

# Medical Mobile Applications for Stroke Survivors and Caregivers

Pirouz Piran, MD,\* Jinu Thomas, MD,\* Saroj Kunnakkat, MD, MPH,\*  
Abhishek Pandey, MD,\* Nadege Gilles, MPH,\* Sarah Weingast, BS,\*  
Dee Burton, PhD,†‡ Clotilde Balucani, MD, PhD,\* and  
Steven R. Levine, MD, FAHA\*§, The Mobile Applications for Stroke (MAPPS)  
Investigators

*Background:* Recent studies estimate nearly half of the US population can access mobile medical applications (apps) on their smartphones. There are no systematic data available on apps focused on stroke survivors/caregivers. *Objective:* To identify apps (a) designed for stroke survivors/caregivers, (b) dealing with a modifiable stroke risk factor (SRF), or (c) were developed for other purposes but could potentially be used by stroke survivors/caregivers. *Methods:* A systematic review of the medical apps in the US Apple iTunes store was conducted between August 2013 and January 2016 using 18 predefined inclusion/exclusion criteria. SRFs considered were: diabetes, hypertension, smoking, obesity, atrial fibrillation, and dyslipidemia. *Results:* Out of 30,132 medical apps available, 843 (2.7%) eligible apps were identified. Of these apps, (n = 74, 8.7%) apps were specifically designed for stroke survivors/caregivers use and provided the following services: language/speech therapy (n = 28, 37%), communication with aphasic patients (n = 19, 25%), stroke risk calculation (n = 11, 14%), assistance in spotting an acute stroke (n = 8, 10%), detection of atrial fibrillation (n = 3, 4%), direction to nearby emergency room (n = 3, 4%), physical rehabilitation (n = 3, 4%), direction to the nearest certified stroke center (n = 1, < 2%), and visual attention therapy (n = 1, < 2%). 769 apps identified that were developed for purposes other than stroke. Of these, the majority (n = 526, 68%) addressed SRFs. *Conclusions:* Over 70 medical apps exist to specifically support stroke survivors/caregivers and primarily targeted language and communication difficulties. Apps encompassing most stroke survivor/caregiver needs could be developed and tested to ensure the issues faced by these populations are being adequately addressed.

**Key Words:** Stroke—cerebrovascular disease—caregiver—mobile applications—recovery

© 2019 Elsevier Inc. All rights reserved.

## Introduction

The number of smartphone users in the United States was estimated 207 million in 2016<sup>1</sup> in a country with

322 million people<sup>2</sup> (64 %). The majority (77%) of these smartphone users have previously downloaded mobile applications (apps).<sup>3</sup> Many stroke-related apps are developed for a target audience of healthcare workers,

From the \*The State University of New York (SUNY) Downstate Medical Center, New York, New York; †College of Medicine, New York, New York; ‡CUNY Hunter School of Public Health Brooklyn, New York, New York; and §Department of Neurology, Kings County Hospital Center, New York, New York.

Received April 10, 2019; accepted July 19, 2019.

Financial Disclosure: Funding supported in part by The Patient-Centered Outcomes Research Institute (PCORI), pilot grant number 1IP2PI000781.

Address correspondence to Pirouz Piran, MD, The State University of New York (SUNY) Downstate Medical Center, 435 E 70<sup>th</sup> Street, Apt: 22 L, New York, NY 10021. E-mail: [pirouzpiran@gmail.com](mailto:pirouzpiran@gmail.com).

1052-3057/\$ - see front matter

© 2019 Elsevier Inc. All rights reserved.

<https://doi.org/10.1016/j.jstrokecerebrovasdis.2019.104318>

including physicians, nurses, and assistants. Similarly, there are patient-centered apps capable of performing wide array of functions.<sup>4</sup> There are no studies, to our knowledge, on apps that are designed for, or could potentially be used by, stroke survivors and caregivers as most current apps are intended for healthcare professionals.

## Objective

Our primary objective was to identify medical apps specifically designed for stroke survivors/caregivers, or apps developed for other purposes that hold the potential for use by stroke survivors/caregivers. Our secondary objective was to propose an efficient method for systematic review of medical apps to explore available resources. At the time of this review the number of health related apps was estimated to be between 40,000 to 165,000.<sup>5,6</sup>

## Methods

### Overview

The Apple iTunes store and Android Google Play Store, together, account for 98.4% of the smartphone market.<sup>7</sup> Several studies showed that Apple iTunes store contains a larger number of the stroke-related apps than the Android Google Play store.<sup>8</sup> Most of the apps overlapped on our preliminary analysis. We therefore only explored the Apple iTunes store for our systematic review.

A list was generated from all apps listed in the iTunes store medical category between August 2013 and January 2016 in alphabetic order. Each app was linked to the corresponding app store product page. We considered an app specifically designed for stroke survivors/caregivers, if the description of the app mentioned stroke survivors/caregivers as the target audience.

In order to decrease data collection bias, we employed systematic literature review and PRISMA flow diagram principles to design a review algorithm system (Fig 1). An extensive list of inclusion and exclusion criteria was

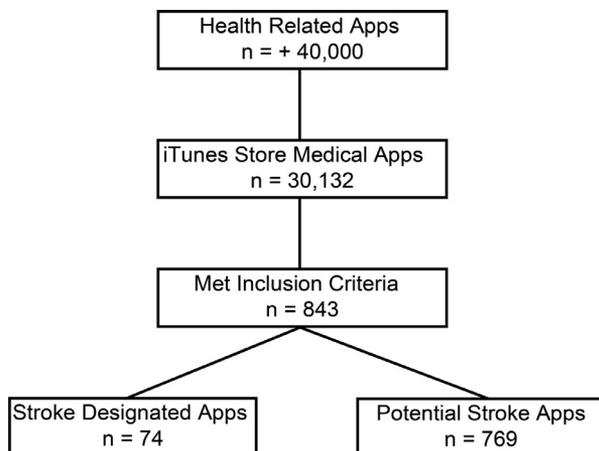


Figure 1. Study flow diagram.

Table 1. Inclusion and exclusion criteria

### Inclusion

- Targeting SRF (diabetes, hypertension, smoking, obesity, atrial fibrillation, and hyperlipidemia)
- Assisting patients/caregivers in acute stroke identification, response, and/or directions to nearby stroke centers
- Directing stroke patients/caregivers to postdischarge facilities, such as a rehabilitation center, nursing facility and/or hospice
- Help addressing and ameliorating stroke deficits, including but not limited to motor weakness, aphasia, dysarthria, apraxia, sensory, and vision loss
- Improving patient independence poststroke
- Providing resources to caregivers to facilitate postdischarge care of stroke patients
- Assist coordinating the care between different caregivers

### Exclusion

- Apps that are intended for use by healthcare professionals
- Informative/educational apps or apps that only provide information such as journals, magazines, articles, guidelines, books, etc
- Apps that address a nonmodifiable stroke risk factor
- Apps that are commercial or intended for business purposes
- Apps that use gimmicks or employ nonevidence-based therapeutic tools
- Apps with product presentation for use by sales representatives or retailers
- Apps that are in languages other than English

developed (Table 1). Information obtained from the app store product page was entered into a database using Microsoft Excel (MS) 2014, with features such as description of app by developer, functionality, popularity, cost, keywords, purpose, and metadata.

## Results

There were 30,132 apps reviewed from the medical category of the Apple iTunes Store between August 2013 and January 2016. Of these, 843 (2.7%) apps fulfilled study criteria. All eligible apps were divided into 2 major categories: (a) apps that were specifically designed for stroke survivors/caregivers use ( $n = 74$ , 8.7%); and (b) apps that were developed for other purposes but could potentially be used by stroke survivors/caregivers ( $n = 769$ , 91.3%).

### Apps Intended for use by Stroke Survivors/Caregivers

Out of the 74 apps that were specifically designed for stroke survivors/caregivers, the majority ( $n = 42$ , 57%) were apps that cost money to download and the rest ( $n = 32$ , 43%) were free of charge. Over 91% ( $n = 67$ ) of the apps had a single purpose and 9% ( $n = 7$ ) were developed for multiple purposes. The stroke dedicated apps provided the following services: language/speech therapy ( $n = 28$ , 37%), communication with aphasic patients

(n = 19, 25%), stroke risk calculation (n = 11, 14%), assistance in spotting an acute stroke (n = 8, 10%), detection of atrial fibrillation (n = 3, 4%), assistance with losing weight (n = 3, 4%), direction to nearby emergency room (n = 3, 4%), physical rehabilitation (n = 3, 4%), management of hypertension (n = 2, 3%), direction to the nearest certified stroke center (n = 1, < 1%), and visual attention therapy (n = 1, < 2%).

### *Language Therapy Apps*

This subset of apps were designed for stroke survivors with a wide variety of language/speech impairments including: aphasia, dysarthria, apraxia, dysprosody, reading difficulties, slow rate of speech, and even difficulty maintaining eye contact while speaking. The apps (listed in Table 2) targeting the language disorders noted above provided diverse activities and language/speech therapies. Others used competing augmentative and alternative communication systems as well as Semantic Feature Analysis to assist patients with language difficulties. The various features included capability of adjusting difficulty and level of performance with scoring system, hints to enable independent practice as well as ability to send results to caregivers and others.

### *Communication Apps*

The apps in this section had different configurations and designs to allow patients to communicate for various reasons under different settings (i.e. at home, hospital, etc.). Images, symbols, audio, text-to-speech voices, yes-no questions, and Wh- questions were used to enhance communication capabilities. Extra features were customizable or preprogrammed vocabulary; ability to decrease background noise; providing different levels of difficulty; using images associated to text and/or audio combined with a configurable interface; ability to add custom words and phrases accompanied by a picture taken with the device's camera; and even ability to build sentences by touching pictures one after another.

### *Stroke Risk Calculators for Patients*

Apps in this category predicted the risk of having a stroke in future. The risk of stroke was calculated based on the (1) data from the existing Framingham study<sup>9</sup> stroke risk assessment tools, (2) American College of Cardiology/American Heart Association (ACC/AHA) cardiovascular risk guidelines, or (3) the CHADS2 and CHA<sub>2</sub>DS<sub>2</sub>-VASc score by the Euro Heart Survey on atrial fibrillation. The latter only predicted the risk of having stroke in the setting of atrial fibrillation and was used by only 1 app. A health risk appraisal function has been developed, using the Framingham cohort to calculate the likelihood of a stroke within the next 5-10 years.<sup>10</sup> These apps used a questionnaire to ask simple questions to

calculate the risk of having stroke in future, based on the data from above-mentioned studies. One app<sup>11</sup> provided the ability to compare one's risk with someone of similar age and gender without risk factors, giving the user the ability to see how each risk factor contributes to his/her overall risk of stroke. It also provided ability to see how modifying a risk factor can impact one's risk of having stroke.

### *Recognizing an Acute Stroke*

Apps under this section address this simple question: "am I, or is someone near me having a stroke?" Almost all used the Facial drooping, Arm weakness, Speech difficulties, and Time (FAST) as an interactive tool to help users recognizing the stroke symptoms. One app<sup>12</sup> was designed specifically to test hearing defects associated with stroke. It presented a wide variety of sound stimuli (such as pure tones, numbers, syllables, environmental sounds, and spondaic words) to each ear and then both ears in a systematic fashion to screen auditory acuity. Following the presentation, the app sorted the responses and stimuli and scored the responses. Additional features provided by the apps in this section were GPS location and the ability to send help message with the user's location and the ability to dial 911 from within the app by 1 click and sending the user's medical information such as medications list, history of intracranial hemorrhage in the past, etc.

### *Detecting Atrial Fibrillation*

Afib detecting apps as companion to an Afib detection monitor were the majority of the apps in the category. Features included utilizing the iPhone camera to produce a heart rhythm graph. The user was asked to place the tip of an index finger or middle finger on the camera lens while the app took a screen shot of the heart rhythm. Once the heart rhythm graph stabilized, the patient could compare the pulse record against an irregular heartbeat. The user was then encouraged to seek medical attention if irregular intervals were observed.<sup>13</sup>

### *Direction to Nearby Emergency Room or a Certified Stroke Center*

Only one app in this section was directing its users specifically to a nearby certified stroke center, while other apps were directing the users to a nearby emergency room based on their location. Other additional features offered were the ability to add "one push" red emergency button added to the mobile home screen to use during an emergency, ability to connect to a 24/7 monitoring center with trained operators available to notify first responders, and real-time location updates to family and friends to notify them with the user's exact location.<sup>14</sup>

**Table 2.** *Language therapy and communication apps*

Apps name	Developer	Description	Features	Extra notes
SmallTalk	Lingraphica	Series of speech-exercise videos, each illustrating the tongue and lip movements	Giving the ability to produce consonant blends	Ex: blended consonants such as “bl” or “str.”
Reading Aphasia	Virtual speech center Inc.	Various stimuli to practice reading comprehension skills at the word, phrase, and sentence levels	Organized in 12 semantic categories in daily activities and daily conversations	Bathing, dressing, grooming, and leisure activities
Speech Pacesetter	Lorraine Curran	Allow choice of text and pace reading rates to improve speech clarity	- Speech adjustable visual cue  - Metronome sound cue	Visual cues: - Bouncing ball - Highlighted text cursor - Gradual appearance of text
Talk around it	Neuro hero Inc.	Improve word finding skills using Semantic Feature Analysis (SFA)	Practice using spoken and written cues as well as circumlocution	To be used with a friend or family member
EyeType	SCV Soft	To help people with severe disabilities communicate with the world	Ability to choose from different categories by blinking or moving the eyes	Choose from - Characters - Numbers
Talk assist	Mubaloo	Text to speech convertor	Ability to convert hand written phrases to speech	Ability to save recent phrases and bookmark for regular use
Speech Amplifier	Speech and Language Solutions Limited	Use iPhone, iPad, etc. to amplify quiet voices for people with speech difficulties	Focus on near/far voices option	Bluetooth enabled
MCS Exchange	Data by Design LLC	Email program designed for use by those with disabilities, visual impairment, or limited fine motor skills	Use photos and pictures to choose desired phrases and send email	Use a platform similar to Outlook email.
Speech Ally EM	Edward Marcus	Let aphasic patients communicate with sound, using a straightforward phonetic approach	Uses a single-page keypad of English phonemes (the phonetic building blocks of all English words).	Each button speaks its sound when tapped

### *Physical/Occupational Therapy Apps*

The apps in this section provided various strategies to enhance physical therapy in stroke survivors such as repeated use of the Left-Right-Trainer to enhance awareness of the affected limb.<sup>15</sup> Introducing different physical therapy protocols based on individual needs of the patients were used by an app. Same app used various customized exercises per patient/caregiver to improve walking, sitting, standing, making transfers, mobility, strength, and balance skills.<sup>16</sup> Another app specifically designed to improve scanning abilities and visual attention.<sup>17</sup>

### *Apps That Could Potentially Be Used by Stroke Survivors/Caregivers*

Seven hundred and sixty-nine apps identified were developed for purposes other than stroke, but could potentially be used by stroke survivors/caregivers. A significant number of the apps (n = 683, 85%) were developed for a single purpose, while a minority (n = 86, 15%) were developed for multiple purposes. The majority of the apps in this section (n = 526, 68%) addressed modifiable stroke risk factors (SRFs). Most (n = 450, 85%) of the apps relating to SRFs only addressed 1 risk factor, while (n = 76, 15%) addressed more than 1 risk factor. Obesity/weight loss was considered in a majority (n = 243, 46%) of the apps related to SRFs, followed by diabetes (n = 183, 34%), hypertension (n = 137, 26%), smoking (n = 52, 10%), dyslipidemia (n = 32, 6%), and Afib (n = 6, 1%). Communication with aphasic patient were addressed in 82 out of 769 (10%) of the apps, followed by language/speech therapy (n = 61, 7%), locating nearest hospital/emergency room (n = 30, 3%), quality of care improvement (n = 26, 3%), physical therapy (n = 19, 2%), hearing and balance impairments (n = 13, <2%), memory deficits (n = 7, <2%), and vision impairments (n = 7, <2%).

### *Weight Loss Apps*

Apps in this section used various methods to address obesity and assist in weight loss. Most of the apps provided a way to calculate Body Mass Index as well as many other values including Ideal Body Weight, Target Heart Rate, Basal Metabolic Rate, health age, etc. These data then were employed to set goals and to assess daily calorie requirements. There were apps that served as “calorie counters” and offered a large database of food with energy content and the amount of calories in each food. These apps guided the users to plan their meals according to their eating behavior and based on their personal weight, height, age, and activity.

One app<sup>18</sup> offered a suggested diet change necessary to achieve a weight goal based on a validated mathematical model of human metabolism.<sup>19</sup> Additional features and strategies were the ability to log weight and analyze

progress using customizable graphs and statistics, the ability to auto-sync or email the data to a doctor or trainer, the ability to chat with a live nutritionist, an intuitive ‘count down’ methodology (users were given the number of calories they have left for the day),<sup>20</sup> different diet plans with the ability to create shopping list based on the diet plan, and tracked daily steps.

### *Diabetes Mellitus related apps*

Apps under this category, addressed pre DM, type I DM, type II DM as well as complications such as hypoglycemia and seizure. Features of these apps are summarized in [Table 3](#).

### *Hypertension Related Apps*

Hypertension related apps mainly focused on accumulating your blood pressure values, keeping sodium under control, and losing weight and managing hypertension. The features offered by these apps are summarized in [Table 4](#).

### *Speech Therapy Apps*

The technologies used by several apps in this section were scientifically proven methods such as Delay Auditory Feedback and Frequency-altered feedback to help improve the fluency of speech. Delay Auditory Feedback is a technology that records your voice and plays it back to you with a delay. Frequency-altered feedback changes the pitch at which the users hear their voice. Features offered included: the ability to create a scene (such as a trip to a doctor, playing in the park, etc.) using photos and adding desired vocabularies with the ability to allocate actions and link to new scene in order to improve speech and communication, a patented method used by one app displayed the words using colors, shapes, structures, and tones, allowing users’ brain to more easily learn and remember the correct writing,<sup>21</sup> speech therapy game tools which respond to sounds and encourage articulation, virtually simulated exercises to strengthen oral musculature and the ability to choose from different consonant groups.

### *Smoking Cessation Apps*

Apps in this section consist of different programs and strategies to help quit smoking. Few apps offered proven scientific methods such as Cognitive Bias Modification and attentional bias, defined as certain objects and behaviors (cues) that trigger the urge to smoke. These apps use Cognitive Bias Modification to alter this attentional bias by teaching users to ignore smoking cues. Few apps provided ability to calculate the monetary cost of smoking, risk of a heart attack compared to risk before quitting and such to encourage patients to remain abstinent from smoking. Various additional features offered by apps in this category.

**Table 3.** *Apps related to diabetes*

Name	Developer	Description	Features	Extra note
Health Stats log	Greg Shaffer	Daily diary to log blood sugar, insulin dose, food, medications, exercise, and weight	iCloud support for data storage across different devices	Compatible with iPhone, iPad, etc.
Diabetes Pilot	Digital Altitude LLC.	Access to a large food database with detailed nutrition facts	Ability to use a barcode scanner to assess which food is good for you based on your levels	Customizable food list from various supermarket products and restaurant menu items
Bluestar Diabetes	WellDoc, Inc	Prescribed app by healthcare provider to manage DM meds	Prescription through access code provided by healthcare professionals	Claimed to be FDA cleared by the developer
MySugr: Easy to use daily diabetes logbook	mySugr GmbH	Ability to set goals such as target blood glucose, carb to insulin ratio, and blood glucose to insulin ratio	Insulin calculator based on food/carbohydrate consumption	- Can be used with insulin pump - HBA1C estimator based on daily glucose and average blood glucose
CANRISK Diabetes	Public Health Agency of Canada	Calculate risk of developing diabetes in future based on 12 questions	Considers BMI, gender, family history, HTN, diet, etc.	Categorized as: - Low risk - Moderate risk - High risk
Glucagon	Eli Lilly and Company	Ability to demonstrate steps necessary to administering Glucagon in case of hypoglycemia	Notifications will remind you when a kit is due to expire	Touchscreen simulator
Diabetes Coach	THink Safe	Coaches through an emergency diabetic situation	Real time audible step-by-step instructions	Locating nearest ED using Google Maps

**Table 4.** Apps related to hypertension

App	Developer	Description	Features	Extra notes
Blood pressure reducer	Arnold Software	Designed to reduce blood pressure and relaxation to decrease blood pressure in stressful situations	Uses gentle tones to help users reduce breathing rate	Claimed to reduce BP by 10–20 points
Sodium one ~ sodium counter	Eulix Inc.	Count sodium intake based on a large database of food items (65,000 from 77 restaurants and 700 food brands)	Detailed nutrition facts including calories, sodium, trans fat, total fat, and saturated fat	Ability to send data, graphs and trends to your healthcare professional
Blood pressure - smart blood pressure (smartbp) bp tracker	Evolve Medical Systems, LLC	Record/trend diastolic blood pressure, systolic blood pressure, and visualize reading values in customizable graphs and statistics	Filter results based on AM/PM reading format, relation to food, relation to medication time, weeks high's and low's as well as Day/Week/Month/Year format	Synchronizes with various devices via Bluetooth - Dropbox, iCloud and HealthVault support to store data

### *Improving the Quality of Care*

The majority of these apps served as a tool to stay organized and coordinate between the caregivers. Various features offered include: ability set up a master calendar to coordinate care between several caregivers and assigning tasks to different caregivers, to get medical attention by 1 click, and directions to nearby healthcare centers. One app provided the ability to check on the patients remotely and sent notifications to caregivers if the patient did not move for a certain amount of time or failed to “check in” as scheduled. For instance, a notification would be sent to the designated caregivers indicating that the patient has not moved or respond.<sup>22</sup>

### *Apps Assisting with Physical Therapy*

The apps under this section turn the iPhone into a physical therapy assistance tool by: using the touch screen to measure left and right hand movements in order to improve right/left discrimination, using the camera to assess users' gait and posture by providing real-time audio and visual feedback to achieve normal gait and posture, and even providing physical therapy demonstration videos based on users' personal information with the ability to track progress and improvement.

### **Limitations**

This was a cross sectional study, which was carried out between September, 2013 and January, 2016 and has several limitations. Hundreds of new apps are developed each day, and reviewing all of the apps related to stroke survivors/caregivers can be onerous. We only reviewed the medical category of Apple iTunes store. Our inclusion criteria did not include medication reminder apps. We focused primarily on the well-established, Framingham-based risk factors, and did not consider sleep apnea or some other specific stroke risk factors. Also, there were apps that were initially included on our review but were no longer available by the time this article was submitted.

### **Discussion**

To our knowledge, this is the largest study on mobile apps related to stroke healthcare to date. Over 70 medical apps identified to specifically support stroke survivors/caregivers. The majority of apps that were designed specifically for stroke survivors/caregivers primarily targeted language and communication difficulties. Unlike previous studies, “keywords” were not used to identify apps in our study. We developed a novel method to overcome current app review challenges and difficulties. Using keywords is not an efficient way to identify and review mobile apps due to the lack of comprehensive searching methods, limited number of keywords, and the inability to scan apps descriptions by the app search engine.

Unlike literature review where the use of a specialized medical vocabulary (such as MeSH or keywords) in search queries is very effective, finding relevant healthcare apps<sup>23</sup> using keywords is not useful to identify relevant apps in the iTunes app store. Cui et al. concluded that only a quarter of the apps were related to stroke when “stroke” and “cerebrovascular disease” were used as keywords.<sup>8</sup> Apple limited keywords to a total of 100 characters. Our preliminary analysis revealed that apps often target a wide variety of diseases with multiple overlapping purposes. It is impossible for a developer to list all related diseases as keywords, given the total character limit. At times, the title of the app was misleading and it was noted during our preliminary analysis that the titles of many apps did not represent the app content at all.

Given the increased number of apps identified using our proposed method of data extraction, our search algorithm could be used to conduct similar studies in future. This significant increase in the number of identified apps using our review method also confirms that the visibility and discoverability of apps are significant challenges to both users and developers. More research is needed in future to focus on the stroke survivor/caregiver needs to ensure that the issues faced by these populations are being adequately addressed. FDA review of medical apps is “risk-based” approach<sup>24</sup> and therefore, most of the apps intended for stroke survivors/caregivers in our study were not reviewed by FDA or any other medical reviewers. More studies focusing on the efficacy of using stroke related medical apps is required.

## Acknowledgments

We thank Tristan G. Tanner, MD for his help in data collection.

## Declaration of Competing Interest

There are no conflicts of interest.

## Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:[10.1016/j.jstrokecerebrovasdis.2019.104318](https://doi.org/10.1016/j.jstrokecerebrovasdis.2019.104318).

## References

1. Statista – The statistics portal. Number of smartphone users in the United States from 2010 to 2019. Available at: <http://www.statista.com/statistics/201182/forecast-of-smartphone-users-in-the-us/>. Accessed November 2, 2016.
2. United States Census Bureau. Available at: <http://www.census.gov/popclock/>. Accessed November 2, 2016.
3. Pew Research Center. Available at: <http://www.pewinternet.org/2015/11/10/the-majority-of-smartphone-owners-download-apps/>. Accessed November 2, 2016.
4. Boulos MN, Brewer AC, Karimkhani C, et al. Mobile medical and health apps: state of the art, concerns, regulatory control and certification. *Online J Public Health Inform* 2014;5:229.
5. Pelletier SG. Explosive growth in health care apps raises oversight questions. *AAMC Reporter* (2012). Available at: <https://www.aamc.org/newsroom/reporter/october2012/308516/health-care-apps.html>. Accessed November 2, 2016.
6. Misra S. New report finds more than 165,000 mobile health apps now available, takes close look at characteristics & use. 2015. Available at: <http://www.imedicalapps.com/2015/09/ims-health-apps-report/>. Accessed November 2, 2016.
7. Gupta A. Gartner says worldwide smartphone sales grew 9.7 percent in fourth quarter of 2015. Egham, UK, 2016. Available at: <http://www.gartner.com/newsroom/id/3215217>. Accessed November 2, 2016.
8. Cui Y, Fu C, Chang H, et al. Could people get quality apps they intend to get? taking finding stroke apps for example. *Stud Health Technol Inform* 2016;225:1040-1041.
9. Kannel WB, Wolf PA, McGee DL, et al. Systolic blood pressure, arterial rigidity, and risk of stroke: the Framingham study. *JAMA* 1981;27:1225-1229.
10. Wolf PA, D’agostino RB, Belanger AJ, et al. Probability of stroke: a risk profile from the Framingham Study. *Stroke* 1991;1:312-318.
11. AUT Enterprise Ltd (2015). Stroke Riskometer (3.0.1) [Apple application software] Available at: <https://itunes.apple.com/us/genre/ios-medical/id6020?mt=8>. Accessed May 12, 2017.
12. Brainmetric. (2012). Auditory (1.0.0) [Apple application software] Available at: <https://itunes.apple.com/us/genre/ios-medical/id6020?mt=8>. Accessed October 10, 2014.
13. Kensuke, I. (2016). Heart\_Rhythm Heart Rhythm App finds risk for onset of Stroke Risk by SoftRobo. Available at: <https://itunes.apple.com/us/genre/ios-medical/id6020?mt=8>. Accessed May 12, 2017.
14. Medalert. (2014). Medlert 24/7 Care (1.2.1) [Apple application software] Available at: <https://itunes.apple.com/us/genre/ios-medical/id6020?mt=8>. Accessed October 10, 2014.
15. Kaasa Health. (2014). Limbs by Dr. Becker (1.1) [Apple application software] Available at: <https://itunes.apple.com/us/genre/ios-medical/id6020?mt=8>. Accessed October 10, 2014.
16. Vloothuis, J. (2014). Care4stroke (V1.2) [Apple application software] Available at: <https://itunes.apple.com/us/genre/ios-medical/id6020?mt=8>. Accessed October 15, 2014.
17. Tactus Therapy Solutions (2016). Visual Attention Therapy – Cognition Therapy (1.07) [Apple application software] Available at: <https://itunes.apple.com/us/genre/ios-medical/id6020?mt=8>. Accessed November 15, 2016.
18. LBM+. (2013). Body weight simulator (1.1) [Apple application software] Available at: <https://itunes.apple.com/us/genre/ios-medical/id6020?mt=8>. Accessed October 15, 2014.
19. Hall KD, Sacks G, Chandramohan D, et al. Quantification of the effect of energy imbalance on bodyweight. *Lancet* 2011;378:826-837.
20. Elegance Applications. (2014). Calitor (V2.0) [Apple application software] Available at: <https://itunes.apple.com/us/genre/ios-medical/id6020?mt=8>. Accessed October 15, 2014.
21. DY buster AG. (2014). Dybuster Basic. [Apple application software] Available at: <https://itunes.apple.com/us/genre/ios-medical/id6020?mt=8>. Accessed October 10, 2014.
22. Zeezao. (2014). Carebeacon. [Apple application software] Retrieve from Available at: <https://itunes.apple.com/us/genre/ios-medical/id6020?mt=8>. Accessed October 10, 2014.
23. Mosa AS, Yoo I, Sheets L. A systematic review of healthcare applications for smartphones. *BMC Med Informatics Decis Making* 2012;12:67.
24. US department of health and human services. Available at: <https://www.fda.gov/MedicalDevices/DigitalHealth/MobileMedicalApplications/default.htm#b>. Accessed February 14, 2019.