Research Article

A content analysis of smartphone–based applications for hypertension management

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Abstract

Smartphone–based medical applications (apps) can facilitate self–management of hypertension (HTN). The content and consumer interaction metrics of HTN–related apps are unknown. In this cross–sectional study to ascertain the content of medical apps designed for HTN management, we queried Google Play and Apple iTunes using the search terms “hypertension” and “high blood pressure.” The top 107 apps were analyzed. Major app functionalities including tracking (for blood pressure [BP], pulse, weight, body mass index), medical device (to measure pulse or BP), general information on HTN, and medication adherence tools were recorded along with consumer engagement parameters. Data were collected from May 28 to May 30, 2014. A total of 72% of the apps had tracking function, 22% had tools to enhance medication adherence, 37% contained general information on HTN, and 8% contained information on Dietary Approaches to Stop Hypertension (DASH) diet. These data showed that a majority of apps for HTN are designed primarily for health management functions. However, 14% of Google Android apps could transform the smartphone into a medical device to measure BP. None of these apps employed the use of a BP cuff or had any documentation of validation against a gold standard. Only 3% of the apps were developed by healthcare agencies such as universities or professional organizations. In regression models, the medical device function was highly predictive of greater number of downloads (odds ratio, 97.08; \( P < .001 \)) and positive consumer reviews (Incidence rate ratios, 1204.39; \( P < .001 \)). A large majority of medical apps designed for HTN serve health management functions such as tracking blood pressure, weight, or body mass index. Consumers have a strong tendency to download and favorably rate apps that are advertised to measure blood pressure and heart rate, despite a lack of validation for these apps. There is a need for greater oversight in medical app development for HTN, especially when they qualify as a medical device. J Am Soc Hypertens 2015;9(2):130–136. © 2015 American Society of Hypertension. All rights reserved.

Keywords: High blood pressure; Internet; mobile health; self-management.

Introduction

Hypertension (HTN) is a highly prevalent and growing public health problem in the United States and worldwide. There are approximately one billion people with HTN worldwide, and an estimated one in three Americans is hypertensive.\textsuperscript{1,2} In up to one–third of these patients, blood pressure (BP) may remain uncontrolled despite the addition of three or more agents, with greatly elevated risk of cardiovascular morbidity and mortality compared with patients with controlled BP.\textsuperscript{3} Self–monitoring of BP (SMBP) can be an effective means of reducing blood pressure in such high–risk patients.\textsuperscript{4} SMBP, along with an additional form of support such as medication adjustment algorithms and educational materials, has been shown to achieve greater BP reduction compared with usual care alone.\textsuperscript{5} Mobile–health (m–health) technologies can be effective means of providing such additional support to promote HTN self–management.\textsuperscript{6} M–health essentially refers to the use

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of mobile devices such as smartphones and tablets for diagnosis, treatment, or health management functions, predominantly carried out via a software interface known as an application or app.

Recent surveys show that 58% of US adults now own a smartphone. A growing number of patients with chronic health conditions such as hypertension are turning to the Internet and m–health technologies for assistance with health management and education. A recent Pew Internet survey showed that 52% of smartphone owners are users of m–health technologies, a sharp increase of almost 2–fold between 2010 and 2012. While Internet and smartphones can greatly facilitate effective management of HTN, a recent study by our group showed that up to one–third of all information on video sharing websites to be inaccurate but highly popular. According to some observers, an estimated 1.7 billion m–health users (23% of the world’s population) are projected by 2018. While this could represent unprecedented opportunities for expanding healthcare delivery and reducing health disparities, the near absence of regulation and standardization of m–health technology could pose significant risks to public/patient safety.

A number of smartphone–based BP measuring devices are currently commercially available. These include automated inflatable cuffs that measure BP using the oscillometric method and cuffless BP measurement using pulse wave signals detected by smartphone cameras. However, extensive validation studies for smartphone–based BP measurement have not been conducted. A recent preliminary analysis of the wireless BP monitors (manufactured by Withings and ihealthlabs) showed poor accuracy when compared with auscultatory readings. There are no large–scale validation studies for BP measurement by apps that utilize pulse wave signals detected by smartphone cameras to measure BP. The proportion of smartphone apps that include a function for BP measurement is unknown.

Given the absence of data on the content and popularity of smartphone applications for HTN and the enormous public health importance of HTN control, we conducted this cross–sectional study of the two most popular smartphone platforms (Google Android and Apple iPhone) to ascertain the functional characteristics and consumer interaction metrics for m–health technologies currently available for HTN management.

Methods

Search Strategy

We screened the two most popular mobile platforms, Apple iTunes for iPhone and Google Play for Android smartphones respectively. We used the search terms “hypertension” and “high blood pressure” to screen the top 50 search results. The search algorithms for Apple iTunes and Google Play are proprietary but do include app popularity and number of downloads in the algorithm. Since users are most likely to pursue the top search results, only the top 50 apps for each search term were included in the analysis. Apps repeated in the results of the two search terms were included only once. A total of 200 apps were screened in this manner and 107 unique apps were included in the analysis. All applications in English that contained information or tools to manage systemic HTN were eligible for analysis. All data were collected in May 2014.

Consumer Interaction Parameters

We recorded data on total number of reviews for all versions of the app using publicly available data on Apple iTunes and Google Play. Cumulative number of one, two, three, four, and five stars along with the average rating of the app on a scale of one to five, with five being the best, was recorded. The total number of downloads are reported only by Google Play in the form of an ordinal variable with nine different categories ranging from 50–100 to 1 million–5 million; this download information was available for a total of 50 apps included in the study.

Functional Characteristics of the App

We recorded major functional characteristics of each app in the following non–mutually exclusive domains including hypertension education, tracking function, tools to promote medication adherence, whether the app can transform the smartphone into a medical device, and whether access to support groups and patient forums was facilitated. These were further subcategorized as shown in Table 1. Additionally we recorded any documentation of healthcare agency (such as universities or professional organization) in the app development process.

Statistical Analysis

Continuous variables were expressed as mean ± standard deviation for normally distributed variables and median (interquartile range) for variables with a skewed distribution. Categorical variables were expressed as proportions or percentages. Differences in continuous variables were assessed using linear regression for continuous variables with a normal distribution and the Kruskal–Wallis test for those with a skewed distribution. Differences in proportions were tested using the χ2 test.

In order to test the functional characteristics of an app that are associated with a higher number of downloads, we built an ordinal logistic regression model with app functionalities and price as categorical predictors. The outcome variable (number of downloads) was available only for the Google Android platform, with the data provided as an ordinal variable ranging from 50–100 (smallest category)
Table 1
App development, consumer interaction metrics, and functional characteristics of all apps on two major smartphone platforms

<table>
<thead>
<tr>
<th>App Characteristics</th>
<th>Apple iPhone (n = 57; 53.3%)</th>
<th>Google Android (n = 50; 46.7%)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size in megabytes, median (IQR)</td>
<td>5.7 (2.2–14.5)</td>
<td>1.4 (0.5–3.1)</td>
<td>.025</td>
</tr>
<tr>
<td>Proportion of free apps, n (%)</td>
<td>28 (49.1%)</td>
<td>42 (84%)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Price in 2014 US dollars, median (IQR)</td>
<td>2 (0.99–3.99)</td>
<td>2.01 (1.4–5.4)</td>
<td>.001</td>
</tr>
<tr>
<td>User interaction metrics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average rating for the app on a scale of 5, median (IQR)</td>
<td>4.5 (3.5–4.5)</td>
<td>3.8 (3.4–4.2)</td>
<td>.025</td>
</tr>
<tr>
<td>Number of reviews, median (IQR)</td>
<td>169 (26–510)</td>
<td>63 (5–363)</td>
<td>.314</td>
</tr>
<tr>
<td>Number of downloads</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>&gt;100K</td>
<td>11 (22%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50K–100K</td>
<td>5 (10%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10K–50K</td>
<td>8 (16%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1K–10K</td>
<td>12 (24%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;1K</td>
<td>14 (28%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proportion of free apps, N (%)</td>
<td>28 (49.1%)</td>
<td>42 (84%)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Positive reviews (four/five stars), median (IQR)</td>
<td>NA</td>
<td>43 (3–216)</td>
<td>NA</td>
</tr>
<tr>
<td>Negative reviews (one and two stars), median (IQR)</td>
<td>NA</td>
<td>7 (1–76)</td>
<td>NA</td>
</tr>
<tr>
<td>Target audience</td>
<td></td>
<td></td>
<td>.100</td>
</tr>
<tr>
<td>Health care professionals</td>
<td>3 (5.3%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td>Patients</td>
<td>52 (91.2%)</td>
<td>50 (100%)</td>
<td></td>
</tr>
<tr>
<td>Both</td>
<td>2 (3.5%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td>Developer a healthcare agency such as university/hospital or professional organization</td>
<td>3 (5.26%)</td>
<td>0 (0%)</td>
<td>.100</td>
</tr>
<tr>
<td>Functional characteristics of the application</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypertension education</td>
<td>23 (40.4%)</td>
<td>17 (34%)</td>
<td>.498</td>
</tr>
<tr>
<td>General information on HTN</td>
<td>19 (33.3%)</td>
<td>16 (32%)</td>
<td>.883</td>
</tr>
<tr>
<td>DASH diet</td>
<td>7 (12.3%)</td>
<td>2 (4%)</td>
<td>.124</td>
</tr>
<tr>
<td>Information on alternative treatments</td>
<td>3 (5.3%)</td>
<td>1 (2%)</td>
<td>.375</td>
</tr>
<tr>
<td>Health care professional assistance tools</td>
<td>3 (5.3%)</td>
<td>1 (2%)</td>
<td>.302</td>
</tr>
<tr>
<td>Tracking function</td>
<td>41 (71.9%)</td>
<td>36 (72%)</td>
<td>.994</td>
</tr>
<tr>
<td>Salt intake tracker</td>
<td>2 (3.5%)</td>
<td>1 (2%)</td>
<td>.637</td>
</tr>
<tr>
<td>Calorie intake tracker</td>
<td>4 (7.0%)</td>
<td>1 (2%)</td>
<td>.220</td>
</tr>
<tr>
<td>Weight/BMI tracker</td>
<td>15 (26.3%)</td>
<td>14 (28%)</td>
<td>.845</td>
</tr>
<tr>
<td>BP tracker</td>
<td>39 (68.4%)</td>
<td>35 (70%)</td>
<td>.860</td>
</tr>
<tr>
<td>Heart rate tracker</td>
<td>36 (63.2%)</td>
<td>30 (60%)</td>
<td>.737</td>
</tr>
<tr>
<td>Does the app have tools to analyze BP trends or give text-based feedback on BP entries?</td>
<td>37 (64.9%)</td>
<td>34 (68%)</td>
<td>.736</td>
</tr>
<tr>
<td>Can tracked information be exported directly to physician?</td>
<td>25 (43.9%)</td>
<td>22 (44.0%)</td>
<td>.988</td>
</tr>
<tr>
<td>Does the app have tools to enhance medication adherence?</td>
<td>14 (25.6%)</td>
<td>10 (20%)</td>
<td>.572</td>
</tr>
<tr>
<td>Medication alert/notification/alarm</td>
<td>6 (10.5%)</td>
<td>5 (10%)</td>
<td>.929</td>
</tr>
<tr>
<td>Medication log</td>
<td>6 (10.5%)</td>
<td>5 (10%)</td>
<td>.929</td>
</tr>
<tr>
<td>BP check reminder</td>
<td>11 (19.3%)</td>
<td>10 (20%)</td>
<td>.927</td>
</tr>
<tr>
<td>Can the app transform phone to a medical device?</td>
<td>0 (0%)</td>
<td>7 (14%)</td>
<td>.03</td>
</tr>
<tr>
<td>BP measurement</td>
<td>0 (0%)</td>
<td>7 (14%)</td>
<td>.03</td>
</tr>
<tr>
<td>Heart rate measurement</td>
<td>0 (0%)</td>
<td>5 (10%)</td>
<td>.014</td>
</tr>
<tr>
<td>Access to support groups</td>
<td>0 (0%)</td>
<td>1 (2%)</td>
<td>.283</td>
</tr>
</tbody>
</table>

BMI, body mass index; BP, blood pressure; DASH, Dietary Approaches to Stop Hypertension; HTN, hypertension; IQR, interquartile range; NA, not applicable.
Results

Of 107 smartphone apps eligible for analysis, 57 (53%) were designed for Apple iPhone and 50 (47%) for Google Android. App characteristics are summarized in Table 1. Of all apps, only 2.8% had documented involvement of a healthcare agency such as university or professional organization in app development. A total of 2.8% of all apps targeted physicians, 95.3% targeted patients, and 1.9% targeted both physicians and patients. Of all apps, 65.4% (95% confidence interval [CI], 55.8%–73.9%) of all apps were free. For apps that were not free, the median price was 2 USD (interquartile range [IQR], 1–3.99). Median number of reviews for all apps was 62.5 (IQR, 6–368). Median rating on a scale of 1–5 was 3.9 (IQR, 3.5–4.4).

A majority of apps (71.9%; 95% CI, 62.6%–79.8%) served as tracking devices. A total of 69.1% (95% CI, 59.6%–77.2%) were capable of tracking BP, 61.7% (95% CI, 52.0%–70.5%) were capable of tracking heart rate, 2.8% (95% CI, 0.9%–8.5%) were capable of tracking salt intake, 4.6% (95% CI, 1.9%–10.9%) were capable of tracking calorie intake, and 27.1% (95% CI, 19.4%–36.4%) were capable of tracking weight/body mass index (BMI). A total of 66.3% (95% CI, 56.7%–74.8%) of all apps had analytical tools for trends in BP and heart rate including text–based feedback tools for high or low BP and/or heart rate. A total of 43.9% (95% CI, 34.7%–53.6%) apps could export data entered by the patient over a period of time directly to the physician via email, thereby facilitating patient–physician communication. There were no differences in any of the aforementioned functions between different smartphone platforms (Table 1). A total of 37% (95% CI, 28.6%–47.1%) of apps contained general information on HTN, and 8.4% (95% CI, 4.4%–15.5%) contained information on the Dietary Approaches to Stop Hypertension (DASH) diet. A total of 22.4% (95% CI, 15.4%–31.5%) of apps had tools to enhance medication adherence. These included medication notification or alarms in 10.3% (95% CI, 5.7%–17.8%), medication logs in 10.3% (95% CI, 5.7%–17.8%), and BP check reminder in 19.6% (95% CI, 13.1%–28.4%). A total of 3.7% (95% CI, 1.4%–9.7%) of apps had information on alternative treatments. Of the apps, 8.4% (95% CI, 4.4%–15.5%) contained healthcare professional assistance tools such as clinical risk–prediction calculators (eg, Framingham Risk Score) or results of hypertension clinical trials.

Interestingly, there were seven apps for Google Android (14% of Android apps and 6.5% of all apps) that could transform the smartphone into a BP– or HR–measuring device. None of these applications had any documentation of validation against a gold standard. All of these apps claimed to measure BP accurately using a cuffless technique by placing a finger on the phone screen or camera. The combined number of downloads for apps that had a device function was 900,000–2.4 million.

In regression models to predict app functionalities that were favored by users, we used ordinal logistic regression to test for app characteristics that predict number of downloads (Table 2). Number of downloads and positive ratings were known only for Google apps, therefore only 50 apps designed for Google Android were included in this model. Apps that could transform the smartphone into a medical device had the highest predicted number of downloads (odds ratio [OR], 97.08; 95% CI, 6.44–1463.55; P < .001). Another feature that was significantly associated with the number of downloads after adjusting for price was tracking function (OR, 16.67; 95% CI, 1.71–162.56; P = .015). In a negative binomial regression model, we found device function (IRR, 1204.39; 95% CI, 48.99–29.609.77, P < .001), tracking function (IRR, 16.67; 95% CI, 1.71–162.56; P = .015), and medication adherence tools (IRR, 5.71; 95% CI, 1.06–30.83; P = .043) to be significantly associated with favorable ratings by consumers after adjusting for price (Table 3). The number of

<table>
<thead>
<tr>
<th>Functional Characteristics of Smartphone App</th>
<th>Odds Ratio (95% Confidence Interval; P Value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tracking function</td>
<td>16.67 (1.71–162.56; P = .015)</td>
</tr>
<tr>
<td>Medication adherence tools</td>
<td>4.82 (0.91–25.61; P = .065)</td>
</tr>
<tr>
<td>Device function</td>
<td>97.08 (6.44–1463.55; P &lt; .001)</td>
</tr>
<tr>
<td>Informational app</td>
<td>0.83 (0.07–3.98; P = .815)</td>
</tr>
<tr>
<td>App is free</td>
<td>23.86 (3.57–159.64; P &lt; .001)</td>
</tr>
<tr>
<td>Overall model significance</td>
<td>P &lt; .0001</td>
</tr>
</tbody>
</table>
downloads, favorable ratings, and major app function for the most popular apps are summarized in Table 4.

**Discussion**

In the present study, we analyzed the content of the top 107 medical applications designed for HTN management on the two most popular smartphone platforms. Our results showed that almost three–fourths of these apps could facilitate health management by recording and tracking blood pressure, heart rate, salt or calorie intake, and weight/BMI. Almost half the apps could directly export this recorded information to a physician’s office in the form of a spreadsheet or graph, thereby greatly enhancing patient–physician communication. Almost one–quarter of apps had tools that could enhance medication adherence. Less than 5% of all apps had any documentation of healthcare agency involvement in app development. Patients were the target audience for greater than 90% of all apps. Apps that had tracking function and those that were capable of transforming the smartphone to a medical device had the greatest likelihood of being downloaded and rated favorably by consumers.

A promising finding regarding the current state of m–health technology for HTN was that a majority of apps were designed to facilitate aspects of care that have been shown to be effective in reducing BP. This included features designed to enhance monitoring of physiologic and lifestyle parameters, tools to increase medication adherence, and information regarding the DASH diet. These attributes of smartphone apps can empower patients with accurate medical information, provide tools to promote self–management, and encourage greater participation in medical decision–making. Recently self–management and self–titration of antihypertensive medications was

<table>
<thead>
<tr>
<th><strong>Table 3</strong></th>
<th>Results of negative binomial regression using number of positive reviews (four and five stars) as the outcome variable and functional characteristics of the app as the predictor variables (data on positive reviews was only available for Google apps)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Functional Characteristics of Smartphone App</strong></td>
<td>Incidence Rate Ratio (95% Confidence Interval; ( P ) Value)</td>
</tr>
<tr>
<td>Tracking function</td>
<td>157.56 (15.06–1647.72; ( P &lt; .001 ))</td>
</tr>
<tr>
<td>Medication adherence tools</td>
<td>5.71 (1.06–30.83; ( P = .043 ))</td>
</tr>
<tr>
<td>Device function</td>
<td>1204.39 (48.99–29,609.77; ( P &lt; .001 ))</td>
</tr>
<tr>
<td>Informational app</td>
<td>0.51 (0.08–3.07; ( P = .458 ))</td>
</tr>
<tr>
<td>App is free</td>
<td>8.58 (2.30–31.96; ( P = .001 ))</td>
</tr>
<tr>
<td>Overall model significance</td>
<td>( P &lt; .0001 )</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Table 4</strong></th>
<th>Top five most popular apps on hypertension for iPhone and Android</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Name of App</strong></td>
<td><strong>Number of Downloads</strong></td>
</tr>
<tr>
<td><strong>Android</strong></td>
<td></td>
</tr>
<tr>
<td>Blood Pressure (My Heart)</td>
<td>1 million–5 million</td>
</tr>
<tr>
<td>Acc. Blood Pressure Monitor</td>
<td>500K–1 million</td>
</tr>
<tr>
<td>BP Watch</td>
<td>500K–1 million</td>
</tr>
<tr>
<td>Real BP Calculator</td>
<td>100K–500K</td>
</tr>
<tr>
<td>Blood Pressure Log</td>
<td>100K–500K</td>
</tr>
<tr>
<td><strong>iPhone</strong></td>
<td></td>
</tr>
<tr>
<td>Blood Pressure Companion</td>
<td>NA</td>
</tr>
<tr>
<td>My Medical</td>
<td>NA</td>
</tr>
<tr>
<td>HeartWise Blood Pressure Tracker</td>
<td>NA</td>
</tr>
<tr>
<td>iBP Blood Pressure</td>
<td>NA</td>
</tr>
<tr>
<td>Blood Pressure – Smart Blood Pressure (Smart BP)</td>
<td>NA</td>
</tr>
</tbody>
</table>

BP, blood pressure.
shown to reduce BP by 9.3 mm Hg systolic and 3.2 mm Hg diastolic at 12–month follow–up in the Telemonitoring and Self–Management IN hypertension 2 (TASMIN–SR) trial.16 Other previous randomized controlled trials have shown that patients randomized to SMBP with additional support such as educational materials and algorithms for medication adjustment achieved a greater reduction in systolic BP of 3.4–8.9 mm Hg and diastolic BP of 1.9–4.4 mm Hg compared with usual care alone.5 M–health technologies could be a powerful tool to provide such individual level support such as text message interventions, especially in low– to middle–income populations.17

The two major components of self care among patients with HTN include lifestyle changes and medication adherence,6 both of which seem to be well–represented in our analysis. BP tracking, reminders to measure BP, and analytical and text based feedback tools have been shown to increase patient’s self–reliance regarding chronic diseases such as HTN. Enhanced monitoring and self–management with the use of m–health technologies has been shown to improve health outcomes in patients with HTN in a recent randomized trial of diabetics with uncontrolled HTN.18 In this study where the m–health based support group was compared with usual care alone, patients in the m–health group achieved 7.1 mm Hg decrease in systolic BP and 3.9 mm Hg in diastolic BP compared with controls.18 This may have been due to enhanced physician–patient communication and consequent medication adjustments in addition to greater medication adherence in the intervention group. Similarly, m–health based adherence management has been shown to increase medication adherence in HTN, diabetes, and hyperlipidemia.19 Our findings are therefore encouraging and show that most HTN apps are designed to facilitate enhanced monitoring of physiologic parameters, lifestyle modification, and greater medication adherence.

Despite the advantages of m–health technology, our study underscores a need for caution among patients and healthcare personnel. We found that a small number of Google Android apps (14%) with up to 2.4 million downloads have the capability of transforming the smartphone to a medical device for measuring BP or heart rate. In regression models, these apps had the highest predicted number of downloads and favorable consumer ratings. This highlights the popularity of these apps among consumers and a growing market for smartphone–based BP measurement devices. However, none of these apps were approved as measuring devices by the Food and Drug Administration (FDA) and did not have documentation of validation against a gold standard in patients with HTN. With the number of medical apps doubling every 2–3 years, the number of apps with a device function is likely to increase exponentially in the near future.20 With millions of patients using such non–validated BP measuring apps, there are serious concerns about patient safety. Smartphone–based cuffless techniques for measuring BP have recently been shown to be feasible.12,13 However, extensive clinical validation studies in different patient populations are required before their commercialization and clinical use. Physicians must remain cognizant of m–health technologies being used by their patients and encourage BP measurement only with validated devices.

In conclusion, a large and growing number of m–health technologies are currently available for patients with HTN. Most applications currently focus on monitoring BP, heart rate, and lifestyle changes, with smaller numbers focused on medication adherence. There are a small number of apps that can transform the application into a medical device, which, although few in number, are highly popular. There is an urgent need for greater regulation and oversight in medical app development. High quality, adequately powered randomized controlled trials are needed to evaluate the effectiveness of m–health interventions on clinical outcomes in hypertension. There is need for leading healthcare organizations such as universities and professional organizations to adopt a greater role in the research and development of m–health technologies.

**Strengths and Limitations**

A few limitations to our study are noteworthy. First, the rapid evolution of smartphone technology, for example, the recent introduction of the iPhone6 and Apple watch, is likely to be associated with an exponential increase in the size of the m–health market. The cross–sectional design of our study cannot account for changing trends in app functionalities and consumer interaction associated with this evolution in m–health technology. Second, since this was a study to evaluate characteristics of m–health applications, other smartphone–based accessory devices such as the Withings and ihealthlabs BP monitors were not included in the study. Third, the study design does not permit an evaluation of the usability of apps from a patient perspective. Despite these limitations, the study has several strengths. We analyzed apps on the two most popular platforms with a large user base. We used regression modeling to find app characteristics that are popular among smartphone users. This information would be useful for content developers to design apps that are engaging to users and for healthcare personnel who are likely to encounter patients using m–health technologies.

**References**


