# Utilization of Smartphones to Access Health-related Information: A Descriptive Analysis (2010-2012)

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Clarence Spigner

David Masuda

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**Abstract**

Utilization of Smartphones to Access Health-related Information: A Descriptive Analysis 2010-2012

Fareeha Siddiqui

Chair of the Supervisory Committee:

Dr. Clarence Spigner

Department of Global Health

***Objective***: To examine the extent to which smartphone utilization to access the internet and health-related information increased from 2010 to 2012, and how this utilization varies by demographics and type of chronic disease. ***Methods***: Analysis was done on publicly available de-identified survey data obtained from the Pew Research Center. Three outcome variables were assessed by demographics and chronic disease: a) Cellphone use to access internet b) Cellphone use to look up health-related information and c) Cellphone with downloadable "apps" to help manage health. ***Results:*** Smartphone utilization to access the internet increased by 17.3% from 2010 to 2012 and smartphone utilization to access health-related information increased by 13.6%. Utilization of health management "apps" increased by 1.3%. ***Conclusions*****:** Smartphone adoption and utilization for accessing health-related information seems to be increasing steadily; however, this increase is primarily happening in individuals from higher income brackets, those that are younger, and those living in urban/suburban areas. Without finding strategies to specifically target low-income, urban/rural, and elderly populations whilst facilitating increased health literacy, mHealth technology solutions run the risk of becoming an amenity available for the privileged few.

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# I. INTRODUCTION

## *Healthcare Information Technology*

In the field of Healthcare Information Technology (HIT), wireless mobile communication devices such as smartphones can work to extend disease prevention and management beyond traditional clinical care, this has come to be known as the field of *mHealth*. These smartphone technologies such as text messaging, downloadable health apps, and wireless monitoring sensors represent innovations in medicine that can improve the accessibility to treatment and provide patients the opportunity to actively engage with their health care providers. Furthermore, these technologies can improve the speed and accuracy of diagnostic tests. Patients can utilize these technology platforms for improved medication adherence; engaging in interactive patient-provider communication; and providing health organizations with methods for data collection, remote diagnosis, and emergency tracking[1, 2].

## *Challenges for Safety-net Service Providers*

Community health centers, which often function as safety-net service providers for socially disadvantaged populations, face many challenges in creating effective programs for patients suffering from chronic diseases. They lack the resources needed to provide holistic care for patients with chronic disease. Furthermore, a significant number of these health centers are the only healthcare service provider for large geographical area, making them independent of integrated health care delivery systems which have the capacity to implement comprehensive care plans in a sustainable way[3,4]. Additionally, patients who seek care at these community health centers are generally impoverished and have low health literacy[5]. Therefore, healthcare service providers that serve disadvantaged populations need to implement innovative approaches that allow for the provision of comprehensive care plans for chronic disease management without creating an extended strain on limited resources.

### *Overcoming Current Challenges with mHealth Technology*

Risks and complications associated with chronic diseases have shown improvement with the utilization of evidence-based interventions such as medication management, lifestyle coaching, improved diet and exercise, self-monitoring, and the appropriate use of healthcare services[6]. However, there are several barriers to implementation of these interventions in socially disadvantaged populations: low health literacy, financial barriers, difficulties with language, cultural beliefs, lack of transportation, and provider mistrust[7]. A number of studies have reported on the utilization of healthcare IT to help address barriers associated with chronic disease management in disadvantaged populations[8]. More specifically, these technologies can be used to provide support to patients, enhance health care delivery, and provide patients and clinicians with timely, useful data about the health status of an individual[9]. In a study conducted by Quinn et al., the use of an mHealth application showed significant improvements in HbA1c levels when compared to the cohort receiving usual care. The use of healthcare IT has also been associated with improvements in health literacy, blood pressure, lipid levels, and frequency of eye and foot exams in diabetic patients[10, 11, 12].

### *Strengthening the Patient-Provider Relationship*

On the provider side, healthcare IT has proven to be useful in helping design patient-specific care plans, enhance communication, strengthen the patient-provider relationship, decrease costs, and provide access to evidence-based guidelines of care. Because these technologies are patient-centric, they enable a partnership between patients', patients' families, and practitioners, which allows for comprehensive treatment plans taking into account individual needs and preferences. This is especially important in settings where there are limited resources for management of chronic disease in disadvantaged populations[13, 14, 15].

### *Rising Smartphone Availability*

Substantial data on the expansion and growth of mHealth technologies can be found, but there is limited to no data available on whether these technologies have been

adopted by low-income and disadvantaged populations in the United States. However, there is clear data indicating the increase in smartphone use by the general population as well as the increasing abundance of mHealth applications available for smartphones.

According to data published in the *Nielsen Report* in June of 2013, smartphone use continues to increase with every three out of five mobile subscribers now using a smartphone (61%). This is more than a 10% increase from May 2012 of last year. The report also projects increased smartphone use by elderly and poorer populations over time. Similarly, the number of mHealth applications available is also accelerating at an unprecedented rate. In 2012, there were over 40,000 mHealth applications available for download and this number is projected to grow alongside increased smartphone users. Additionally, the number of mHealth application users (defined as those who downloaded an mHealth application at least once) increased to 247 million in 2012 compared to just 124 million users in 2011[16,17].

### *Purpose of Our Study*

The purpose of this analysis was to conduct an exploratory analysis using data obtained from two national surveys conducted in 2010 and 2012. The data was used to determine the extent of smartphone utilization to access health-related information by demographics and type of chronic disease for each survey year. The following three outcome variables were used: a) Cellphone use to access internet b) Cellphone use to look up health-related information and c) Cellphone with downloadable "apps" to help manage health.

## II. METHODS

### *Data Source*

Analysis was done on publicly available de-identified survey data obtained from the Pew Research Center. Two national telephone surveys conducted in 2010 and 2012 assessing user behavior pertaining to smartphone use and accessing the internet and health-related information were used. To our knowledge, these were the only nationally representative and publicly available surveys assessing trends in smartphone

use in recent years. The 2010 Health Tracking Survey was conducted by Princeton Survey Research Associates International between August 9 and September 13, 2010, among a sample of 3,001 adults, age 18 and older, including 1,000 cell-phone interviews. Interviews were conducted in English and Spanish. Survey data was weighted by the Pew Research center to overcome biases associated with disproportionate sampling and non-responses, thus ensuring the weighted sample was nationally representative. The weighting was accomplished in multiple stages to account for the disproportionately-stratified sample, the overlapping landline and cell phone sample frames and differential non-response associated with sample demographics.

The 2012 Health Tracking Survey obtained telephone interviews among a sample of 3,014 adults, age 18 and older, including 1,206 cell-phone interviews. Interviews were done in English and Spanish by Princeton Survey Research associates International between August 7 and September 6, 2012. Data was weighted by the Pew Research Center to account for the disproportionately-stratified sample, the overlapping landline and cell phone sample frames and differential non-response associated with sample demographics using the same methodology as the 2010 Health Tracking Survey. *The weighted sample size for the 2012 survey is significantly smaller than the 2010 survey, this is often the case when weighting sample sizes to make them nationally representative and has no effect on analysis outcomes.*

### *Data Analysis*

In order to determine the extent of smartphone utilization to access health-related information, the following three key outcome variables were analyzed: a) Smartphone use to access internet b) Smartphone use to look up health-related information c) Smartphone with downloadable "apps" to help manage user health. Un-weighted and weighted frequency tables were created for the three outcome variables (Appendix 1-2). To further analyze the data by demographics, cross-tabulation with chi-square on weighted data for both 2010 and 2012 surveys was done to assess differences in a) Smartphone use to access internet and b) Smartphone use to look up health related

information. The demographic variables sex, age, income, race, and region were analyzed. For both the 2010 and 2012 surveys, the "age" variable was transformed from a continuous variable to a categorical variable for easier exploration and depiction of results. The "income" variable categories were also combined from 8 categories to 5 to ensure a more accurate depiction of known income brackets across the United States. To analyze the data by chronic disease, cross-tabulation with chi-square on weighted data for both 2010 and 2012 surveys was done to assess differences in use for a) Smartphone use to access the internet b) Smartphone use to access health-related information and c) Smartphone with downloadable "apps" to manage health. Data for the following chronic diseases was analyzed and compared: diabetes, hypertension, heart attack, heart failure, and heart disease. Hypertension, heart attack, and heart failure were categorized as one variable in the original dataset obtained by PEW research center for both 2010 and 2012 surveys. Weighted data with a significance level of $p=<.05$ was used, and all analysis was done using SPSSv19. Categories of "do not know" and "refused" were excluded from final analysis.

## III. RESULTS

Table 1 below shows an overall increase in smartphone utilization from 2010 to 2012. Smartphone to access internet increased by 17.3% and smartphone to access health-related information increased by 13.6%. Smartphone with "apps" to manage health only increased by 1.3%.

**Table 1- Smartphone utilization: 2010-2012**

| INCREASE IN SMARTPHONE UTILIZATION 2010-2012 | | | | | |
|---|---|---|---|---|---|
| **Smartphone to Access the Internet** | | | | | |
| | FREQUENCY | | PERCENT | | |
| **2010** | 12,802 | | 39.0% | | |
| **2012** | 8,776 | | 56.3% | | |
| | | | | | |
| **% INCREASE** | | 17.3% | | | |
| | | | | | |
| **Smartphone to Access Health-related Information** | | | | | |
| | FREQUENCY | | PERCENT | | |
| **2010** | 5,566 | | 17.0% | | |
| **2012** | 4,781 | | 30.6% | | |
| | | | | | |
| **% INCREASE** | | 13.6% | | | |
| | | | | | |
| **Smartphone with "Apps" to Manage Health** | | | | | |
| | FREQUENCY | | PERCENT | | |
| **2010** | 2,962 | | 9.0% | | |
| **2012** | 1,692 | | 10.8% | | |
| | | | | | |
| **% INCREASE** | | 1.8% | | | |

Weighted Sample Size 2010: 32,836
Weighted Sample Size 2012: 15,599

Table 2 below depicts results for smartphone use to access internet by different demographic variables. Being male, being between the ages of 18-24, being mixed race, residing in an urban area, and having an income of above 100,000 had the highest percentage of accessing the internet from a smartphone in 2010. For the year 2012, being male, between the ages of 18-24, being Asian/Pacific Islander, residing in a suburban area, and having an income of above 100,000 had the highest percentage of accessing the internet from a smartphone.

## Table 2- Smartphone to Access the Internet by Demographics: 2010-2012

| INCREASE IN SMARTPHONE UTILIZATION BY DEMOGRAPHICS 2010-2012 | | | | | | | |
|---|---|---|---|---|---|---|---|
| Smartphone to Access Internet | | | | | | | |
| | | 2010 | | | 2012 | | |
| DEMOGRAPHICS | | TOTAL | FREQUENCY | PERCENT | TOTAL | FREQUENCY | PERCENT |
| **SEX** | | | | | | | |
| | Females | 16,364 | 5,913 | 36.1% | 6,227 | 3,605 | 57.9% |
| | Males | 16,433 | 6,889 | **41.9%** | 6,298 | 3,685 | **58.5%** |
| | | | | | | | |
| **AGE** | | | | | | | |
| | 18-24 | 8,278 | 5,371 | **64.9%** | 3,684 | 2,837 | **77.0%** |
| | 30-49 | 11,869 | 5,098 | 43.0% | 5,777 | 4,011 | 69.4% |
| | 50-64 | 8,319 | 1,703 | 20.5% | 3,730 | 1,503 | 40.3% |
| | 65+ | 4,025 | 520 | 12.9% | 2,207 | 352 | 15.9% |
| | | | | | | | |
| **RACE** | White | 24,427 | 8,606 | 35.2% | 11,155 | 5,949 | 53.3% |
| | Black/AA | 4,443 | 2,201 | 49.7% | 2,135 | 1,333 | 62.4% |
| | Asian/Pac. Islander | 1,160 | 575 | 49.6% | 492 | 375 | **76.2%** |
| | Mixed Race | 557 | 349 | **62.7%** | 497 | 369 | 74.2% |
| | Native Am/Am. Indian | 427 | 127 | 29.7% | 219 | 121 | 55.3% |
| | | | | | | | |
| **REGION** | | | | | | | |
| | Rural | 4,561 | 1,082 | 23.7% | 1,962 | 750 | 38.2% |
| | Suburban | 15,153 | 5,930 | 39.1% | 7,043 | 4,143 | **58.8%** |
| | Urban | 9,462 | 4,297 | **45.4%** | 4,526 | 2,623 | 58.0% |
| | | | | | | | |
| **INCOME** | | | | | | | |
| | <30,000 | 8,678 | 3,213 | 37.0% | 4,361 | 2,256 | 51.7% |
| | 30,000 - <50,000 | 5,878 | 2,090 | 35.6% | 2,587 | 1,289 | 49.8% |
| | 50,000 - <75,000 | 4,491 | 1,693 | 37.7% | 1,981 | 1,170 | 59.1% |
| | 75,000 <100,000 | 3,111 | 1,337 | 43.0% | 1,494 | 1,026 | 68.7% |
| | 100,000+ | 4,257 | 2,410 | **56.6%** | 2,101 | 1,550 | **73.8%** |

2010 -Weighted Sample Size for "yes" to internet: 12,802
2012-Weighted Sample Size for "yes" to internet: 8,776
*All variables were significant at a p-value <.05

Table 3 below depicts results for smartphone use to access health-related information by different demographic variables. Being male, being between the ages of 18-24, being mixed race, residing in an urban area, and having an income of above 100,000 had the highest percentage of accessing the internet from a smartphone in 2010. For the year 2012, being female, between the ages of 18-24, being Asian/Pacific Islander, residing in

a suburban area, and having an income of above 100,000 had the highest percentage of accessing health-related information from a smartphone.

**Table 3- Smartphone to Access Health-related Information by Demographics: 2010-2012**

| INCREASE IN SMARTPHONE UTILIZATION BY DEMOGRAPHICS 2010-2012 | | | | | | | |
|---|---|---|---|---|---|---|---|
| Smartphone Access to Health-related Information | | | | | | | |
| | | 2010 | | | 2012 | | |
| DEMOGRAPHICS | | TOTAL | FREQUENCY | PERCENT | TOTAL | FREQUENCY | PERCENT |
| **SEX** | | | | | | | |
| | Females | 16,364 | 2,688 | 16.4% | 6,227 | 2,245 | **36.1%** |
| | Males | 16,433 | 2,879 | **17.5%** | 6,298 | 1,838 | 29.2% |
| | | | | | | | |
| **AGE** | | | | | | | |
| | 18-24 | 6,625 | 2,038 | **30.8%** | 2,976 | 1,298 | **43.6%** |
| | 30-49 | 10,042 | 1,850 | 18.4% | 5,000 | 2,052 | 41.0% |
| | 50-64 | 6,970 | 492 | 7.1% | 3,051 | 584 | 19.1% |
| | 65+ | 2,779 | 308 | 11.1% | 1,497 | 148 | 9.0% |
| | | | | | | | |
| **RACE** | | | | | | | |
| | White | 20,665 | 3,511 | 17.0% | 9,619 | 2,803 | 29.1% |
| | Black/AA | 3,867 | 739 | 19.1% | 1,842 | 753 | 40.9% |
| | Asian/Pac. Islander | 1,003 | 231 | 23.0% | 441 | 232 | **52.6%** |
| | Mixed Race | 507 | 177 | **34.9%** | 409 | 201 | 49.1% |
| | Native Am/Am. Indian | 373 | 30 | 8.0% | 213 | 93 | 43.7% |
| | | | | | | | |
| **REGION** | | | | | | | |
| | Rural | 3,975 | 479 | 12.1% | 1,699 | 335 | 19.7% |
| | Suburban | 13,298 | 2,140 | 16.1% | 6,043 | 2,072 | **34.3%** |
| | Urban | 7,844 | 1,783 | **22.7%** | 4,007 | 1,322 | 33.0% |
| | | | | | | | |
| **INCOME** | | | | | | | |
| | <30,000 | 8,678 | 1,288 | 14.8% | 4,362 | 1,234 | 28.3% |
| | 30,000 - <50,000 | 5,879 | 979 | 16.7% | 2,587 | 768 | 29.7% |
| | 50,000 - <75,000 | 4,491 | 763 | 17.0% | 1,981 | 717 | 36.2% |
| | 75,000 <100,000 | 3,112 | 639 | 20.5% | 1,494 | 548 | 36.7% |
| | 100,000+ | 4,256 | 1,020 | **24.0%** | 2,102 | 816 | **38.8%** |

2010-Weighted Sample Size for "yes" to health related information: 5,566
2012-Weighted Sample Size for "yes" to health related information: 4,781
*All variables were significant at a p-value <.05

Table 4 below compares chronic disease type and use of a smartphone to access the internet, access health-related information, or use “apps” for health management. Results show respondents with hypertension use their smartphones to access the internet, access health-related information, and use “apps” to manage health at higher percentages than those patients with diabetes, heart disease, heart failure, or heart attack. This trend is seen in both 2010 and 2012 survey years. Respondents with diabetes show a decrease in utilization of health management “apps” from 2010 to 2012.

## Table 4- Smartphone Utilization by Chronic Disease: 2010-2012

| INCREASE IN SMARTPHONE UTILIZATION BY CHRONIC DISEASE 2010-2012 | | | | | | |
|---|---|---|---|---|---|---|
| **Smartphone to Access Internet** | | | | | | |
| | **2010** | | | **2012** | | |
| **CHRONIC DISEASE** | TOTAL | FREQUENCY | PERCENT | TOTAL | FREQUENCY | PERCENT |
| DIABETES | 2,344 | 586 | 25.0% | 1,374 | 508 | 37.0% |
| HEART DISEASE or HEART ATTACK or HEART FAILURE | 1,300 | 242 | 18.6% | 938 | 302 | 32.2% |
| HYPERTENSION | 5,739 | 1,719 | **29.8%** | 3,320 | 1,294 | **39.0%** |
| **Smartphone Access to Health-related Information** | | | | | | |
| | **2010** | | | **2012** | | |
| **CHRONIC DISEASE** | TOTAL | FREQUENCY | PERCENT | TOTAL | FREQUENCY | PERCENT |
| DIABETES | 2,344 | 238 | 10.2% | 1,374 | 272 | 19.8% |
| HEART DISEASE or HEART ATTACK or HEART FAILURE | 1,300 | 98 | 7.5% | 938 | 184 | 19.6% |
| HYPERTENSION | 5,739 | 710 | **12.4%** | 3,320 | 756 | **22.8%** |
| **Smartphone with "Apps" to Manage Health** | | | | | | |
| | **2010** | | | **2012** | | |
| **CHRONIC DISEASE** | TOTAL | FREQUENCY | PERCENT | TOTAL | FREQUENCY | PERCENT |
| DIABETES | 2,344 | 140 | 6.0% | 1,373 | 77 | 5.6% |
| HEART DISEASE or HEART ATTACK or HEART FAILURE | 1,299 | 79 | 6.1% | 938 | 61 | 6.5% |
| HYPERTENSION | 5,739 | 382 | **6.7%** | 3,320 | 242 | **7.3%** |

2010 -Weighted Sample Size for "yes" to internet: 12,802
2010-Weighted Sample Size for "yes" to health-related information: 5,566
2010-Weighted Sample Size for "yes" to Apps for managing health: 2,962
2012-Weighted Sample Size for "yes" to internet: 8,776
2012-Weighted Sample Size for "yes" to health-related information: 4,781
2012-Weighted Sample Size for "yes" to Apps for managing health: 1,692
*All variables were significant at a p-value <.05

## IV. DISCUSSION

### *What does the Data show?*

Evaluation of our data showed an increase in smartphone utilization and adoption across all three outcome variables from 2010 to 2012 (Table 1). When broken down by demographics, each variable showed an increase from 2010 to 2012 with regards to using smartphones to access the internet and access health-related information (Table 2-3). Patients suffering from chronic diseases such as hypertension, diabetes, heart disease, heart attack, or heart failure also showed an increase in smartphone utilization to access health-related information in 2012 when compared to 2010 (Table 4). Results showed a possible association between using a smartphone to access the internet and using a smartphone to look up health-related information. Across all demographic variables in 2010, those categories with the highest percentage of smartphone use to access the internet also had the highest percentage of using smartphones to access health-related information (Table 2-3). Results were similar for the 2012 survey, with one notable exception, which is discussed below. When looking specifically at chronic disease, a similar trend was noted, patients with hypertension used their smartphones to access the internet at higher rates and access health-related information at a higher percentage than those patients with other chronic diseases (Table 4).

### *Smartphone utilization by Gender*

The prevalence of gender-based disparities that relate to how health information is processed in males and females has been well established, and many previous studies have reported on the disparities relating to computer or internet access in females[18, 19]. Contrary to prior findings, our analysis showed females at a substantially greater increase in smartphone utilization than males when comparing both survey years. Females using smartphones to access internet increased by 21.8% (36.1% to 57.9%) from 2010 to 2012, and an increase of 19.7% (16.4% to 36.1%) was seen in smartphone use to access health-related information from 2010 to 2012 (Table 2-3). This suggests a possible decrease in the digital divide between genders as smartphones become more

accessible and affordable. In our study, males had higher percentages of accessing the internet on their smartphones for both years but the percentages for females accessing the internet followed closely behind (Table 2). Furthermore, females were more likely to use their smartphone to access health-related information at 36.1% when compared to males at 29.1% for the 2012 survey, despite having a lower percentage of using smartphones to access the internet at 57.9% when compared to males at 58.5% (Table 2-3).

Surveys assessing the differences in importance of healthcare information exchange by gender have found that men are more likely than women to positively assess the benefits of healthcare information exchange. However, previous research has suggested that women generally have greater concern for health issues and actively seek health information more often than men[20]. In addition to this, past Internet research has indicated that women are more likely than men to search for health-related information[21], use online patient-provider communication[22], and use online support groups or health-based support forums[23]. Similar findings of gender differences in online health searching have also previously been reported by the Pew Internet and American Life Project[24]. Other studies have shown that men use the Internet for instructional aid while women use the Internet for seeking emotional support[25]. It seems much of the computer based technology accessibility gaps seen between genders can be alleviated with the increased availability of smartphones and provision of "on the go" access.

### *Smartphone utilization by Age*

Our results showed the 18-24 age group was associated with the highest percentage of smartphone use to access the internet and smartphone use to access health-related information across both surveys (Table 2-3). Although each age category showed substantial increases from 2010 to 2012, participants between the ages of 30-49 showed the greatest increase with 69.4% using smartphones to access the internet in 2012 compared to just 43% in 2010 (Table 2). Participants in this same age group also

showed a considerable increase in smartphone use to access health-related information going from just 18.4% in 2010 to 41% in 2012 (Table 3). Although previous literature and reports have predicted greater increases in smartphone adoption by elderly populations, limited increase in smartphone use to access the internet and health-related information was seen in our analysis from 2010 to 2012. In fact, as age increased, the percentage of smartphone utilization to access the internet and health-related information decreased steadily, with the lowest percentage of use being in the 65+ age group (Table 2-3). This is especially important to note considering chronic disease management is often most difficult in elderly populations.

A vast majority of older patients who require disease management are elderly, and have functional limitations such as reduced sensory, cognitive, and motor skills. Given that older age groups are the most frequent and heaviest users of health services, as well as the fastest growing segment of the US population, barriers in utilization of mHealth technologies will likely lead to increased disparities. mHealth has the potential to revolutionize the process of health care delivery and empower these patients. However, these individuals are at a higher disadvantage because designers of both software and hardware technology fail to consider them as a potential user group[26]. Furthermore, usability and accessibility issues are important quality measures for mHealth interventions, but are frequently ignored by designers and evaluators[27]. In addition to age, other studies have reported demographic and socioeconomic variables such as race/ethnicity, level of education, gender, and family income as significant determinants of healthcare information technology use among older adults[28].

Designing usable mHealth technology systems is challenging enough, and when age-related constraints and functional limitations of the elderly need to be taken into consideration, this becomes even more difficult. Additionally, with the advent of web-based portals for Medicare sign-ups, benefit assessments, and renewals, it is of utmost importance that investments are made in innovative strategies that allow older and elderly populations to seek benefits from available mHealth tools.

### *Smartphone utilization by Race*

Our results showed being Caucasian was associated with the smallest percentage increase from 2010 to 2012 for both smartphone use to access the internet and smartphone use to access health-related information (Table 2-3). Being Asian/Pacific Islander showed the greatest increase in smartphone use to access the internet going from 49.6% to 76.2%, and being Native American/Native Indian showed the greatest increase in smartphone use to access health-related information going from 8.0% to 35.7% (Table 2-3).

Previous studies have mentioned the increased benefit of the Internet to individuals with lower incomes and education levels despite their lower use of the Internet to access health-related information[29]. While many historically underserved populations have lower access to the Internet on a computer, they have higher usage rates of mobile Internet access on handheld devices[30]. Almost two-thirds of African American (64%) and Hispanic people (63%) have wireless access to the Internet. More African American and Hispanic people own cell phones (87%) when compared to the Caucasian population (80%). Furthermore, these historically underserved populations use their phone data functions significantly more than Caucasians [31]. Due to high usage rates, mHealth tools can work to improve patient engagement and be an effective means for delivering interventions[32].

Whilst it is promising to see that mHealth technology use is increasing in some of these populations, further analysis with a multivariate approach should be carried out in order to control for demographic variables such as income, sex, and region which would allow for more transparent look at barriers to utilization. That being said, substantial increases need to be seen across all races and ethnicities in order for these innovative approaches to be successful at alleviating barriers associated with receiving quality healthcare. Additionally, respondents from our growing indigenous immigrant and refugee populations may not always identify with set forth race categories; therefore, future

surveys assessing racial disparities should be cognizant of this when assigning categories.

### *Smartphone utilization by Urban, Suburban, and Rural Populations*

Urban populations showed the highest percentage of smartphone use to access the internet as well as accessing health-related information in 2010 (Table 2-3). In 2012, suburban populations had the highest percentage of smartphone use to access internet at 58.8% and access health-related information at 34.3% (Table 2-3). Suburban populations also showed the greatest percent increase in both smartphone use to access internet and smartphone use to access health-related information from 2010 to 2012 (Table 2-3). Rural populations had significantly lower utilization percentages for accessing the internet and health-related information from their smartphones in comparison.

Individuals residing in rural and under-resourced areas face extra barriers related to provider availability, health services access, and transportation[33]. The use of mHealth technologies and telemedicine, where providers can be located in a different region and still provide care, can overcome these barriers and aid geographically isolated populations in accessing patient-centered care[34]. As mentioned before, there is significant potential for mobile-health interventions to have beneficial effects on health and health service delivery processes, especially in resource-poor settings such as rural geographical areas. Mobile health interventions designed to improve health care service delivery have been used to provide support and services to health care providers in terms of diagnosis and patient management as well as improve communication between health care providers and their patients.

Existing literature on mHealth interventions has largely focused on technologies used in low-income and resource poor countries. In these countries, mHealth interventions have aided in remote diagnosis, medication adherence, increased literacy, and improved health outcomes. However, based on evidence, mHealth technologies and strategies that have been proven successful in developing countries should be adopted to

decrease inequities in accessing healthcare in our own country. This is especially important with the implementation of the Affordable Care Act, where mHealth technologies can provide a valuable add-on to current treatment regimens and improve health outcomes for rural populations across the country.

### *Smartphone utilization by Income*

Not surprisingly, greatest increases in utilization of smartphones to access internet and health-related information from 2010 to 2012 was seen in those individuals making 50,000 or above. Those individuals making 50,000- <75,000 had the greatest increase (19.2%) from 2010 to 2012 in smartphone use to access health-related information when compared to other income brackets (Table 3). Individuals making 75,000- <100,000 had the greatest increase (25.7%) from 2010 to 2012 in accessing the internet on their smartphones (Table 2). Our analysis showed a hierarchal trend between income and increased smartphone access to the internet and health-related information. One exception can be seen in those individuals making less than 30,000. These individuals show a higher percentage of smartphone use to access internet at 37% than the higher income bracket of 30,000- <50,000 at 35.6% (Table 2). Perhaps this can be attributed to the 18-24 year old age group of university students, graduates, and young professionals that access internet on their smartphones and also fall into this income bracket.

Several studies have shown that access to the internet and mHealth technologies correlates with higher income levels and educational attainment[35]. Similarly, our analysis showed smartphone utilization increasing across all income brackets with largest utilization rates being seen in higher income categories. Note, that when looking at the accessing of health-related information from a smartphone, the hierarchal trend holds true for all income brackets including those making less than 30,000 (Table 3). Additionally, recent literature has stated that personal innovativeness tends to be a positive predictor when assessing acceptance of mHealth technologies[36]. Given that the delivery of health services on wireless platforms is currently at the early

stages of development, it is likely that high income individuals who are seeking innovative technologies are more likely to adopt and use mHealth interventions.

### *Smartphone utilization and Chronic Disease*

According to a report released by the CDC in 2011, 25.8 million Americans have diabetes, approximately 7 million of which, remain undiagnosed[37]. Diabetes is a major cause of heart disease and stroke. Death rates for heart disease and the risk of stroke are about 2–4 times higher among adults with diabetes than among those without diabetes. Additionally, 67% of U.S. adults who report having diabetes also report having high blood pressure[38]. Approximately 67 million Americans suffer from high blood pressure, half of which, do not have their blood pressure under control. Similar to diabetes, high blood pressure is also known to be a major risk factor for heart disease and stroke. Heart disease and stroke are currently the two leading causes of death in the United States[39].

Successful treatment of chronic diseases such as diabetes and high blood pressure require coordinated care processes involving both the provider and patient. Much of the responsibility falls upon the patient to routinely measure metrics such as blood glucose levels and blood pressure. Additionally, provider suggested protocols associated with dietary changes, exercise regimens, and medication adherence must also be followed. Due to this, there is a heavy reliance on self-management and education of the patient when treatment plans are being implemented. However, compliance with self-management regimens has shown to be quite poor due to the inability of patients to consistently follow through with the logging of their metrics[40]. This is especially true in those patients coming from disadvantaged backgrounds, where prevalence of chronic diseases is disproportionately higher.

The issue of compliance, coupled with the need to create bi-directional communication between provider and patient, emphasizes the need for the use of appropriate healthcare information technology (HIT) methods to help manage chronic disease in disadvantaged populations who need it the most[41, 42]. These populations can be

described as those that do not have access to primary care either because they are socioeconomically disadvantaged or reside in rural areas. They have significantly higher risks for the development of chronic diseases such as diabetes and high blood pressure due to late diagnosis, inadequate control of risk factors, poor self-management, and increased complications[43].

Our analysis showed respondents suffering from heart disease, heart failure, and heart attack had the greatest increase in utilization from 2010 to 2012. A 13.6% increase (18.6% to 32.3%) was seen in accessing the internet and a 12.1% increase (7.5% to 19.6%) was seen in accessing health-related information from a smartphone (Table 4). Respondents with hypertension utilized their smartphones to access health-related information and download health management "apps" at a significantly higher percentage than respondents with other types of chronic disease for both the 2010 and 2012 survey years (Table 4). Negligible increases were seen in utilization of health management "apps" overall, as well as, when broken down by disease type. Respondents with diabetes showed a decrease in utilization of health management "apps" from 2010 to 2012 which is likely due to "do not know" and "refused" categories being excluded from the analysis, rather than, the showcasing of a viable trend (Table 4).

Recent studies have stated that individuals worried about their diet, blood pressure, weight, and exercise are more likely to search for health-related information on their phones. These individuals are also more likely to download "apps" for managing their health when compared to individuals who perceive themselves as healthy. Individuals with chronic diseases in general, are also more likely to look for health-related information online but thus far, no comparative trends have been observed based on different chronic disease types[44].

## V. STUDY LIMITATIONS

There are several limitations to this analysis. The categories of "do not know" and "refused" were excluded from final analysis. However, these categories would likely

have a negligible effect on the final results obtained. Heart disease, heart attack, and heart failure categories were combined in both the 2010 and 2012 nationally representative samples. This is problematic primarily because behavior pertaining to the accessing of health-related information is likely to vary considerably among these three conditions, and the severity associated with them.

## VI. CONCLUSIONS

### *Health Literacy, Socio-Cultural Differences, and mHealth*

Numerous studies have demonstrated the benefits associated with internet and technology use to provide interactive, health teaching tools to patients with chronic disease[45]. While internet and technology use is increasing significantly, widespread use in populations from vulnerable backgrounds still remains a concern. Among vulnerable populations in particular, barriers that must be addressed include health literacy, cultural differences, language, income, and access to technology.

Although level of literacy was not part of our analysis, previous studies have shown that literacy levels are an important factor in determining an individual's health status in addition to cultural differences, language barriers, income, and access[46]. Health literacy can be defined as the capacity of an individual to attain, interpret, and understand basic health information. Increasing health literacy would allow an individual to comprehend such information and utilize this information in a way that improves their health. It is estimated that 48% of Americans experience low health literacy to some degree[47]. Low health literacy is more common in those older than 65, minorities, and among low-income populations. It is estimated that more than 33% of Americans aged 65 or older have inadequate or marginal health literacy[48]. Oftentimes, due to the stigma and shame associated with low health literacy, patients are apprehensive about discussing these issues with their providers leading to obstacles in self-management.

On a daily basis, health care providers encounter people from a range of diverse backgrounds. These individuals present with an assembly of varied perceptions, values, beliefs, and behaviors regarding their health and well-being. This diversity is becoming

even more prevalent as the United States continues to experience significant immigrant and refugee influx as well as minority population expansion.

Sociocultural differences between patients and their healthcare providers influence not only communication but also decision making patterns. This is especially important in mHealth, where smartphone technologies may be customized for patients coming from varied backgrounds. A repeatedly identified problem with the Internet has been its inability to provide customized content. Websites do not change dynamically to meet the needs of the individual accessing the site. Thus, issues such as language proficiency, race, culture, and other sociocultural differences often go without acknowledgement. Therefore, addressing different cultural values, beliefs, and customs, can support an individual's care-seeking activities, increase health literacy, instill provider trust, and foster adherence to recommended healthcare treatment and self-management plans.

### *Improving the Digital Divide with mHealth*

Historically, computer-based technologies have always had a digital divide. This is referred to the gap seen between those that access the internet or health-related information from their computers, and those that do not. Many studies have described decreased internet and computer use among patients with less education, females, those that are low-income, minorities, and older adults[49]. This digital divide tends to be most persistent for older populations that are already at a disadvantage, putting them at risk for losing the potential benefits of increased access to computer-based health technologies[50]. With the increasing abundance of affordable and user-friendly smartphones on the market, health care information technology has the ability to bridge the gap seen with previous computer-based technologies and decrease the current inequities seen in health care service delivery.

Smartphone adoption and utilization for accessing health-related information seems to be increasing steadily, however; this increase is primarily happening in individuals from higher income brackets, those that are younger, and those living in urban/suburban areas. It is no secret that patients with the worst chronic disease health outcomes are

generally elderly, low-income, and from rural/urban disadvantaged populations. These patients also suffer from low health literacy, limited access to integrated health care delivery systems, and limited provider support.

Improving health outcomes for chronic diseases is highly dependent upon self-management, behavior change, and bi-directional communication with providers. Without finding strategies to specifically target low-income, urban/rural, and elderly populations whilst facilitating increased health literacy, mHealth technology solutions run the risk of becoming an amenity available for the privileged few.

### *Implications for future research*

Research using qualitative approaches is crucial for assessing facilitators and barriers to mHealth technology use among minorities, women, geographically isolated individuals, and those from low-income backgrounds. Additionally, future studies should use culturally informed technological approaches when looking at chronic disease management, and focus on how these technologies will need to be adapted and reformed for different populations. This is especially important, since emphasis of self-management support programs has shifted from informative education to educational content defined by an approach that addresses individual patient needs.

## **Appendix 1**

## Un-Weighted Frequency Tables 2010

### Statistics

Q13d. Do you ever use your cell phone to -- Access the internet?

| | | |
|---|---|---|
| N | Valid | 2485 |
| | Missing | 516 |

**Q13d. Do you ever use your cell phone to -- Access the internet?**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 851 | 28.4 | 34.2 | 34.2 |
| | No | 1631 | 54.3 | 65.6 | 99.9 |
| | Don't know | 3 | .1 | .1 | 100.0 |
| | Total | 2485 | 82.8 | 100.0 | |
| Missing | System | 516 | 17.2 | | |
| **Total** | | **3001** | **100.0** | | |

### Statistics

Q15. Do you ever use your cell phone to look up health or medical information?

| | | |
|---|---|---|
| N | Valid | 2485 |
| | Missing | 516 |

**Q15. Do you ever use your cell phone to look up health or medical information?**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes, do this | 372 | 12.4 | 15.0 | 15.0 |
| | No, do not do this | 2112 | 70.4 | 85.0 | 100.0 |
| | Don't know | 1 | .0 | .0 | 100.0 |
| | Total | 2485 | 82.8 | 100.0 | |
| Missing | System | 516 | 17.2 | | |
| Total | | 3001 | 100.0 | | |

### Statistics

Q14. On your cell phone, do you happen to have any software applications or 'apps' that help you track or manage your health, or not?

| | | |
|---|---|---|
| N | Valid | 2485 |
| | Missing | 516 |

**Q14. On your cell phone, do you happen to have any software applications or 'apps' that help you track or manage your health, or not?**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 200 | 6.7 | 8.0 | 8.0 |
| | No | 2259 | 75.3 | 90.9 | 99.0 |
| | Don't know | 23 | .8 | .9 | 99.9 |
| | Refused | 3 | .1 | .1 | 100.0 |
| | Total | 2485 | 82.8 | 100.0 | |
| Missing | System | 516 | 17.2 | | |
| Total | | 3001 | 100.0 | | |

# Weighted Frequency Tables 2010

**Statistics**

Q13d. Do you ever use your cell phone to -- Access the internet?

| | | |
|---|---|---|
| N | Valid | 32836 |
| | Missing | 5959 |

**Q13d. Do you ever use your cell phone to -- Access the internet?**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 12802 | 33.0 | 39.0 | 39.0 |
| | No | 20007 | 51.6 | 60.9 | 99.9 |
| | Don't know | 27 | .1 | .1 | 100.0 |
| | Total | 32836 | 84.6 | 100.0 | |
| Missing | System | 5959 | 15.4 | | |
| Total | | 38795 | 100.0 | | |

**Statistics**

Q15. Do you ever use your cell phone to look up health or medical information?

| | | |
|---|---|---|
| N | Valid | 32836 |
| | Missing | 5959 |

**Q15. Do you ever use your cell phone to look up health or medical information?**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes, do this | 5566 | 14.3 | 17.0 | 17.0 |
| | No, do not do this | 27268 | 70.3 | 83.0 | 100.0 |
| | Don't know | 2 | .0 | .0 | 100.0 |
| | Total | 32836 | 84.6 | 100.0 | |
| Missing | System | 5959 | 15.4 | | |
| Total | | 38795 | 100.0 | | |

**Statistics**

Q14. On your cell phone, do you happen to have any software applications or 'apps' that help you track or manage your health, or not?

| | | |
|---|---|---|
| N | Valid | 32836 |
| | Missing | 5959 |

**Q14. On your cell phone, do you happen to have any software applications or 'apps' that help you track or manage your health, or not?**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 2962 | 7.6 | 9.0 | 9.0 |
| | No | 29551 | 76.2 | 90.0 | 99.0 |
| | Don't know | 268 | .7 | .8 | 99.8 |
| | Refused | 55 | .1 | .2 | 100.0 |
| | Total | 32836 | 84.6 | 100.0 | |
| Missing | System | 5959 | 15.4 | | |
| Total | | 38795 | 100.0 | | |

## Appendix 2

## Un-Weighted Frequency Tables 2012

**Statistics**

**Cell1d. Do you ever use your cell phone to -- Access the internet?**

| | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|

Cell1d. Do you ever use your cell phone to -- Access the internet?

| | | |
|---|---|---|
| N | Valid | 2581 |
| | Missing | 433 |

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 1303 | 43.2 | 50.5 | 50.5 |
| | No | 1278 | 42.4 | 49.5 | 100.0 |
| | Total | 2581 | 85.6 | 100.0 | |
| Missing | System | 433 | 14.4 | | |
| Total | | 3014 | 100.0 | | |

**Statistics**

Cell1e. Do you ever use your cell phone to -- Look for health or medical information online?

| | | |
|---|---|---|
| N | Valid | 2581 |
| | Missing | 433 |

**Cell1e. Do you ever use your cell phone to -- Look for health or medical information online?**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 703 | 23.3 | 27.2 | 27.2 |
| | No | 1874 | 62.2 | 72.6 | 99.8 |
| | Don't know | 3 | .1 | .1 | 100.0 |
| | Refused | 1 | .0 | .0 | 100.0 |
| | Total | 2581 | 85.6 | 100.0 | |
| Missing | System | 433 | 14.4 | | |
| Total | | 3014 | 100.0 | | |

**Statistics**

Q22. On your cell phone, do you happen to have any software applications or 'apps' that help you track or manage your health, or not?

| | | |
|---|---|---|
| N | Valid | 2581 |
| | Missing | 433 |

**Q22. On your cell phone, do you happen to have any software applications or 'apps' that help you track or manage your health, or not?**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 254 | 8.4 | 9.8 | 9.8 |
| | No | 2298 | 76.2 | 89.0 | 98.9 |
| | Don't know | 26 | .9 | 1.0 | 99.9 |
| | Refused | 3 | .1 | .1 | 100.0 |
| | Total | 2581 | 85.6 | 100.0 | |
| Missing | System | 433 | 14.4 | | |
| Total | | 3014 | 100.0 | | |

## Weighted Frequency Tables 2012

**Statistics**

Cell1d. Do you ever use your cell phone to -- Access the internet?

| | | |
|---|---|---|
| N | Valid | 15599 |
| | Missing | 2723 |

**Cell1d. Do you ever use your cell phone to -- Access the internet?**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 8776 | 47.9 | 56.3 | 56.3 |
| | No | 6823 | 37.2 | 43.7 | 100.0 |
| | Total | 15599 | 85.1 | 100.0 | |
| Missing | System | 2723 | 14.9 | | |
| Total | | 18322 | 100.0 | | |

**Statistics**

Cell1e. Do you ever use your cell phone to -- Look for health or medical information online?

| | | |
|---|---|---|
| N | Valid | 15599 |
| | Missing | 2723 |

**Cell1e. Do you ever use your cell phone to -- Look for health or medical information online?**

| | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| Valid | Yes | 4781 | 26.1 | 30.6 | 30.6 |
| | No | 10796 | 58.9 | 69.2 | 99.9 |
| | Don't know | 20 | .1 | .1 | 100.0 |
| | Refused | 3 | .0 | .0 | 100.0 |
| | Total | 15599 | 85.1 | 100.0 | |
| Missing | System | 2723 | 14.9 | | |
| Total | | 18322 | 100.0 | | |

**Statistics**

Q22. On your cell phone, do you happen to have any software applications or 'apps' that help you track or manage your health, or not?

| | | |
|---|---|---|
| N | Valid | 15599 |
| | Missing | 2723 |

**Q22. On your cell phone, do you happen to have any software applications or 'apps' that help you track or manage your health, or not?**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 1692 | 9.2 | 10.8 | 10.8 |
| | No | 13729 | 74.9 | 88.0 | 98.9 |
| | Don't know | 159 | .9 | 1.0 | 99.9 |
| | Refused | 19 | .1 | .1 | 100.0 |
| | Total | 15599 | 85.1 | 100.0 | |
| Missing | System | 2723 | 14.9 | | |
| Total | | 18322 | 100.0 | | |

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