when they are made available to you?
1) ☐ Direct Identifier (e.g., subject name, address, social security number).

a) Will you record any direct identifiers that are available to you? Yes* ☐ No ☐

b) Will you have access to the data from home or office? Yes* ☐ No ☐

2) ☐ Indirect Identifier (e.g., an assigned code that could be used by the investigator or the source providing the data or specimens to identify a subject, such as a pathology tracking number or a tracking code used by the source).

a) Will you or a team member have access to the data set code key? Yes* ☐ No ☐

*If you will receive data with indirect identifiers only, please contact the IRB staff for consultation. You may not be conducting research involving human subjects as defined in the federal regulations governing research involving human subjects (45 CFR 46.102).*

3) ☐ No Identifier (i.e., neither the researcher nor the source providing the data or specimens can identify a subject based upon information provided with the data or specimens).

*If it will be impossible for anyone to identify subjects based upon information provided with the data or specimens, you will not be conducting research involving human subjects as defined in the federal regulations governing research involving human subjects (45 CFR 46). Please contact the IRB staff for confirmation.*

g. Will any data or specimens be collected from participants after the submission of this application? (Data or specimens are considered to "exist" if ALL the data or specimens to be used for the research have been collected prior to the submission of this application.)

Yes* ☐ No ☐

*Your research does not qualify for exemption from IRB review under Exemption Category B4.

***PLEASE NOTE: If you are applying for exemption only under Exemption Category B4, please skip to question 22.***

**15. Study Sample:** (Groups specifically targeted for study)

Describe the participants you plan to recruit and the criteria used in the selection process. Indicate if there are any special inclusion or exclusion criteria.

NOTE: If individuals who are incarcerated will be participants, your research is not exemptible. Please complete the Expedited / Full Review Application.

**Description:** Participants for user interface analysis will be nursing students recruited from an introductory level class in the nursing department. Participation in the survey will be completely voluntary.

Age range of participants: 18-40 Projected number of participants: 20

☐ Employees ☒ Students ☐ Minors (under 18) [1]

☐ Pregnant women [1] ☐ Fetuses / neonates [1] ☐ Educationally / economically disadvantaged [1]

☐ Minors who are wards of the state, or any other agency, institution, or entity [1]

☐ Individuals who are incarcerated [2]

☐ Persons incompetent to give valid consent [1]

☐ Other–specify: ______ ☐ Military personnel

[1] State necessity for using this type of participant: Our study seeks to evaluate interactions with user interfaces specific to those who work in the clinical field.

[2] Please note that research involving prisoners (incarcerated individuals) requires full board review. Please submit an Expedited / Full Board Review Application and a Prisoner Research Addendum (available here).

**16. Study Locations:**

☒ Clemson University

☐ Other University / College ______

☐ School System / Individual Schools ______

☐ Other – specify ______

You may need to obtain permission if participants will be recruited or data will be obtained through schools, employers, or community organizations. Are you required to obtain permission to gain access to people or to access data that are not publicly available? If yes, provide a research site letter from a person authorized to give you access to the participants or to the data. Guidance regarding Research Site Letters is available here.

☐ Research Site Letter(s) not required.

☐ Research Site Letter(s) attached.

☐ Research Site Letter(s) pending and will be provided when obtained.

**17. Recruitment Method:**

Describe how research participants will be recruited in the study. How will you identify potential participants? How will you contact them? **Attach a copy of any material you will use to recruit participants (e.g., advertisements, flyers, telephone scripts, verbal recruitment, cover letters, or follow-up reminders).**

**Description:** Potential participants will be contact about the study via email from the faculty in charge of the nursing lab classroom where Leanne Loper will adminster the study. The students will receive the informational letter via email. The subject for this email will be "Request for Participation in Clinical Technology Study". The body of the email will be as follows:

"Your participation in a research study focusing on the use of mobile applications in clinical settings is requested. The study will be held during lab on [insert date of study here]. Please refer to the attachment for more information on this study."

**18. Participant Incentives:**

a. Will you pay participants? ☐ Yes ☒ No

Amount: $______ When will money be paid?: ______

b. Will you give participants incentives / gifts / reimbursements? ☐ Yes ☒ No

Describe incentives / gifts / reimbursements: ______

Value of incentives / gifts / reimbursements: $______

When will incentives / gifts / reimbursements be given?: ______

c. Will participants receive extra credit? ☐ Yes ☒ No

If yes, an equivalent alternative to research participation must be provided and described in your informed consent document(s).

**19. Informed Consent:**

a. Attach a copy of the informational letter or consent script you plan to provide to your participants (and their parents or guardians, if applicable). Consent Document Templates

b. Will you use concealment (incomplete disclosure) or deception in this study? ☐ Yes ☒ No

*If yes, please see guidance regarding Research Involving Deception or Concealment here, submit a copy of the Additional Pertinent Information / Permission for Use of*

*Data Collected in a Research Study form you will use, and provide a justification in the following space for this use of concealment or deception.* ______

**20. Procedures:**

a. What data will you collect? Evaluation survey following interaction with user interface

b. Please describe in detail the process each participant will experience and how you will obtain the data. Participants will be given a tablet and a phone with the sample applications preloaded on to both devices, as well as a printed copy of the informational letter. They will be asked to open and run each mobile application. Additionally, they will be asked to evaluate the portability and convenience of the commercially available mobile sensors. Finally, they will be asked to complete a paper survey evaluating the user interfaces and sensors. The goal is to gain information on user interfaces. As such, the devices and sensors are all currently approved commercial devices and the data presented on the interface is simulated patient data (no humans will be connected to the sensors). All data for this study will be collected within the hand written surveys and no data will be stored on the tablet or phone regarding how participants interact with the applications. Three versions of the survey will be randomized among participants to indicate which of the three versions of the user interface will be viewed by the participant on the tablet platform. Hard copies of the informational letter will be available at the testing site for participants to read and keep a copy if desired.

c. How many participation sessions and how much time will be required for each participant, including follow up sessions? It will take approximately 8 minutes for each individual to complete the study and the study will be adminstered over the course of 2.5 hours during a normally scheduled lab period. No follow up sessions will be required.

d. How will you collect data?

☒ in-person contact ☐ telephone

☐ snail mail ☐ email

☐ website ☒ other, describe written survey

***Please include copies of surveys, interview questions, data collection tools and debriefing statements. If survey or interview questions have not been fully developed, provide information on the types of questions to be asked, or a description of the parameters of the survey / interview. Please note: finalized survey or interview instruments will need to be reviewed and approved by amendment, before implementation.***

e. Will you audio record participants? ☐ Yes ☒ No
f. Will you video record participants? ☐ Yes ☒ No
g. Will you photograph participants? ☐ Yes ☒ No

*If you will audio or video record or take identifiable photographs of participants, please consult the IRB's Guidance on the Use of Audio / Video Recording and Photography here. Please include all the information addressed by this guidance document in the application and, where appropriate, in the consent document(s).*

**21. Protection of Confidentiality:** Describe the security measures you will take to protect the confidentiality of the information obtained. Will participants be identifiable either by name or through demographic data? If yes, how will you protect the identity of the participants and their responses? Where will the data be stored and how will it be secured? Who will have access to the data? How will identifiers be maintained or destroyed after the study is completed?

**Description:** The participants will not be identifiable by name or demographic data because that information will not be recorded. By waiving the documentation of consent, we avoid the signature required by written consent. Each participant will be assigned a number that the data will be linked to rather than a name; therefore, it cannot be tied back to the participant. The data will be maintained from a password-protected laptop.

**22. PI Signature:**

I have reviewed this research protocol and the informed consent document(s), if applicable. I request approval of this research study by the IRB of Clemson University.

**Conflict of Interest Statement:**

Could the results of the study provide an actual or potential financial gain to you, a member of your family, or any of the co-investigators, or give the appearance of a potential conflict of interest?

☒ No.

☐ Yes. I agree to disclose any actual or potential conflict of interest prior to IRB action on this study.

Financial Conflict of Interest Policy for PHS / NIH Supported Research

Financial Disclosure Policy for All Other Sponsored Programs

__________________________________________________
___________________________

Signature of Principal Investigator Date

(hard-copy signature only needed if application will not be submitted via PI's email account)

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**Submission Instructions:** Exempt applications are processed as received. There is no deadline for submitting exempt applications for review. Approval is usually granted within 14 days of receipt of the application. It is recommended that you submit your IRB application at least a month before your desired start date.

International research - please note that the approval of international research may require additional time due to requirements in other countries, negotiation of Individual Investigator Agreements, arranging appropriate local context reviews, and geographical and communication constraints. It is recommended you plan to submit your IRB application at least three months prior to your desired study start date. More information on local context reviews is available on our FAQ webpage, http://www.clemson.edu/research/compliance/irb/faq.html.

Please submit this application and all associated documents from the Principal Investigator's (PI's) email address to the IRB staff. Receipt of the application electronically from the PI will qualify the application as a signed electronic submission. Alternatively, the signed, hard-copy application may be mailed or delivered to the Office of Research Compliance, 223 Brackett Hall, Clemson, SC 29634-5704.

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## APPENDIX E: SURVEY RESPONSE SUMMARIES

| Mobile Technology Self-Assessment | | | |
|---|---|---|---|
| | None/Very Little Experience | Some Experience | A lot of Experience |
| # of Participants Total | 6 | 17 | 18 |
| % of Participants Total | 14.6% | 41.5% | 43.9% |
| # of Participants Mexico | 3 | 7 | 0 |
| % of Participants Mexico | 30.0% | 70.0% | 0.0% |
| # of Participants U.S. | 3 | 10 | 18 |
| % of Participants U.S. | 9.7% | 32.3% | 58.1% |

| Health App 1: Cell Phone | | | | | | |
|---|---|---|---|---|---|---|
| | Q1: The app was intuitive | Q2: Time to display vital signs was appropriate | Q3: Icons and text are clearly displayed | Q4: Icons used for the app buttons clearly indicated function | Q5: The number of screen changes is appropriate | Q6: The app was easy to use |
| Overall Mode | 5 | 6 | 6 | 6 | 6 | 6 |
| Overall Median | 5 | 6 | 6 | 6 | 5 | 6 |
| Mexico Mode | 6 | 6 | 6 | 6 | 5 | - |
| Mexico Median | 5 | 5 | 5.5 | 5.5 | 5 | - |
| U.S. Mode | 5 | 6 | 6 | 6 | 6 | 6 |
| U.S. Median | 5 | 6 | 6 | 6 | 5 | 6 |

| Health App 2: Cell Phone | | | | | | |
|---|---|---|---|---|---|---|
| | Q1: The app was intuitive | Q2: Time to display vital signs was appropriate | Q3: Icons and text are clearly displayed | Q4: Icons used for the app buttons clearly indicated function | Q5: The number of screen changes is appropriate | Q6: The app was easy to use |
| Overall Mode | 6 | 6 | 6 | 6 | 6 | 6 |
| Overall Median | 5 | 6 | 6 | 6 | 6 | 6 |
| Mexico Mode | 6 | 6 | 6 | 6 | 6 | - |
| Mexico Median | 5 | 5 | 6 | 6 | 5 | - |
| U.S. Mode | 5 | 6 | 6 | 6 | 6 | 6 |
| U.S. Median | 5 | 6 | 6 | 6 | 6 | 6 |

| Health App 3: Cell Phone | | | | | | |
|---|---|---|---|---|---|---|
| | Q1: The app was intuitive | Q2: Time to display vital signs was appropriate | Q3: Icons and text are clearly displayed | Q4: Icons used for the app buttons clearly indicated function | Q5: The number of screen changes is appropriate | Q6: The app was easy to use |
| Overall Mode | 6 | 6 | 6 | 6 | 6 | 6 |
| Overall Median | 6 | 6 | 6 | 6 | 6 | 6 |
| Mexico Mode | 6 | 6 | 6 | 6 | 6 | - |
| Mexico Median | 6 | 6 | 6 | 6 | 6 | - |
| U.S. Mode | 6 | 6 | 6 | 6 | 6 | 6 |
| U.S. Median | 6 | 6 | 6 | 6 | 6 | 6 |

| Health App 1: Tablet | | | | | | |
|---|---|---|---|---|---|---|
| | Q1: The app was intuitive | Q2: Time to display vital signs was appropriate | Q3: Icons and text are clearly displayed | Q4: Icons used for the app buttons clearly indicated function | Q5: The number of screen changes is appropriate | Q6: The app was easy to use |
| Overall Mode | 5 | 5 | 6 | 6 | 6 | 5 |
| Overall Median | 5 | 5 | 6 | 6 | 5 | 5 |
| Mexico Mode | 6 | 6 | 6 | 6 | 6 | - |
| Mexico Median | 6 | 6 | 6 | 6 | 6 | - |
| U.S. Mode | 5 | 5 | 5 | 5 | 5 | 5 |
| U.S. Median | 5 | 5 | 5 | 5 | 5 | 5 |

| Health App 2: Tablet | | | | | | |
|---|---|---|---|---|---|---|
| | Q1: The app was intuitive | Q2: Time to display vital signs was appropriate | Q3: Icons and text are clearly displayed | Q4: Icons used for the app buttons clearly indicated function | Q5: The number of screen changes is appropriate | Q6: The app was easy to use |
| Overall Mode | 6 | 6 | 6 | 6 | 6 | 6 |
| Overall Median | 6 | 6 | 6 | 6 | 6 | 6 |
| Mexico Mode | 6 | 6 | 6 | 6 | 6 | - |
| Mexico Median | 6 | 6 | 6 | 6 | 6 | - |
| U.S. Mode | 6 | 6 | 6 | 6 | 6 | 6 |
| U.S. Median | 5.5 | 6 | 6 | 6 | 6 | 6 |

| Health App 3: Tablet | | | | | | |
|---|---|---|---|---|---|---|
| | Q1: The app was intuitive | Q2: Time to display vital signs was appropriate | Q3: Icons and text are clearly displayed | Q4: Icons used for the app buttons clearly indicated function | Q5: The number of screen changes is appropriate | Q6: The app was easy to use |
| Overall Mode | 6 | 6 | 6 | 6 | 6 | 6 |
| Overall Median | 5 | 6 | 6 | 6 | 6 | 6 |
| Mexico Mode | 4 | 4 | 6 | 4 | #N/A | - |
| Mexico Median | 4 | 4.5 | 5.5 | 4.5 | 4.5 | - |
| U.S. Mode | 6 | 6 | 6 | 6 | 6 | 6 |
| U.S. Median | 6 | 6 | 6 | 6 | 6 | 6 |

| App Rank | | | |
|---|---|---|---|
| | App 1 | App 2 | App 3 |
| Overall Mode | 3 | 2 | 1 |
| Overall Median | 3 | 2 | 1 |
| Mexico Mode | 3 | 2 | 1 |
| Mexico Median | 2 | 2 | 1 |
| U.S. Mode | 3 | 2 | 1 |
| U.S. Median | 3 | 2 | 1 |

| Applicability of Mobile App Technology | | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Total # of Responses | 2 | 1 | 2 | 11 | 28 |
| % of Participants | 4.5% | 2.3% | 4.5% | 25.0% | 63.6% |
| Total # of Response Mexico | 2 | 1 | 1 | 0 | 7 |
| % of Participants Mexico | 18.2% | 9.1% | 9.1% | 0.0% | 63.6% |
| Total # of Responses U.S. | 0 | 0 | 1 | 11 | 21 |
| % of Participants U.S. | 0.0% | 0.0% | 3.0% | 33.3% | 63.6% |

| Technology Utilization | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Hospital | Physician Office | Mobile Clinics | Resource-Poor Setting | Other | Home Use | Work Use | Teaching |
| Total # of Responses | 30 | 36 | 40 | 21 | 9 | 8 | 1 | 1 |
| % of Participants | 66.7% | 80.0% | 88.9% | 46.7% | 20.0% | 17.8% | 2.2% | 2.2% |
| Total # of Response Mexico | 6 | 9 | 8 | 3 | 6 | 5 | 1 | 0 |
| % of Participants Mexico | 50.0% | 75.0% | 66.7% | 25.0% | 50.0% | 41.7% | 8.3% | 0.0% |
| Total # of Responses U.S. | 24 | 27 | 32 | 18 | 3 | 3 | 0 | 1 |
| % of Participants U.S. | 72.7% | 81.8% | 97.0% | 54.5% | 9.1% | 9.1% | 0.0% | 3.0% |

| Device Type Preference | | | |
|---|---|---|---|
| | Cell Phone | Tablet | No Preference |
| Total # of Responses | 19 | 8 | 14 |
| % of Participants | 46.3% | 19.5% | 34.1% |
| Total # of Response Mexico | 3 | 1 | 4 |
| % of Participants Mexico | 37.5% | 12.5% | 50.0% |
| Total # of Responses U.S. | 16 | 7 | 10 |
| % of Participants U.S. | 48.5% | 21.2% | 30.3% |

| Sensors: Easy to Understand Intended Use | | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| Total Number of Responses | 0 | 0 | 3 | 2 | 18 | 21 |
| Total Percent | 0.0% | 0.0% | 6.8% | 4.5% | 40.9% | 47.7% |
| Number of Responses Mexico | 0 | 0 | 3 | 0 | 5 | 3 |
| Percent Mexico | 0.0% | 0.0% | 27.3% | 0.0% | 45.5% | 27.3% |
| Number of Responses U.S. | 0 | 0 | 0 | 2 | 13 | 18 |
| Percent U.S. | 0.0% | 0.0% | 0.0% | 6.1% | 39.4% | 54.5% |

| Sensors: Portable | | | | | | |
|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** |
| **Total Number of Responses** | 0 | 0 | 2 | 3 | 19 | 20 |
| **Total Percent** | 0.0% | 0.0% | 4.5% | 6.8% | 43.2% | 45.5% |
| **Number of Responses Mexico** | 0 | 0 | 3 | 0 | 5 | 3 |
| **Percent Mexico** | 0.0% | 0.0% | 27.3% | 0.0% | 45.5% | 27.3% |
| **Number of Responses U.S.** | 0 | 0 | 0 | 3 | 14 | 16 |
| **Percent U.S.** | 0.0% | 0.0% | 0.0% | 9.1% | 42.4% | 48.5% |