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DIET, EXERCISE, AND SMARTPHONES - A CONTENT ANALYSIS OF MOBILE HEALTH APPLICATIONS FOR WEIGHT LOSS

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A Dissertation
Submitted in Partial Fulfillment of the Requirements for the
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DISSERTATION APPROVAL

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The recent proliferation and adoption of smartphones has resulted in the widespread use of mobile applications. Mobile applications, or apps, are small programs that are designed to run on smartphones and mobile devices for providing information on a wide range of topics addressing the varied needs of an individual. Health apps are one of the more popular categories of apps that are used extensively among people who are interested in health and fitness. Apps in this category focus on topics such as diet, nutrition, fitness, and weight loss. This study examined popular, free weight loss health applications available in Apple iTunes (iOS) and Google Play (Android) to identify their characteristics and adherence to national health guidelines. A total of 89 weight loss apps across both platforms were selected for the content analysis. Each app was coded to examine the general characteristics and the presence of features such as interactivity, adherence to evidence-informed practices and health guidelines, user engagement, and credibility of health information. Descriptive statistics such as frequencies and percentages were calculated once the coding was done.

Perhaps the most important finding of the study was that no single app completely adhered to all the health guidelines or evidence-informed practices outlined by national health

agencies. However, there were some apps that showed high levels of adherence in certain categories. The study further indicated that weight loss apps are designed more for people interested in physical fitness and training and less for people who are trying diet and nutrition to lose weight. A majority of the apps analyzed did not adhere to evidence-informed practices, did not follow the clinical 10-step guidelines for treatment of weight loss recommended by national health agencies, and failed to meet HON (Health on the Net) standards for credibility. E-mail was the preferred form of communication present in all the apps, and interactive features were under utilized by app developers.

This study found that mobile app developers make minimal use of theory-driven components in their app design. The provision to track user progress was the most employed user engagement (66%), followed by facilitating goal setting (53%), and self-monitoring (51%). Of all the 89 apps analyzed, the study found only one app with health professional input, seriously highlighting the need for involvement of health professionals in app design and development.

Weight loss through mobile apps has a lot of potential for growth in terms of incorporating interactive features, theory-driven content, evidence-informed practices, and credibility of health information. While there is much emphasis on improving the functionality and features of apps, it is also important that health professionals with an understanding and knowledge of national health guidelines need to be actively involved in developing apps that are tailored, appropriate, and relevant for those interested in losing weight. There needs to be more initiatives where app developers, health professionals and agencies, avid app users, nongovernmental organizations, and policy makers come together and help address some of the issues highlighted in this study.

DEDICATION

For

The American Dream & Kamma

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I come from a very humble background from Southern part of India. I grew up in a place called Ayanavaram in Chennai, Tamilnadu. I never dreamt of pursuing higher studies or getting into academia, if not for my father who was also my class teacher in high school. He constantly reminded me to excel in education and believed that investing in education was the best thing to do in life. He cited many real life examples of how people had access to better lifestyle because of proper education. My mother was a good woman who instilled great values in me. She showed the meaning of true love and the importance of being there for the family at all times. She used to make lovely paper dosas (a version of pancake) and lentil curry, the taste of which still lingers in my mouth. She would buy me goodies and cajoled me to go to church with her. Dressed in light blue saree (dress worn specially for Mother Mary) she would walk to St. Lourdes shrine in Perambur, fasting and praying to give me and my sister Sugi, the best life could offer. Yes, her prayers were answered, but both of my parents never had the chance to see us succeed in life.

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CHAPTER 1

INTRODUCTION

The technology revolution particularly in the last couple of decades has had a tremendous impact on people's lifestyles across the globe. A staggering 7 billion mobile-connected devices, more than the number of people on the planet (Cisco, 2012), allow people to stay connected and informed at all times. Mobile phones have become so indispensable that they are almost an extension of our body and mind (Alvarez-Lozano, Frost, Osmani, Bardram, Kessing, Mayora, & Faurholt-Jepsen, 2014). According to the study conducted by the PEW research center, 85% of U.S. adults own a mobile phone and 56% own smartphones (Fox, 2013). This study further revealed that 19% of smartphone users have tracked their weight, diet, or exercise routine online using apps.

Applications, or apps, are marketed and distributed through major smartphone platforms. Android of Google, iOS of Apple, Blackberry (previously known as RIM or Research in Motion Limited), and Windows Phone Apps+Games Store of Microsoft are some of the major applications stores listed in order of the market share of operating systems for smartphones (Roa, 2014). Google Play and Apple iTunes store are the global market leaders in applications (apps) stores (BinDhim, Freeman, & Trevena, 2014). As of 2012, Apple iPhone customers downloaded more than 25 billion apps, up from 15 billion in 2011. The Android market reached 10 billion app downloads by mid-2011 (The Official Google Blog, 2011).

Counting calories, gauging nutrition, tracking workouts, calculating body mass index, and quitting smoking are some of the popular mobile health apps among smartphone subscribers (Collins, 2011). A considerable number of health-care professionals also use apps, and many apps are designed exclusively to cater to their professional needs (Ralf, 2010). In response to

such health information seeking behavior, a large number of health organizations, medical professionals, and software professionals have been prompted to create and develop apps for many health-related issues (West, Hall, Hanson, Barnes, Giraud-Carrier, & Barrett, 2011).

However, the credibility of health information available within apps, breaches of patient confidentiality, inaccurate information, poor design of interface and usability, and the malfunctioning of apps resulting in misinformation could adversely impact the end user, leading to the conclusion that apps deserve to be monitored and studied. The open nature and independence of app development and distribution is a positive sign, but at the same time, there are legitimate concerns for the need to monitor and streamline the growing app market (Yang & Silverman, 2014).

Individuals recently have gained easy access to health information, and there has been a significant rise in the number of people managing their health through mobile phone apps (Kvedar, Coye, and Everett, 2014). Based on the 2012 Consumer Health Apps Report, consumers of health applications via iOS rose significantly from 2,993 in February 2010 to 13,619 in 2012 (MobiHealthNews, 2012). Despite the ubiquitous nature of smartphones, very limited research has been conducted until now (Wei, Karlis, and Haught, 2012). The rise and phenomenal growth of the mobile phone industry and popularity of health apps on mobile devices have prompted the need for research and evaluation of the effectiveness of health apps. It is the responsibility of health professionals, mobile app designers, mobile service providers, and authorities to ensure that quality and credible health apps are available for mass consumption. With the increased usage of these apps by individuals at home and by health-care professionals, it is imperative to evaluate the extent to which such health apps adhere to current and specified health standards and policies.

This study discusses whether health apps need to be regulated by governing bodies in the field of health, and the need for app developers to follow guidelines of health professionals for better quality and delivery of health care. High-quality apps that are designed according to the suggested guidelines backed by health-accredited organizations are more likely to benefit individual users and ensure quality of health care information delivered through smartphones (Eysenbach, 2001). The results and recommendations made from this study are likely to be of interest to health researchers, technology developers, software designers, and policy makers who work in the field of mobile health applications.

Rationale for the Study

Globally, around 4.5% of all searches on the Internet are for health-related information (Eysenbach, & Köhler, 2003). According to the PEW Internet and American Life Project, 72% of American adult Internet users searched for health information online, and of these, 77% said that their search inquiries for health started from major search engines (Fox, 2012). These figures imply that the Internet has become an important source for consumers seeking health information and health-care services online (Eysenbach, Powell, Kuss, & Sa, 2002). The flip side of this easy availability of health information is that it can be overwhelming for the users (Skinner, Biscope, & Poland, 2003). Studies have shown that many adults have difficulty using and understanding online health information (Jaffe, Tonick & Angell, 2014), and people with low literacy levels have more trouble comprehending and using health care information (Nijman, Hendriks, Brabers, de Jong, & Rademakers, 2014). Information on the Internet is totally unregulated, allowing anyone with access to the Internet to publish anything (Morahan-Martin, 2004). The Internet presents a great possibility for providing plenty of quality health information

while at the same time including equal amounts of information that can be misleading, conflicting, and inaccurate (Morahan-Martin & Anderson, 2000).

According to a recent study, people on average spend more time using mobile applications than browsing the Web (Nielsen, 2014). This study reported that U.S. adults spend twenty-seven hours per month accessing the Internet via desktop; on the other hand, they spend thirty-four hours per month using the Internet on their smartphone. The considerable difference in time spent on the desktop versus mobile phone is mainly because of innovations in the smartphone sector. Also, the usage of apps accounted for 86% of the smartphone Internet time, indicating that people are spending more time with their apps (Nielsen, 2014).

Many health professionals are genuinely concerned about the credibility and quality of online information and how it is interpreted (Kitchens, Harle, & Li, 2014). The United States Department of Health and Human Services report *Healthy People 2010* clearly states that the ability to retrieve relevant health information is one of the health literacy skills that is critical for health communication (U.S. Department of Health and Human Services, 2000). User-friendly technology can be achieved only when the health information provided is easy to understand and can be incorporated by consumer-oriented navigation tools (Ye, 2010). Studies have shown that user-friendly designs and interactive elements are vital components for leveraging maximum engagement and access. Irrespective of the size of the computers, user-centered design is a factor that is crucial for the efficacy of health communication across various strata of the society (Misra and Wallace, 2012).

Smartphone apps have great potential to help improve the health of our people (Abroms, Padmanabhan, Thaweethai, & Phillips, 2011). At the same time, there are legitimate concerns that the research on apps and health promotion is not able to keep pace with the innovation and

diffusion of these technologies in our society (Atienza, Hesse, Baker, Abrams, Rimer, Croyle, & Volckmann, 2007). Scholars are pointing out the dearth of research in this area, especially in the field of mobile apps that concentrate on many chronic conditions, and more research is needed to gain understanding of the interface and content, and to help in enhancing various features in the development of an app (Årsand, Frøisland, Skrøvseth, Chomutare, Tatara, Hartvigsen, & Tufano, 2012). Researchers who have done studies on weight-loss apps have recommended that research is needed to improve and evaluate these apps (Breton, Fuemmeler, & Abroms, 2011). This study has taken the considerations suggested by researchers to evaluate the efficiency of weight loss apps to improve their quality, content, and standards. Recommendation based on research is essential to design and distribute evidence-informed weight-loss apps for users.

Purpose and Objectives

The purpose of this study was to analyze and evaluate popular, free weight-loss apps available in Android and Apple iOS stores designed to assist individuals to lose weight. The two platforms were chosen because they are the global leaders in app marketing and distribution (BinDhim, Freeman, & Trevena, 2014). In terms of the number games for apps, Apple's iTunes and Google Play both have crossed the magic mark of 1 million apps and several billion app downloads (Appbrain, 2015).

The aim of the study was to analyze weight-loss-oriented apps for content, as well as their features, to determine their strengths and weaknesses with regard to information credibility and adherence to recognized national health guidelines. The study identifies shortcomings and suggests recommendations to improve efficiency, interactivity, content, user engagement, and overall credibility of health information.

Findings from the study are expected to benefit and influence policy makers and app designers with regard to weight-loss app content and regulation. A content analysis of popular, free weight-loss apps with regard to adherence to evidence-informed practices and National Institute of Health (NIH) clinical guidelines for treating overweight and obesity, interactivity, quality of health information, and user engagement based on the Transtheoretical Model was undertaken. Popular free weight loss apps available from Apple iTunes (iOS) and Google Play (Android) were considered for this study.

CHAPTER 2

LITERATURE REVIEW

Information Seeking and the Internet

The Internet has dramatically and drastically changed the way people communicate, share information, and acquire knowledge and is rightly considered an information revolution of unprecedented scale in the history of humankind (Jadad & Gagliardi, 1998). A very powerful tool, the Internet has numerous uses, including connecting with and expanding social support networks and keeping updated with all the news and sporting action from around the world. From a health perspective, the capability to use cellular network or broadband to connect from anywhere for health information is significant, and because of this 24/7 connectivity and health information delivery, user data can be tracked, recorded, and shared with servers for storage, retrieval, and diagnosis (Vaidya, Srinivas, Himabindu, & Jumaxanova, 2013).

A PEW study found that 35% of U.S. adults have gone online to learn about medical conditions and followed up with a visit to the hospital for consultation (Fox, 2013). There are many reputable websites that provide health information for various problems, and there are many support groups on almost all chronic diseases and other ailments. Blogs, video logs, podcasts, forums, and subscriptions for RSS (rich site summary) feeds to get alerts and updates on certain health topics are widely available. People make use of these online platforms and participate in online support groups, discuss health concerns, and seek social support from others (Coulson, 2005). Patients feel empowered when they share emotions, read others' experiences in dealing with situations, bond with people who have a similar chronic illness, and acquire information and skills to treat and manage health problems (Barak, Boniel-Nissim, Suler, 2008).

With the ability to access all these features on the go, health consumers are able to address their health issues with confidence (Klasnja and Pratt, 2012).

The Internet is perhaps the world's largest repository of health information (Morahan-Martin, 2004). This is a positive sign, but at the same time, the wealth of information can be confusing and misleading (Skinner et al., 2003). For instance, a Google search for weight loss in March 2015 found about 269,000,000 results in 0.64 seconds (Figure 1). It would be impossible to sort through all this information, and at the same time overload of information can be challenging and confusing (Lee, Hoti, Hughes, and Emmerton, 2014).

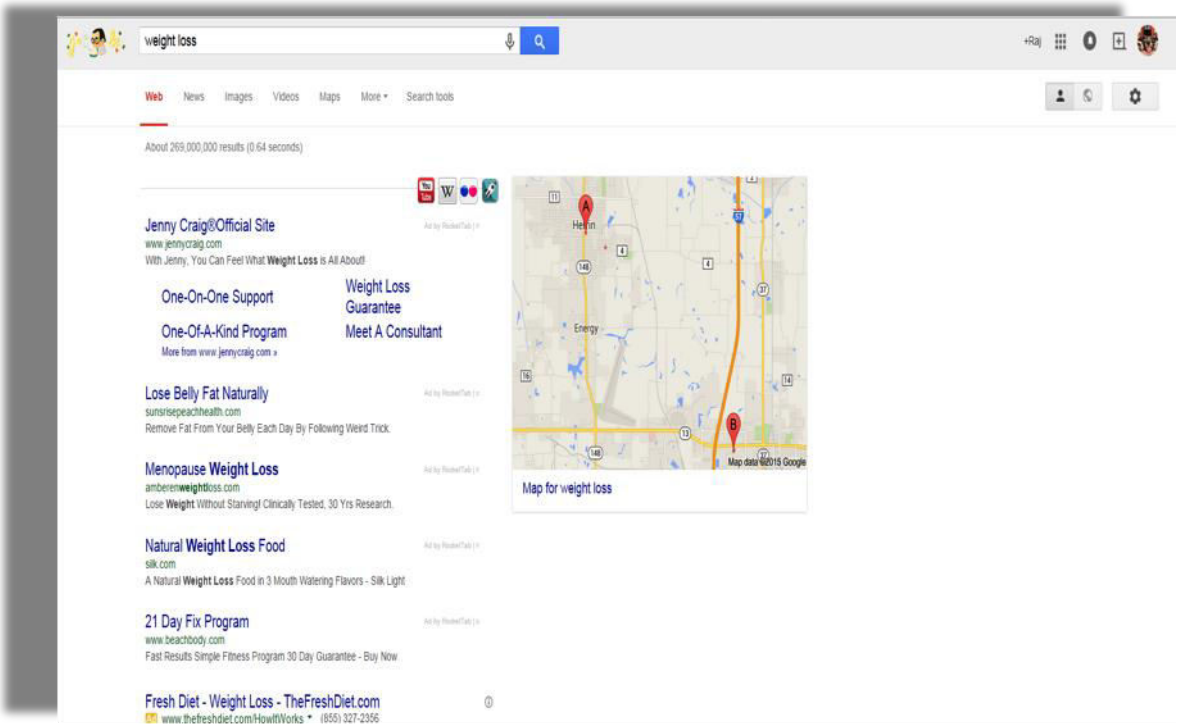

Figure 1 Screenshot of Google website for search query 'weight loss'

Moreover, people who look for information for health on search engines restrict their results to the first two web pages (Berland, Elliott, Morales, Algazy, Kravitz, Broder, & McGlynn, 2001). Thus the ranking of the results in a search is crucial for the visibility of particular information or a condition. Nowadays, most sites are equipped with user-rating and

feedback mechanisms that can instill a sense of confidence in the consumers to use a particular site or a product. The success of sites like eBay can be attributed solely to its feedback feature or reputation system wherein the buyers and sellers can rate and write about their transaction experience (Grant, 2002). A type of rating and review known as "word of web" (WOW), in which consumers communicate their perspectives or views about a certain product or service to another consumer via the web, is important for engaging the users (Weinberg & Davis, 2005). Similarly, in the context of mobile health apps, it can be understood that user feedback is an important factor for increasing the consumer base. But unlike online feedback, reviews for mobile app stores are generally short and based on software versions that are updated constantly (Fu, Lin, Li, Faloutos, Hong, & Sadeh, 2013). Fu et al. also point out that a quick review of the ratings and reviews will give only a rough understanding of some of the merits and concerns raised by the consumers. So the relative ease with which ratings and reviews are understood by the user can be a sign of the product's popularity among users. (Chatterjee, 2001).

Behavior Change and Technology

Various techniques have evolved over the years to motivate behavior change. Traditional methods are usually delivered in face-to-face situations by experts or trained specialists, either individually or in group settings (Lin, Mamykina, Lindtner, Delajoux, & Strub, 2006). Interpersonal communication, also widely known as "word of mouth" (WOM) communication, is regarded as one of the most important and effective communication channels (Keller, 2007). When it comes to health communication campaigns, traditional means of dissemination of information through mass media channels to adopt specific behaviors have proven to be beneficial to an extent, but there is conclusive evidence that traditional health communication has a high rate of failure to promote behavior change (Snyder & Hamilton, 2002). Specifically, the

traditional method of health communication intended for weight-loss-related health behavior is ineffective (Marcus, Owen, Forsyth, Cavill, & Fridinger, 1998). However, in recent years, advanced computing technologies have come to complement and at times replace traditional communication for behavior change (Lin et al., 2006).

One advancement in computing is the development of persuasive technologies (Fogg, 2002) that help people change their routine behaviors to support the lifestyle they desire (Nawyn, Intille, & Larson, 2006). The emergence of the era of the Internet has led to a proliferation of websites designed to persuade or motivate people to change their attitudes and behavior (Fogg, 2002). The accelerated adoption of mobile computing devices that are capable of information transmission (Saroiu & Wolman, 2010) and the concept of context aware computing combination, allows for increased health promotion and preventive care (Intille, 2004). This could pave the way to a new type of just-in-time persuasive interfaces that can motivate behavior change (Intille, Kukla, Farzanfar, & Bakr, 2003). By providing timely information to individuals who face a multitude of choices, mobile computing devices can be helpful in directing the individual's change in behavior (Intille, 2004a). Intille discovered that well-timed delivery of motivational messages in public places could motivate individuals to make healthy choices, such as deciding to use the stairs instead of an escalator. Smartphones are equipped with automated sensors that can be effectively used to deliver personalized messages to promote healthy behavior (Lin et al., 2006). However, users can fabricate their sensor readings data, resulting in "data pollution," and in the process distort the concept of just-in-time persuasive interfaces (Tippenhauer, Rasmussen, Pöpper, & Čapkun, 2009; Saroiu & Wolman, 2010).

There is no short route for lifestyle behavior change. It is a long-term commitment that encompasses all aspects of our life, and the technology should be built around it to ensure its

success (Consolvo, Klasnja, McDonald, Avrahami, Froehlich, LeGrand, & Landay, 2008). We can expect more sophisticated mechanisms through emerging computing technologies to deliver timely health interventions that are tailored for the user, and if this continual advance of technology could be sustained without irritating the users, then desired behavior change is a possibility (Intille, 2004).

Mobile Communication

Mobile phones can be defined as fully functional telephones that do not require a landline connection (Smith, 2010). Mobile phones have become an indispensable and integral part of most societies across the globe (Akinyemi, Atapu, Adetona, & Coker, 2009). Of all the technologies that have been invented, the cellular phone has the greatest penetration in terms of numbers, with 3 billion subscribers (Brouwer & Brito, 2012). The adoption rate of this technology is staggering, and in some developing countries, mobile phone subscriptions have exceeded the size of the population (Kailas, Chia-Chin, Watanabe, 2010). Globally, we are approaching a state in which there is one mobile phone subscription per person (Fjeldsoe, Marshall, & Miller, 2009).

Smartphones

The first smartphone is considered to be the Simon, which was conceived by IBM in 1992 (Terry, 2008), but it was discontinued because mobile web browsing did not even exist at that time, and the cost involved was exorbitant (Dougherty, 2012). The smartphone market took off with the launch of Nokia's Communicator in 1996, followed by the Ericsson R 380, but the real launch of a smartphone with features and capabilities like wireless web browsing, e-mail, calendars, syncing with a computer, and downloading third-party applications happened in 2001 with the launch of the Palm OS Treo (Terry, 2010).

Mobile phones are generally divided between a low-end "cell phone" with basic talk and text features and a high-end "smartphone" with a keyboard (physical or virtual) and high-resolution screen. Smartphones are powerful and have more device capabilities such as access to the Internet and Internet-enabled apps (Allen, Graupera, & Lundrigan, 2010). Smartphones mimic the functionality of computers and come with standard features such as texting, e-mail, and cameras. The computing capability and portability of smartphones have paved the way for ubiquitous information and new channels of interaction. In particular, the smartphone has provided a platform for third-party applications (apps), which have greatly enhanced the functionality and utility of these mobile devices (Holzer and Ondrus, 2011). The use of apps has increased greatly over the past few years, resulting in the creation of numerous apps to serve the manifold needs and interests of users (Melnik, 2011).

Mobile Apps

The average smartphone user in the United States has 22 apps, and entertainment, digital content, games, and health apps are some of the more popular ones (CTIA, 2011). Apps range from business applications like Adobe PDF Reader, MS Office Suite, and mobile banking applications to entertainment software such as music, games, and social networking apps. The smart features of mobile applications have altered the landscape of mobile technology in terms of increasing space, power, and flexibility for the growth of software development (Kuniavsky, 2010).

Applications, or *apps*, have become common household terms, and the term *app* was voted "Word of the Year" by the American Dialect Society in 2010 (Garzon and Poguntke, 2012). The boost in the sales of mobile phones has been attributed to the growing popularity of app usage for offering unique smartphone content and experience (Kenney and Pon, 2011). In a study

by Comscore (2012), the researchers found that mobile subscribers are spending more time with their apps than browsing on the web: 51.1% versus 49.8%, respectively.

Researchers have pointed out that Apple and Google are responsible for laying a strong foundation for the app industry (Goggin, 2011; Allen et al., 2010; Kim, Park, Kim, and Lee, 2014). Ever since the launch of Apple's iOS app store on July 10, 2008, the mobile app market has continued to grow both in numbers as well as in profits (Gartner, 2012). Apple has more than 1 million apps in their iOS app store, and more than 60 billion total apps have been downloaded (Nathan, 2013). The other big player in the app platform market is the Android store, which also has more than a million android apps in its store with more than 50 billion app downloads (Welch, 2013). These are the two powerful players in app distribution at the moment in the world. There are many other players in the app market, and they all use different operating systems to design, produce, and distribute their apps.

Table 1

Smartphone Operating Systems and Languages

OS	Symbian	RIM Blackberry	Apple iOS	Windows Mobile	Android	Palm WebOS
Language	C++	Java	Objective C	C#	Java	Javascript

Table 1 shows the major operating systems that constitute the app market (Allen, Graupera, and Lundrigan, 2010). As of February 2013, Android and Apple iOS have been the dominant platforms in the U.S. market (Ristau, Yang, & White, 2013). Every operating system has a unique native development language, which is an important component for app development. What is developed and tested on one particular platform cannot work on other systems, unless it is developed with the intent of use across multiple platforms (Allen, Graupera,

& Lundrigan, 2010). For instance, the app Effective Weight Loss Guide is a very popular app on the Android store, but it is not available on Apple iOS, thereby restricting users of this app to the Android platform. Anybody with access to tools and expertise can create an app, market it, and distribute it through any of the major smartphone platforms (Suh, Lee, & Park, 2012). This has helped in the creation of thousands of apps across all platforms covering various sectors, including books, music, videos, social networking, banking, travel, and health care (Murray, Liang, Haubl, 2010).

New features are incorporated into smartphones, making people more reliant on their phone for everyday activities (Taylor & Wang, 2010). This dependency and demand created by smartphones and apps is key to the growth and profits for all the stakeholders in the mobile ecosystem (Kim, Kim, Lee, 2014). This includes mobile telephony companies, network operators, device vendors, service providers, content providers, software developers, and so forth. A recent study found that 21% of all European mobile users say that the availability of apps and app stores is an important prerequisite for buying a new mobile handset (Husson & Ask, 2011). There were times when people used to buy phones for the make and model, but nowadays, the features and services that accompany the phone seem to be an important selling point.

Many phones come with preinstalled apps, but users can customize their phones by downloading other free and premium (paid) apps from app stores (Kimbler, 2010). Once an app is downloaded, the individual can make use of it anytime, depending on whether it works with connectivity or without it (Ito, Okabe, Matsuda, 2006). Apps are available for free and usually in English, a few are localized for other languages, and paid apps usually range from $0.99 to less than $10 (Godwin-Jones, 2011).

App Store

The concept of mobile application stores has its origins in Japan and dates back to 1999 with the launch of the Japanese semi-walled garden I-Mode; although it was a resounding success in Japan, the rest of the world failed to catch up (Barnes & Huff, 2003). From zero revenue and jobs in 2008, the app industry has spawned $25 billion in revenue and 466,000 jobs by 2011 (Mandel, 2012). A market analysis company that studies the app economy—Visionmobile—reported that downloads of applications have exceeded 100 billion and have led to the creation of nearly 800,000 jobs in the European Union, attaining revenues of more than 10 billion sterling pounds per annum (Visionmobile, 2013).

The technological framework of mobile applications has three major components: the hardware device (smartphone), the software platform (operating system and base services) that executes the applications, and the mobile application (apps) store. Together they form the mobile ecosystem, where the consumer acts as the nodal agency and creates interaction (Cuadrado & Dueñas, 2012). Developers form the backbone of the app industry, and with basic app design skills anyone can launch an app in any of these platforms (Ooley, Tichawa & Miller, 2014). Apps can be downloaded for free or for a fee from any of the app stores (O'Neill & Brady, 2012). The low entry barriers into the app industry have aided in the design and development of many apps, indicated by the presence of 78% of app developers in small businesses (Godfrey, Reed, & Herndon, 2012). As a result, low-quality apps flood the app market, and the app stores weed out these as well as malicious apps on a regular basis (Perez, 2013). We focused on the two major app stores, Apple iTunes (iOS) and Google Play (Android), for this study.

Apple iTunes (iOS)

Apple Inc. is based in California and is the world's most profitable technology company (Duhigg & Kocieniewski, 2012). It develops, designs, and sells computer software, personal computers, and other electronic devices. The most popular merchandise in this company is the Mac line of computers, iPod music players, iPhone, and the iPad tablet computer (Sin & Yazdanifard, n.d). iTunes was launched by Apple on April 28, 2008, with the aim of establishing a virtual store where people can buy and download digital music (Apple, 2008). Currently, they are the largest digital music vendor in the world (Cusumano, 2013), distributing over 10 billion songs (Harris, n.d). With the introduction of the iPhone in 2007, Apple entered the smartphone market for the first time and carved a niche for themselves (Schultz, Zarnekow, Wulf, & Nguyen, 2011). It was the first smartphone that successfully revolutionized the mobile sector, creating new business models and mobile service delivery for the subscribers (Cripps, 2009). Apple dominated the industry for many years as the world market leader in phone manufacturing (Hinds, Sutton, Barley, Boose, Bailey, Cook, & Tabrizi, 2010). The apps were created by a small army of 43,000 developers, as reported by market analyst AppstoreHQ (Kimbler, 2010). But in 2013, Research Firm Strategy Analytics announced that Apple was pushed to second place by Samsung (Reisinger, 2013).

Google Play (Android)

Google is one of the first companies to understand and tap the capabilities of the Internet and its users to the maximum (Warren, 2008). It has accomplished so much since its foundation in 1998, that no other company can match its phenomenal growth. It entered the app market in 2008 with Android and was considered a strong competitor for Apple, largely owing to its strong subscriber base (Schultz, Zarenekow, Wulf, Nguyen, 2011). The structure of its functioning is

similar to Apple's iPhone mobile ecosystem (Schultz et al., 2011). Apps available on this platform are compatible only with Google handsets and associated vendors (MCEWING, 2012). They have different categories for apps and feature several thousand apps in a wide range of areas, including entertainment, lifestyle, education, personalization, tools, and so forth. According to AppBrain Stats, there are 1,547,966 android applications available as of March 15, 2015, out of which 14% are branded as low-quality apps; of these, 1,338,101 are free and 210,475 are paid (AppBrain, 2015).

Android is the leader in offering free apps, nearly 57% of apps in Android are free, while 28% of apps are free in iOS (Van Den Elzen, 2010). Google's advantage can be attributed to its subscriber base and built-in features like GPS that help in the customized service of location-aware search results (Schultz et al., 2011). Also, Schultz points out that the difference between Google's and Apple's app stores is that Google Play has absolute control over the development of its platform. To maintain uniformity, henceforth only iOS and Android will be mentioned in this study.

mHealth

The advent of personal computers, the Internet, and mobile phones has helped in the innovative and inventive approaches to address the health issues in our society using technology (West, 2013). People are increasingly using mobile technology to monitor their chronic conditions with the help of apps (Ristau, Yang, & White, 2013), and health-care professionals are also tapping their smartphones for crucial health information in clinical practice (Pandey, Hasan, Dubey, & Sarangi, 2013). Online support group intervention has helped individuals to lose weight (Webber, Tate, & Quintiliaini, 2008), and text-messaging interventions have been implemented to facilitate smoking cessation (Obermayer, Riley, Asif, & Jean-Mary, 2004).

Clinicians use mobile apps to monitor heart patients (Scherr, Zweiker, Kollmann, Kastner, Schreier, & Fruhwald, 2006), and patients use apps to track physical activities (Consolvo et., 2008). A growing number of health-care professionals and health consumers depend on technology for various issues, including public policy, research, and service (Adams & Leath, 2008).

eHealth

eHealth is the adopted term that is used to characterize not only "Internet medicine" but also virtually everything related to computers and medicine (Eysenbach, 2001). Electronic health (eHealth) applications refer to software apps that present tools and communication means to establish electronic health-care practices (Liu, Zhu, Holroyd, & Seng, 2011). Eysenbach (2001) goes on to add that eHealth is not just about technological innovation: it is at the crossroads of diverse disciplines that are promoting growth of this society.

He characterizes eHealth as:

> "an emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the Internet and related technologies. In a broader sense, the term characterizes not only a technical development, but also a state of mind, a way of thinking, an attitude, and a commitment for networked, global thinking, to improve health care locally, regionally, and worldwide by using information and communication technology." (Eysenbach, 2001, p. 20)

With the recent growth in the hardware capacity of smartphones, eHealth capabilities are now accessible from mobile platforms, making mobile health (mHealth) applications an important component of eHealth (Liu et al., 2011). *mHealth* is defined as the use of mobile

devices for communicating health information and health services (Akter, D'Ambra, & Ray, 2011). Mobile phone health intervention is considered to be better than eHealth because people access the Internet through cell phones at any time and at any place (Rosen, Sanne, Collier, & Simon, 2005). Also, fewer skills are needed to use the features of mobile phones than those needed for computers or the Internet (Kaplan, 2006). The mobile platform is sought for health intervention because of its portability, economical feasibility, powerful technical capabilities (Rainie, 2010), the existing dependency on mobile phones (Venta, Isomursu, Ahtinen, & Ramiah, 2008), and context-aware sensing features for timely health interventions (Intille, 2004).

The United Nations Foundation in its report on mobile health grouped the usefulness of mHealth in six categories:

i. Education, awareness, and health promotion
ii. Diagnostic and treatment support
iii. Communication and training for health care workers
iv. Disease and epidemic outbreak tracking
v. Remote monitoring
vi. Data collection (Vital Wave Consulting, 2009)

mHealth programs and initiatives are implemented in many parts of the world. Text messaging programs, in particular, are popular both in developed countries such as the United Kingdom, Norway, and New Zealand (Whittaker, Borland, Bullen, Lin, McRobbie, & Rodgers, 2009) and developing countries like India, South Africa, Uganda, Peru, and Rwanda (Vital Wave Consulting, 2009). Text messaging interventions have shown effective health behavior change in the areas of smoking cessation, weight loss, diabetes management, and physical activity (Whittaker et al., 2009; Cole-Lewis & Kershaw, 2010). Unlike text messaging, the use of

smartphone apps for health promotion appears to be rare in developing countries, because of the low penetration of smartphones (Yadav, Naik, Singh, Singh, & Chandra, 2012). Despite its wide use and appeal, phone intervention is still not ubiquitous on a global scale because of limited access to smartphones by people living in remote parts of the world, the elderly, and the poor (Lenhart, 2010).

In a study evaluating the role of mobile health technology, the authors predict that mobile health will have a significant impact in the delivery of health care:

> Creative use of new mobile health information and sensing technologies (mHealth) has the potential to reduce the cost of health care and improve health research and outcomes. These technologies can support continuous health monitoring at both the individual and population level, encourage healthy behaviors to prevent or reduce health problems, support chronic disease self-management, enhance provider knowledge, reduce the number of healthcare visits, and provide personalized, localized, and on-demand interventions in ways previously unimaginable. (Kumar, Nilsen, Abernethy, Atienza, Patrick, Pavel, & Swendeman, 2013, p. 232)

There are many studies that have evaluated web-based electronic health apps, but the evaluation of mHealth apps has been minimal (Brown, Chetty, Grimes, & Harmon, 2013). Researchers who have assessed and evaluated mobile health technology suggest that mHealth is promising and has great potential to improve health care and health education for the public (Liu et al., 2011), but health interventions must be appropriately designed and tested for target users (Wolf, Akilov, Patton, English, Ho, & Ferris, 2013). Studies have also shown that many apps had problems like small text, poor color contrast, and connectivity issues (Brown et al., 2013; Boulos, Wheeler, Tavares, & Jones, 2011). In a startling find, a study points out that 95% of

mobile health apps for consumers are not created on thorough research or properly tested for quality assurance (Bryant, 2012). The present state of mHealth apps highlights the need to gear up research in this field (Krishna, Boren, & Balas, 2009) and encourage IT designers to enhance usability and focus on evidence-based content in their apps for better engagement and credible health outcomes.

Technologies Shaping mHealth Apps

Recent innovations in the field of technology are boosting the functionality and performance of smartphone features (Patrick, Griswold, Raab, & Intille, 2008). However, not all mobile phones are designed to perform the same way: basic cell phones are used for calls and text messaging, while smartphones have third-party applications, sensors, Bluetooth, and wireless connectivity that increase their functionality (Klasnja & Pratt, 2011).

SMS, or text messaging, is widely used in developing as well as developed countries (ITU, 2010), and an estimated 98% of cell phones have texting capabilities. Texting is a short form of communication that can be transmitted between any mobile phone and is limited to 160 characters (Cole-Lewis & Kershaw, 2010). Given its global reach, texting is one of the most easily accepted technologies and the best platform to deliver all kinds of health intervention (Klasnja & Pratt, 2012).

Text messaging applications for health promotion send out texts to the target group that provide health information and tips, reminders for behavior change, and advice (Abroms & Padmanabhan, 2012). Since text messages can be sent back and forth, they provide an easy way to log health-related activities and record physiological parameters (Anhøj & Møldrup, 2004). SMS interventions have been successfully implemented in both developed countries like the United States through text4baby, a mobile messaging service aimed at prenatal and postnatal

health (Whittaker, Matoff-Stepp, Meehan, Kendrick, Jordan, Stange, Rhee, 2012), and developing countries like Kenya through WelTel Kenya 1, a messaging service that reminds HIV-infected patients to take their medication, requiring a response from the patient within 48 hours (Lester, Ritvo, Mills, Kariri, Karanja, Chung, & Plummer, 2008).

The camera phone does not have a long history, but it is very popular among the general public (Goggin, 2011). The camera is a standard feature on almost all basic mobile handsets, and although its quality is not superior to that of digital cameras, it is very useful in the collection of health-related data (Klasnja & Pratt, 2011). Camera phones can capture pictures or shoot videos that can be viewed on the phone or transmitted to others via the web from a computer or phone (Patrick, Griswold, Raab, Intille, 2008). The storage capacity of camera phones has increased considerably in the past few years (Kelly, Marshall, Badland, Kerr, Oliver, Doherty, & Foster, 2013). Camera phones are currently being used as an alternative to journaling health-related behaviors like food consumption (Brown et al., 2006), and to share with health-care providers information about conditions like skin rashes (Schreier, Hayn, Kastner, Koller, Salmhofer, & Hofmann-Wellenhof, 2008). New innovations such as wearable cameras can be used for measuring sedentary behavior, active travel, and eating behaviors (Gurrin, Qiu, Hughes, Caprani, Doherty, Hodges, & Smeaton, 2013). The disadvantage of using the camera is that sometimes images require more time to process than text messages, and the successful transfer of images depends on variables such as connection speed through either broadband or Wi-Fi, level of battery power, and the processing capability of the phone. In some countries, multimedia messaging is a premium service, and not everyone can afford to subscribe to this service (Goggin & Spurgeon, 2007).

The incorporation of different sensors is attributed to the rapid penetration of smartphones (Saroiu & Wolman, 2010). Most of the smartphone models that have been distributed recently are equipped with sensors such as accelerometers, GPS, proximity sensors, ambient light sensors, microphones, and features that can connect with other devices over Bluetooth (Klasnja & Pratt, 2012). There are many apps that incorporate sensors to monitor, record, and share physical activity: BodyMedia's Sensewear weight-management solution consists of an armband monitor, wrist-mounted display, and a website. Together they track skin temperature and heat flux, and a two-dimensional accelerometer infers energy expenditure to calculate calories burned, step count, sleep duration, and sleep efficiency (Rofey, Hull, Phillips, Vogt, Silk, & Dahl, 2010). These body area networks (BANs) monitor not only fitness activity but also indicators like glucose or oxygenated blood. For example, to check pulse rate and oxygen saturation, an oximeter sensor is attached to the fingers of the patient, and for the ECG measurement electrodes are placed on the chest and arm of the patient (Dokovsky & Van Halteren, 2004). However, an increasing number of mobile phones are released with built-in sensors to avoid the inconvenience of having to wear an external device; for instance, an app uses GPS to track running distance, create maps for exercise routes, and calculate calories burned during a workout (Consolvo et al., 2008). More sensors like fingerprint readers, radiation detectors, water quality sensors, and personal health sensors are expected to hit the market in the future (Saroiu & Wolman, 2010).

Health Apps

The omnipresence of mobile phones powered by Internet connectivity cuts across socioeconomic status, ethnicity, and age groups (Noar & Harrington, 2012; Pagoto, Schneider, Jojic, DeBiasse, & Mann, 2013). Mobile health applications have the potential to be a viable tool

that can easily communicate vital health information to improve health and well-being to its users (Kahn, Yang, & Kahn, 2010). About half of all smartphone owners have used their devices to get health information, and one-fifth of smartphone owners have downloaded and used health apps (Fox, 2012). The Global Mobile Health Trends and Figure Market Report forecasts that there will be 500 million users of health apps out of a total of 1.4 billion smartphone users in 2015 (Ralf, 2010).

A study that was done across all the major app stores found that there were about 6,000 health-related apps; of those, 4,200 were identified as intended for use by patients and consumers, and 1,800 were intended for use by health-care professionals (Dolan, 2010). However, a PEW Internet research study puts the number at 250,000 apps for iPhone, 30,000 for Android, and several thousand for Blackberry (Fox, 2010). Health apps are useful for clinicians and consumers and widely used as reference tools (Dasari, White, & Pateman, 2011; Van Velsen, Beaujean, & van Gemert-Pijnen, 2013; Franko & Tirrell, 2012; Nolan, 2011). Apps help clinicians and health-care professionals to make quick diagnosis decisions with fewer errors, and even manage health records of the patient (Prgomet, Georgiou, & Westbrook, 2009). They also include reminders for appointments, compliance monitors, health questionnaires, and critical access to information at point of care (Van Velsen et al., 2013). Patients use apps for self-management of chronic conditions and patient education (Mosa, Yoo, & Sheets, 2012).

Many health-care systems all over the world have taken note of the growing significance of apps and are shifting toward clinical information systems running on smartphones and mobile devices (Makanjuola, Rao, Hale, Bultitude, Challacombe, & Dasgupta, 2012). Many health organizations have taken a cue from the use of technology and have ventured into the web and app industry by releasing their own range of health services; one such example is the WebMD

Mobile app (Liu et al., 2011). The WebMD website attracts nearly 19.5 million visitors every month (Lefebvre & Bornkessel, 2013), showing the growing desire for health information among the general population.

The powerful built-in features of the smartphones are utilized by developers to design different types of health applications (Klasnja & Pratt, 2012): using the phone's camera to scan food labels and provide nutritional information, using GPS to track running routes and to locate the nearest pharmacy, using Bluetooth to track glucometers and glycemic load over a period of time (Lanzola, Capozzi, D'Annunzio, Ferrari, Bellazzi, & Larizza, 2007), and to store personal health records and share them with health-care professionals (Fox, 2010). Fitness apps can act as pedometers, keep track of workout sessions, and help meet exercise goals, and there are apps that can help identify pills and tablets by color, shape, and markings (DeBenedette, 2013). The number of mobile health apps in the several thousands and downloads in the billions is ample proof that smartphones are increasingly used for health information purposes (Payne, Wharrad, Watts, 2012; Appbrain, 2015).

Despite the widespread use of smartphones for health promotion, there exists very little scholarly literature about their role, reach, usage, and impact (Abroms et al., 2012; Noar & Harrington, 2012). These are legitimate concerns raised by scholars, and they highlight the need to boost the research agenda in the area of mobile health.

Credibility

Credibility of information has been studied in various disciplines, including marketing (Levy & Gvili, 2015), advertising (Kareklas, Muehling & Weber, 2015), political communication (Johnson & Kaye, 2014), and health communication (Schiavo, 2013). It is especially important to study the credibility of health-related apps because of their widespread adoption and use.

Because of the newness of this technology, very little has been studied or researched in the area of credibility.

Scholars and researchers have expressed concern over the credibility of health information available in apps (Rosser & Eccleston, 2011; O'Neill & Brady, 2012). Many of the health apps distributed through smartphone platforms lack authenticity details such as authorship, and references are completely outdated (Buijink, Visse, & Marshall, 2012; Pandey et al., 2013; Haffey, Brady, & Maxwell, 2013). A major worrisome trend is the minimal involvement of health-care professionals in the development and design of health apps. The content of health apps is not always reliable because software experts create and design apps, with little or no knowledge of health issues (O'Neill & Brady, 2012). In a study conducted on smartphone microbiology apps, they found that only 34% of these apps had medical professionals involved in their development (Visvanathan, Hamilton, & Brady, 2012). Another study revealed that 86% of 111 pain management apps had no medical professional involvement (Rosser & Eccleston, 2011). Many other researchers have consistently pointed out that technology companies need to collaborate with health-care professionals in the design and creation of health apps (Lieffers, Vance, & Hanning, 2014). The easy availability of health information through medical apps has led many researchers and health professionals to raise concerns about unregulated content and noncompliance to health guidelines (Lindeque, Franko, & Bhola, 2011; Buijink et al., 2012; Aungst, Clauson, Misra, Lewis, & Husain, 2014).

Technology in smartphones allows for medical data of an individual to be collected over extended periods of time and shared with health providers and agencies (Kotz, 2011). Given the possibility of accumulated data, issues of privacy and confidentiality become critical and the user needs to shrewdly control the collection, recording, and dissemination of data, as well as the

access to their data (Kotz, Avancha, & Baxi, 2009). However, issues of privacy do not deter active app enthusiasts from downloading their favorite apps.

Another option that mobile users adopt while installing health apps is the ability to see users' reviews of apps, which provide feedback on what one can expect while using a particular app (O'Neill & Brady, 2012). However, reviews can be manipulated because of their anonymity and can be misleading (Aungst et al., 2014). Consumers pay particular attention to the source of the apps because their perception of the credibility of information, especially in fitness apps, is based on the reputation of the source (Yoganathan & Kajanan, 2014). Providing a credible source in the field of health care is an important aspect of usage intention (Lanseng & Andreason, 2007). However, the role of health-care professionals in the design and development of health apps is very limited, leaving the space wide open for amateur app developers (Rosser & Eccleston, 2011).

Within the largely unregulated app market, there are organizations funding apps that encourage harmful health behaviors such as smoking or that promote illicit drugs (Bindhim, Freeman, & Trevena, 2014). There are instances of malicious apps disguised as popular apps that provide false information in the metadata, and some users may inadvertently install a virus (Forte, Coskun, Shen, Murynets, Bickford, Istomin, & Wang, 2012). While technology enables ready access to instantaneous information, the same technology can be misused to exploit unaware users. Hogan and Kerin (2012), in their letter to the editor of the journal *Patient Center and Counseling*, write,

"Medical application developers and providers will not be deterred by small case series reporting inaccuracy of their apps or by administrative bodies threatening regulation which it does not have the manpower to efficiently execute" (p. 360). While there are many health

agencies and authorities in place to help people, a small army of amateur app designers are in charge of recommending health apps for the masses. Unless inaccurate information manifests into disastrous consequences by users, concerned authorities will be hesitant to pursue this issue. For instance, a GPS app may show us the wrong route, but one can eventually find an alternative route; errors in medical or health apps can have far more serious consequences. The number of health and fitness apps is on the rise, but the number of health-care professionals involved in their design and development is going down, and the importance of this trend cannot be underestimated or ignored (Rosser & Eccleston, 2011).

The numbers may seem to favor the app industry; however, a Consumer Health Information Corporation survey done in 2011 found out that health applications have a high dropout rate, with 26% of apps used only once, and 74% of apps discontinued by the tenth use (CHIC, 2011). In a study done by the IMS Institute for Healthcare Informatics, researchers reported that more than 50% of health apps had fewer than 500 downloads, and only 5% of apps accounted for all the downloads in the category of health (Munro, 2013). Apple iOS and Google Play app stores may boast of several thousand health apps and millions of users downloading from their platform, but the quality of many of these apps is limited (Robustillo Cortés, Cantudo Cuenca, Morillo Verdugo, & Calvo Cidoncha, 2014).

Research on Mobile Health Apps

Mobile health app industry is still in its infancy, there is not much scholarly literature on the analysis of the quality of apps (Hasman, 2011). However, the increasing popularity of health apps and usage among clinicians and consumers has resulted in elevated interest among scholars and researchers interested in studying the impact of apps on health management. Their studies fall under the multiple, overlapping areas of communication, health, health informatics, computer

science, technology, psychology, and clinical psychology. This literature review is limited to research relevant to this study.

Health apps focus on a range of uses, from treating simple conditions like migraines to chronic conditions and various specialties. Studies include topics such as migraines (Liu et al., 2011), ankle sprain (Van Reijen, Vriend, Zuidema, van Mechelen, & Verhagen, 2014), pain management (Rosser & Eccleston, 2011), first aid (Thygerson, West, Rassbach, & Thygerson, 2010), diabetes (Arnhold, Quade, & Kirch, 2014; Ristau et al., 2013), cancer (Bender, Yue, To, Deacken, & Jadad, 2013; Pandey et al., 2013), weight loss (Breton, Fuemmler, & Abroms, 2011; Pagoto, Schneider, Jojic, DeBiasse, & Mann, 2013; Azar, Lesser, Laing, Stephens, Aurora, Burke, Palaniappan, 2013), asthma (Huckvale, Car, Morrison,& Car, 2012), orthopedics (Lindeque et al., 2011), colorectal cancer (O'Neill & Brady, 2012), pediatric obesity (Schoffman, Turner-McGrievy, Jones, & Wilcox, 2013), hypnosis (Sucala, Schnur, Glazier, Miller, Green, & Montgomery, 2013), nutrition (Wang, 2013), orthodontics (Singh, 2013), urology (Makanjuola et al., 2012), and smoking cessation (Abroms et al., 2011; Choi, Noh, & Park, 2014), among many others.

One of the most important studies cited in many of the scholarly articles on mobile applications is the series of the PEW Internet studies, which provides a comprehensive view on the trends of the Internet and its impact on the life of Americans over the last decade. In one of their recent studies, the Pew report states that 72% of Internet users searched online for health information (Fox & Duggan, 2013), and 31% of cell phone users and 52% of smartphone users used their phone for health information (Fox & Duggan, 2012). Nineteen percent of smartphone owners have downloaded an app specifically to track or manage health (Fox, 2012). Despite the rate of adoption of mobile phones across the world and their success in health intervention (Kahn

et al., 2010), very little is known about the utility of smartphones for health (Noar & Harrington, 2012).

Obesity

In 2014, a staggering 2.1 billion or 30% of people globally were either obese or overweight (Dunham, 2014). These figures are based on research compiled using data covering 188 nations stretching more than three decades. The United States has the largest population of obese people, followed closely by China and India. Obesity has been often termed an "epidemic" (Young & Nestle, 2002), a "plague" (Lara, Kothari & Sugerman, 2005), and a "national crisis" (Klein, 2004). Studies in the medical field have shown that excess weight is a leading predictor of heart disease and diabetes, and it even may lead to cardiac arrests (Must, Spadano, Coakley, Field, Colditz, & Dietz, 1999).

Obesity is usually defined by an indirect measure of body fat, the body mass index (BMI) that is based on the height and weight of an individual (Noel & Pugh, 2002). Many international organizations and health agencies like the National Institute of Health (NIH) have established a set of guidelines for classifying weight based on body mass index (NHLBI, 2002). BMI can be calculated by (weight/height^2) (Lean, Han, & Morrison, 1995). Individuals with BMI scores of more than 30 are considered obese, between 25.0 and 29.9 are considered overweight, and a score between 18.5 and 24.9 are considered lean (Klein, Allison, Heymsfield, Kelley, Leibel, Nonas, & Kahn, 2007). However, BMI is not a perfect indicator of the distribution of body fat and the presence of adipose tissue in the body (NHLBI, 2002).

Studies have disputed the efficacy of the BMI measurement, claiming that it's not applicable in certain populations. In a study of overweight Asians in North India, they found that BMI does not accurately predict overweight (Dudeja, Misra, Pandey, Devina, Kumar, & Vikram,

2001; Poirier, 2007). However, Klein et al. (2007) comment that "BMI has become the 'gold standard' for identifying patients at increased risk of adiposity-related adverse health outcomes" (p.1061).

Obesity, Overweight, and Health Care

Christiaan Barnard, who did the first heart transplant, rightly said in his book, that obesity will be the greatest health problem of the 21st century (Barnard, 2001). The drastic rise in sedentary lifestyles, coupled with modern conveniences and affordable automation, have compounded the issue of obesity and overweight. The increase in the rates of obesity is occurring across all ethnic groups, regardless of age, gender, socioeconomic status, and education level (Flegal, Carroll, Kuczmarski, & Johnson, 1998). Obesity is responsible for at least 300,000 premature deaths and almost $90 billion in direct health care expenditures every year in the United States (Manson, Skerrett, Greenland, & VanItallie, 2004).

In a recent Gallup poll brief, the state of Mississippi topped the list with the highest rate of obesity, while Montana had the lowest. According to Levy, "three in 10 adults were obese in 11 states—Mississippi, West Virginia, Delaware, Louisiana, Arkansas, South Carolina, Tennessee, Ohio, Kentucky, Oklahoma, & Alaska—compared with only five states in 2012. Those living in the 10 most obese states are more likely to report chronic diseases" (Levy, 2014, p.1).

The alarming rise in the number of obese people has concerned health authorities and medical professionals. The American Medical Association (AMA), the nation's largest physicians' organization, took a step further when it announced that obesity is a disease in June 2013 (Chriqui, Economos, Henderson, Kohl III, Kumanyika, & Ward, 2014; Jarris, 2013). This

move to recognize obesity as a chronic disease generated a lot of media attention and discussion among the medical fraternity.

Further, in the United States, there has been an alarming 30% rate of increase in obesity since 1987, and the widening health risks are not economically sustainable (Mokdad, Ford, Bowman, Nelson, Engelau, Vinicor, & Marks, 2000). In 2008, for instance, overall medical care costs related to obesity for U.S. adults were estimated to be as high as $147 billion. People who were obese had medical costs that were $1,429 higher than the cost for people of normal body weight (CDC, 2011). Overweight and obesity affects not only the health of individuals but also the financial health of the country (Ogden, 2012). To address this problem, many programs and initiatives have been implemented all over the country by government and nongovernmental organizations to lighten the burden of obesity and overweight, such as the Heroes project for childhood obesity (King, Lederer, Sovinski, Knoblock, Meade, Seo, & Kim, 2014), an Internet-based walking program for obese adults (Zulman, Damschroder, Smith, Resnick, Sen, Krupka, & Richardson, C.R. 2013), and Communities Putting Prevention to Work (CPPW), which pumped more than $300 million into 50 communities to tackle the prevalence of chronic diseases caused by overweight and obesity (Bunnell, O'Neil, Soler, Payne, Giles, Collins, & Bauer, 2012). At the same time, many overweight and obese individuals try to maintain their weight by self-monitoring and eating a low-fat diet (Noel & Pugh, 2002).

In 2011, U.S. consumers spent an estimated $62 billion on weight loss products and services (Singer, 2011). A majority of Americans perceive dietary programs as the most effective methods of losing weight (Saad, 2011). Consumers spend money on a wide range of products and services, including health club memberships, exercise tapes, weight-loss pills, diet sodas, and—despite little evidence in support of their effectiveness—commercial weight-loss

programs. According to the Boston Medical Center, 45 million Americans diet each year and spend about $33 billion on related programs (Singer, 2011; Uzoma, 2011). With the obesity crisis looming large on the horizon and the U.S. health-care system under pressure, the treatment of obese patients is moving away from hospitals toward improving their quality of life at home through self-management (Zhang, 2012). Many people with chronic diseases and conditions are forced to find an alternative within their means to manage their health problems, and obese patients are no exception (Newman, Steed, & Mulligan, 2004).

Weight Loss and Mobile Apps

Computers and the Internet have come in handy for many obese and overweight individuals for easily and anonymously accessing weight management programs (Polzien, Jakicic, Tate, & Otto, 2007). Recent advancements in technology have great potential to deliver effective weight loss programs on a large scale at a reasonable cost (Coons, DeMott, Buscemi, Duncan, Pellegrini, Steglitz, & Spring, 2012). In a meta study conducted by Marcus et al. (2008) to analyze health behavior intervention in scholarly articles, they found that the ones that focused on a combination of traditional and electronic health interventions showed that these intervention affected behavior change. Tate, Wing, & Winnett (2001) in their research concluded that Internet intervention coupled with providing weight loss resources and tailored therapist feedback via e-mail helped people to lose weight significantly more than those who had access to just online weight loss resources. Latner (2001) in his analysis of obesity self-management intervention found that self-help initiatives could be a viable tool to address weight loss. In line with this study, many organizations and individuals have commercialized this self-help strategy to attract people seeking to lose weight (Tufano & Karras, 2005). The concept of self-monitoring is a vital part of altering dietary behavior to help people lose weight, and technology

presents the right platform to improve compliance and efficient self-monitoring (O'Neil, 2001). Just-in-time persuasive messages tailored for an individual can help in making healthy choices. Giving timely tips to shoppers made them switch to healthier choices (Huang, Barzi, Huxley, Denyer, Rohrlach, Jayne, & Neal, 2006). Mobile technologies, with their powerful capabilities and interactive features, can be effectively used to promote a healthy lifestyle and to manage weight (Phillips, Felix, Galli, Patel, & Edwards, 2010; Webb, Joseph, Yardley, & Michie, 2010). But when it comes to health behavior change, mobile interventions are better than Internet interventions because of their compatibility, portability, and unprecedented opportunity for feedback occurring in real time (Patrick et al., 2008).

Kristin Azar and her colleagues conducted a content analysis on weight management applications in iOS and found that all of the 23 apps analyzed found that many of the apps did not incorporate theory to guide behavior change. Their study also found that a few apps, which scored very high in employing behavioral and persuasive technology content, were not ranked among the popular apps by app stores. This assumes significance because the categorization and promotions of popular apps by app stores need not necessarily imply that the apps are theory driven or the best in that category.

There has been a study rise in the use of mobile health apps by clinicians, health-care professionals, and consumers (Dasari, White, & Pateman, 2011; Van Velsen et al., 2013), but the content available in these apps remains totally unregulated or not monitored (Yang, 2014). In a study done by Stevens, Jackson, Howes, & Morgan (2014) on obesity smartphone apps, they found that the majority of weight-loss surgery apps did not involve medical professionals. Nevertheless, studies also suggest that health consumers hardly notice the information about authorship or credibility of the source (Eysenbach & Köhler, 2002). On the contrary, they are

more impressed with the general layout of the design (Fogg, Soohoo, Danielson, Marable, Stanford, Tauber, 2002), showing that an app poor in health content and quality but rich in design and interface can be well received by health consumers.

Sherry Pagoto and her colleagues conducted a study to find evidence-based behavioral weight loss strategies present in weight loss apps both on iPhone and Android platforms. They analyzed 30 apps for 20 behavioral strategies, and the results ranged from 0% to 65% of behavioral strategies of evidence-based weight loss interventions. Ironically, apps with higher ranking for behavioral strategies were from the free apps category (Pagoto et al., 2013). There is a general notion that paid apps are better than free apps, and studies have highlighted that premium apps are more credible and trustworthy than free apps (West et al., 2011). Studies also have shown that adherence to practical guidelines for tobacco cessation is greater for those who use paid apps than those who use free apps (Abroms et al., 2011). However, studies such as the one on microbiology apps on smartphones reported that free apps (63.2%) had more health-care professional involvement than paid apps (58.5%) (Visvanathan et al., 2012); another study found that free calculator apps performed better than paid calculator apps (Terry, 2010). In a study conducted for the presence of 13 evidence-informed practices for weight control in 204 weight loss apps available in iOS, it was found that only 15% of apps had 5 or more of the 13 evidence-informed practices (Breton et al., 2011). Most of the studies mentioned point out that many of the apps for various conditions and programs lack evidence-informed principles in their design and development.

Transtheoretical Model

Individual behavior change has been studied extensively in the field of cognitive and clinical psychology (Brinthaupt & Lipka, 1994). James Prochaska introduced his

Transtheoretical Model (TTM) and stages of change in the early 1980s (Prochaska & DiClemente, 1986). The model clearly explains how individuals address a problem behavior or initiate change to adopt a healthy behavior. This model incorporates a set of independent variables and 10 cognitive and behavior processes of change (Velicer, Prochaska, Fava, Norman, & Redding, 1998). When it comes to modifying health behavior, the TTM is one of the most reliable models (Andrés, Saldaña, & Gómez-Benito, 2009), and it can be a viable option for people to lose their weight (Peterson, 2009). The TTM, also known as "Stages of Change," posits that individual behavior slowly progresses along five distinct stages (Lin et al., 2006). These stages are "pre-contemplation—not intending to take action in the next six months, contemplation—intending to take action in the next six months, preparation—intending to take action in the immediate future or the next month, action—have made specific overt modification in their lifestyles within the past six months, maintenance—working to prevent relapse" (Wells & Gallelli, 2011). A sixth stage, termed "termination," applies to addiction behaviors in which individuals have no more temptation to revert back to the earlier behavior (Prochaska et al., 1992).

Self-efficacy, decisional balance, processes of change, and temptation are the other constructs of the TTM. Self-efficacy "refers to the belief in one's capabilities to perform well in a particular situation" (Bandura, 1982, p. 122). The construct of temptation is the converse of self-efficacy (Velicer et al., 1998), and decisional balance refers to the concept in which a person evaluates the pros and cons related with changing a particular behavior (Steele, Steele, & Cushing, 2012). Self-efficacy and decisional balance form the basis for the assessment of an individual's motivation to change. The final component of the TTM-the 10 processes of change-attempts to explain change through intervention (Paulson, 2011), and it describes whether

environment and experiences influence people to change their behavior (Romain, Attalin, Sultan, Boegner, Gernigon, & Avignon, 2014). These 10 processes of change are very crucial for the development of any health intervention programs because they are the independent variables that individuals that individuals will engage and progress through various stages (Velicer et al., 1998).

Unfortunately, this construct does not get the importance that it deserves in the domain of research (Horwath, 1999). The first five processes are experiential and mainly used for early stage transitions, and the remaining processes are behavioral and used for later stage transitions (Romain et al., 2014). These 10 processes of change are considered to be effective predictors for modifying behavior change in health interventions aimed to promote healthy eating habits, exercise, smoking cessation, and weight management (Prochaska, Norcross, Fowler, Follick, & Abrams, 1992). Weight management interventions based on the processes of change are shown to have proven results (Rossi, Rossi, Rossi-DelPrete, Prochaska, Banspach, & Carleton, 1994), but this significance can be influenced by other constructs such as decisional balance and self-efficacy.

Table 2

Processes of Change

	Stage of change	Process of change	Definition of process
Experiential processes	Pre-contemplation	Consciousness raising	Efforts by the individual to seek new information and to gain understanding and feedback about the problem.
	Pre-contemplation	Dramatic relief	Affective aspects of change, often involving tense emotional experience related to the problem behavior.
	Contemplation	Environmental reevaluation	Consideration and assessment by the individual of how the problem affects the physical and social environments.
Behavioral process	Contemplation	Self-reevaluation	Emotional and cognitive reappraisal of values by the individual with respect to the problem behavior.
	Preparation	Social liberation	Awareness, availability, and acceptance by the individual of alternative problem free lifestyles in society.
	Preparation	Counterconditioning	Substitution of alternative behaviors for the problem behavior.
	Action	Helping relationship	Trusting, accepting, and utilizing the support of caring others during attempts to change the problem behavior.
	Action	Reinforcement management	Changing the contingences that control or maintain the problem behavior.
	Maintenance	Self-liberation	The individual's choice and commitment to change the problem behavior, including the belief that one can change.
	Maintenance	Stimulus control	Control of situation and other causes that trigger the problem behavior.

Note. Adapted from, *Motivating People to be Physically Active* (p. 21), by B. H. Marcus and L. H. Forsyth, 2003, Champaign, IL: Human Kinetics.

For instance, in terms of obesity, the processes of change are consciousness raising (awareness about losing weight), dramatic relief (affective aspect of gaining weight), environmental reevaluation (overweight and impact on the environment), self-reevaluation (emotional and cognitive appraisal of dependence of food attributing to weight gain), social liberation (changing society's outlook of overweight to empathize with their problem), counter conditioning (taking stairs is better than elevator for burning calories), helping relationship (connecting with people who value your weight loss goals), reinforcement management (reward yourself for regular workouts), self-liberation (set goals for weight loss, new year resolutions), and stimulus control (remove chips and sodas out of sight) (Velicer et al., 1998).

The Transtheoretical Model has been criticized by many scholars for its categorization of stages of change. According to Bandura, "a genuine stage has three defining properties: qualitative transformation across stages, invariant sequence of change, and no reversibility, and the TTM violates all these requirements" (Bandura, 1997, p. 412). Questionnaires and the algorithms that the researchers employed to assign the stages of changes for people have not been standardized, compared empirically, or validated (Adams & White, 2005). There are many studies that show strong evidence supporting the TTM and its constructs, but there is also research that criticizes the conceptual framework of this model. This model was conceived only in the late 1970s and is much younger than all the other theories in its genre.

The TTM has been successfully implemented in health intervention programs on topics such as smoking cessation (DiClemente et al., 1991), physical activity (Marshall & Biddle, 2001), high-fat diets, mammography screening, and so on (Prochaska, Norcross, Fowler, Follick, & Abrams, 1992). A study examining self-efficacy and processes of change of the TTM found evidence that the principles of this apply to a diverse group of populations (Rodgers, Courneya,

& Bayduza, 2001). Research has shown that the TTM can be applied in the context of dietary planning for obese and overweight individuals who are expected to lose weight in a short span (Tuah, Amiel, Qureshi, Car, Kaur & Majeed, 2011). In a study done by Johnson, Paiva, Cummins, Johnson, Dyment, Wright & Sherman (2008) with overweight and obese adults, researchers found that TTM-based interventions helped them modify their behavior in terms of healthy eating and improved physical activity, and individuals gradually moved to action and maintenance stages. There has been a significant shift in the numbers of health practitioners to implement the constructs of the TTM in clinical settings for weight management in overweight and obese patients (Andrés, Gómez, & Saldaña, 2007). When the constructs of the TTM have shown effective results in clinical settings, the next obvious step it to try and incorporate these components in the area of mobile technology interventions.

The Health Belief Model (Becker & Rosenstock, 1984), Theory of Planned Behavior (Ajzen & Fishbein, 1970), Theory of Reasoned Action (Ajzen & Fishbein, 1980), Transtheoretical Model (Prochaska & Di-clemente, 1982), and Social Cognitive Theory (Bandura, 1986) are some of the theories that were considered for this study. After much deliberation, the Transtheoretical Model was considered the most appropriate for this study based on the research questions. When it comes to engaging individuals to modify their weight based on the TTM, apps can be designed with the stages of the user in mind.

Contemplation	Tips and advice for weight loss
Preparation	Encouraging them to start weight loss steps by setting specific and achievable goals
Action	Encouraging them to move forward with their current weight loss goals
Maintenance	Incorporate new activities and balancing them to continue

The Transtheoretical Model offers a good framework for conceptualizing the interventions of the weight loss app. The concepts and processes of the TTM will be used to identify the most employed stages of change engagement and user engagement in popular, free weight loss apps available in iOS and Android.

Research Questions

RQ1: What types of weight loss apps are available through Android and iOS?

RQ2: What are the characteristics of popular, free weight loss apps in Android and iOS?

RQ3: How do popular, free weight loss apps make use of interactivity as part their applications?

The distinct feature of computer-mediated communication is "interactivity," and it is considered the key factor of the medium (Morris & Ogan, 1996). There has been a significant rise in the amount of research based on interactivity in the recent past, largely owing to the fact that computers and mobile devices allow users to access and manipulate content in real time and interact at different levels (Papakonstantinou & Brujic-Okretic, 2009). Interactivity in new media can be between users and messages, between users and the gadget, and between senders and receivers (Cho & Leckenby, 1998). This important concept of interactivity has a great potential to influence learning, attitude change, and behavior change (Stout, Villegas, & Kim, 2001). There has been extensive study about interactivity on corporate, news, and health-related websites (Capriotti & Moreno, 2007; Chung, 2007; McMillan, 2002), but very limited or rather none in the area of smartphones and weight loss applications. Interactivity in the context of Web studies focuses on the relationship between the individual and the technology, which encompasses software engineering, hardware, artificial intelligence, cognitive science, sociology, ergonomics, mathematics, and psychology (Booth, 1989).

Interactivity has been defined in many ways, and researchers have developed different interactive models (McMillan, 2002). Heeter (1989) identified six dimensions of interactivity such as audience control, exchange of roles between sender and receiver, speed, information collection, personalization, and sensory engagement. In a study conducted on news websites by Deuze (2003), interactivity is categorized into three types: navigational interactivity, or the ability of an individual to navigate a site using the menus; functional interactivity, the ability to produce content through chat and bulletin board, and to correspond through e-mail; and adaptive interactivity, the ability to adapt to the customization features present in the sites. Steuer's study, "Defining Virtual Reality," expressed the basic idea of interactivity as the extent to which users contribute in altering the form and content of a mediated environment in real time (Steuer, 1992). In this study, we focused on the interactivity tools present in weight loss apps and depended on the study conducted by Witherspoon (2001) and Stout et al., (2001) on interactivity in health-related websites to compile the present coding for interactivity in weight loss apps.

RQ4: To what extent do popular, free weight loss apps use evidence-informed practices issued by the Centers for Disease Control (CDC), Food and Drug Administration (FDA), and U.S. Department of Agriculture (USDA)?

One of the very first studies to evaluate the quality of apps for weight loss (Breton et al., 2011) found that many of the apps do not adhere to evidence-based principles and behavior strategies. The study by Breton et al. (2011) focused on weight loss apps available on iOS in 2009 and used 204 apps, but the present study undertakes popular weight loss apps available in Apple iOS and Android app stores. With thousands of new health apps released on a monthly basis, there have been many updates with interactive features. The large number of new health apps and updates affords an opportunity to study the quality of apps with regard to evidence-

informed practices and determine whether it has changed over time or not. At the dissertation level, there has been no such study, although one study has been done at the Master's level, with a focus on nutrition and fitness apps available on the iPhone (Wang, 2013).

The Centers for Disease Control and Prevention (CDC), United States Food and Drug Administration (FDA), and U.S. Department of Agriculture (USDA) have 13 evidence-informed practices for weight loss. These practices are listed along with the associated app functions.

- Assess one's weight: Does the app provide means to calculate BMI?
- Eat a diet rich in fruits and vegetables: Does the app recommend daily servings?
- Regular physical activity: Does the app recommend amount of physical activity?
- Drink water instead of beverages: Does the app recommend daily servings of water?
- Maintains calorie balance: Does the app allow calculation of calories needed?
- Weight loss of 1 to 2 lbs. a week: Does the app recommend weight loss goals of 1 to 2 lbs. in a week?
- Portion control: Does the app illustrate portion size?
- Nutrition labels: Does the app recommend nutrition label readings?
- Track weight: Does the app provide means to track weight?
- Physical activity journal: Does the app provide a journal to track daily physical activity?
- Plan meals: Does the app recommend ways to plan meals or search recipes?
- Seek social support: Does the app allow users to connect to forums or message boards?
- Keep food diary: Does the app have a food journal entry?

(Breton et al., 2011)

The aim was to find out whether apps incorporated these 13 evidence-based practices for weight loss as part of their design and content.

RQ5: To what extent do popular, free weight loss apps adhere to NIH clinical 10-step guidelines on treating obesity and overweight?

A recent study by Appel, Clark, Yeh, Wang, Coughlin, Daumit, & Brancati (2011) has effectively proved through control trial experiments that clinical weight loss interventions in a primary setting (hospital-based) and a remote setting (website) have been successful. Potentially, the success of remote support for weight loss through health applications can be applied to other chronic conditions (Appel et al., 2011).

The National Institute of Health (NIH) clinical guidelines for weight loss suggest that treatment of overweight or obese persons incorporates a two-step process: assessment and management. The component of assessment includes the assessment of the degree of obesity and overall health, and the component of management involves approaches for weight loss, maintenance of body weight, and measures to control other risk factors (NHLBI, 2002). It includes the 10 steps to treat obesity and overweight in the primary care setting and the three major components of weight loss therapy. In this study, popular, free weight loss apps were analyzed for whether they incorporated the NIH clinical 10-step guidelines for weight loss.

- Height and weight to estimate BMI: Does the app recommend BMI?
- Measure waist circumference: Does the app recommend waist circumference?
- Assess co-morbidities: Does the app assess the history of CVD, diabetes, sleep apnea, etc.?
- Assessment to treat the patients: Does the app have provision of treatment algorithms?
- Is patient ready and motivated: Does the app have evaluation provision for individual readiness to lose weight, previous attempts to lose weight, attitude toward physical activity, time availability, potential barriers, etc.?

- Diet recommendations: Does the app recommend daily diet and calorie consumption?
- Discussing physical activity: Does the app provide information about the pros and cons of physical activity and prod their users to step-by-step approach to work out?
- Review weekly food and activity: Does the app have provision for weekly review?
- Give the patient copies of the dietary information: Does the app have provision to access all the dietary information?
- Enter patient information and reminders: Does the app have provision to keep track of their goals, gentle reminders, and follow up? (NHLBI, 2002)

RQ6: To what extent are the content and quality of health information provided in popular, free weight loss apps credible based on Health on the Net (HON) standards?

One of the most widely used modalities to assess the quality of health information online was developed by HON (Health on the Net), a self-governing body based in Switzerland that promotes eight ethical standards for online health information (Silberg, Lundberg, & Musacchio, 1997; Stout et al., 2001; Boyer, Gaudinat, Baujard, & Geissbuhler, 2007; Boyer, 2013):

- Principle 1: Authority—give qualification of authors
- Principle 2: Complementarity—information to support, not replace
- Principle 3: Confidentiality—respect the privacy of app users
- Principle 4: Attribution—cite the sources and dates of information
- Principle 5: Justifiability—balanced and objective claims
- Principle 6: Transparency—provide valid contact details
- Principle 7: Financial disclosure—details of funding
- Principle 8: Advertising—distinguish editorial from advertising

(Adapted from Boyer et al., 2007)

Many studies have found that health apps are designed and developed by technologists who have no medical expertise, and health-care professional involvement is very minimal in many of the apps (Visvanathan et al., 2012; Stevens et al., 2013). With millions of people having access to health apps, there is a considerable risk of people being misled. Health on the Net (HON) foundation guidelines have been used in the evaluation of many websites since 1995, and this instrument is deemed applicable for other areas in which trust and transparency are key factors, implying that this is a good fit for evaluation of mobile health apps (Boyer et al., 2007).

There are more than 70,000 health-related websites, with traffic close to 50 million people. This is a clear indication that there is a great demand for health information among Internet users, and there is a dire need to address the quality of these sites (Cline & Haynes, 2001). In a study conducted to evaluate the quality of asthma education websites employing HON criteria, researchers found that many of the websites failed to meet the standards. Even more surprising was that even some HON-approved sites did not comply with the standards (Croft & Peterson, 2002). This is a matter of concern because people can be misled by these certifications, thinking that the site content meets quality health standards and is credible; however, the certifications and approval function as only an honor system and are not usually monitored by any agency (Eysenbach, 2002).

RQ7: What user engagement and stages of change as identified by the Transtheoretical Model are most frequently used in popular, free weight loss apps?

The easy availability of information made possible by technological innovations is a great tool for patient engagement. There seems to be very little literature about the need to address health concerns or behavior offered by current mobile health applications. In a recent study on exercise apps available for the iPhone (Cowan, Van Wagenen, Brown, Hedin, Seino-Stephan,

Hall, & West, 2012), researchers found that very few apps employed theoretical frameworks in their design, and the majority of the app developers had no prior knowledge in the field of health education and promotion. Apps that are based on a sound theoretical framework hold great potential to address health behavior change. Azar et al. (2013) found that weight management apps in iOS had very few theory-based health interventions in their designs. Exercise and calorie calculation apps were the most popular apps in the category of health and fitness in iOS, and self-monitoring and progress tracking seemed to be the most common mode of user engagement (Sama, Eapen, Weinfurt, Shah, & Schulman, 2014).

In this study, we wanted to identify the most common stages of change and user engagement found in popular, free weight loss applications on both iOS and Android based on the Transtheoretical Model. The stages of change were conceptualized as follows: the stage of contemplation—apps that give tips and advice about weight loss; preparation—apps that encourage the individual to set specific goals; action—apps that encourage the user to pursue weight loss goals; and maintenance—apps that incorporate new regimens and help to continue routine activities. There were 10 processes of changes, including covert and overt activities that people utilize to progress through the six stages. We conceptualized these processes as consciousness raising, changing personal environment, facilitation of social support, setting goals, tracking progress, reinforcement tracking, self-monitoring, social presentation or announcement. This study adapted the instrument designed by Sama et al. (2014) to evaluate mobile health app tools. The aim was to find the most common user engagement among popular, free weight loss apps.

RQ8: What proportions of popular, free weight loss apps are subject to FDA regulation and oversight?

The surge in the use of health apps and the potential of smartphones to function as medical devices prompted the FDA to issue guidelines concerning the regulation of mobile medical applications in September 2013 (Mobile Medical Applications, 2013). The FDA is very receptive to the idea of using mobile health applications to deliver health care, and toward that end, they want to streamline the entire process of app content and delivery. Apps that have the ability to transform the smartphone into a medical device using built-in sensors and features will come under the scrutiny of the FDA, and the ability of these apps to display, transfer, and store health data will also warrant FDA oversight (MMA, 2013).

The report also mentions that the FDA intends to exercise enforcement discretion to apps that pose minimal risk to patients and consumers, leaving speculation that they might take action and don't expect manufacturers to submit premarket review applications or to register and list their apps with the FDA. This includes apps that help patients self-manage their disease or condition, track their health information, and so forth (MMA, 2013). This implies that the majority of the apps in the Health & Fitness category will fall under this section, but app developers don't have to necessarily register with the FDA for review.

On the other hand, the FDA has cleared only about 100 mobile medical apps over the course of the past 10 years, and about 40 apps were approved in the past 2 years (Dolan, 2010). The decision to exercise enforcement discretion is a prudent move, given the history of the FDA's app clearance, but it also leads to speculation that erring app developers can face serious consequences. The availability of health apps on various platforms and the open nature of accessibility is a welcome sign, but at the same time, adherence to the guidelines and authority

can ensure the safety of app users. The FDA has categorized apps into three main categories. The study attempted to find weight loss apps that warrant FDA regulation or oversight.

Category 1: Apps intended to be utilized as reference materials and are not intended for use in the diagnosis of disease or other conditions

Category 2: Apps that help patients self-manage their disease or conditions without providing specific treatment or treatment suggestions; provide patients with simple tools to organize and track their health information

Category 3: Apps that are an extension of one or more medical devices by connecting to such devices and ability to display, store, analyze, transmit patient medical data, or suggest treatment options

(West, 2013)

CHAPTER 3

METHOD

In order to address the eight research questions, a quantitative content analysis was conducted on popular, free weight loss applications available in iOS and Android app stores. "Content analysis is a method of analyzing written, verbal, or visual communication messages" (Elo & Kyngäs, 2008, p. 107). In earlier days, it was used as a technique to analyze hymns, newspapers, and magazines. Content analysis can be defined as "a systematic and objective means of describing and quantifying phenomena" (Krippendorf, 1980; Sandelowski, 1995). It can be used to increase the understanding of the significance of communication (Cavanagh, 1997). It is a method that is growing in popularity in the domain of the Internet and the World Wide Web (Bar-Ilan & Echermane, 2005) and is used in different fields such as psychology, journalism, and consumer behavior. It is also widely used in the field of health, especially in nursing, gerontology, and health care (Elo & Kyngäs, 2008). Content analysis has been done on health-related issues like the unregulated promotion of smoking on the web (Hong & Cody, 2002), emergency contraception (Gainer, Sollet, Ulmann, Levy, & Ulmann, 2003), eating disorders (Tu & Zimmerman, 2000), smoking cessation (Abroms et al., 2011), and weight loss (Azar et al., 2013).

This study was a comparative descriptive assessment of popular, free weight loss applications. This design used content analysis to review and summarize the content of the popular, free weight loss apps available in iOS and Android platforms as of February 2015. The extent to which each app adheres to evidence-informed practices and recognized national health guidelines for weight loss, credibility of health information, and user engagement was analyzed.

Sample

A listing of all popular, free weight loss apps in the Health & Fitness category available was downloaded from iOS and Android and analyzed in February 2015. Only English-language apps were considered for sample selection. The Health & Fitness category in both platforms is a dynamic page, and the ranking of apps continually changes. Care was taken to examine both app platforms simultaneously to ensure that the list remained intact during the time of analysis.

A study done by Breton et al. (2011) states that an app getting listed in the top 20 is a clear sign of its popularity. Within the categories of Health & Fitness in Android and iOS platforms, apps are classified as (a) Top Paid, (b) Top Free, (c), Top Grossing, (d) Top New Paid, and (e) Top New Free. Apps that were featured in the Top Free section in both Android and iOS were retained for sampling purposes. The reason for studying only free apps is that the majority of mobile apps that are downloaded are free (Hearn, 2012). The free concept may be lucrative enough in that people often experiment with the apps and upgrade later to use premium features. The apps listed in the top free apps category change frequently, based on their popularity and the set algorithms that determined their place in the listing.

Initially, a total of 300 apps, 150 from each platform, were downloaded for sample selection. These 300 apps were then examined to check if they mentioned “weight” or “weight loss” or “lose weight” in the description section. Apps that used these terms were retained as part of the sample, and apps that didn’t mention these terms were discarded. Certain apps were common to both iOS and Android platforms. These apps were treated as independent and were subject to be coded separately for each platform. Apps were excluded from the sample when the term *weight* was used within the context of bodybuilding or fitness. Apps that qualified for

sample selection also required stand-alone functionality, which refers to the capability of operation without the aid of another program or upgrade features.

Using the criteria mentioned above, a total of 89 apps were identified from the initial list of 300. Out of this, 40 (45%) apps were designed for iOS platform, 49 (55%) apps were designed for the Android platform, and 14 (15%) apps were common to both platforms.

Procedure

Mobile apps were downloaded to an Apple iPhone 4s (Verizon) 8.1.2 and Samsung Galaxy S3 (Sprint) 4.2.2 device for this project. Apps were downloaded using Wi-Fi connections at the campus of Southern Illinois University Carbondale and not through the telephone carrier networks. The time for apps to download and work using telephone carrier networks and Wi-Fi can significantly differ because of coverage and bandwidth data availability. While there is a large selection of the latest smartphones with high-level capabilities, the phones used for this study were two of the most popular models of smartphones for the Android and iOS platform.

The unit of analysis for this study was popular, free weight loss apps available in the Health & Fitness category of Apple iOS and Google Android. The independent variables in the study are the selected weight loss apps from Apple iOS and Google Android. The dependent variables are the frequencies of the occurrence of the items to assess interactivity, adherence to evidence-informed guidelines and national health guidelines for weight loss, user engagement approach based on the Transtheoretical Model, and the credibility of health information based on the Health on the Net standard.

As mentioned earlier, only apps that mention “weight” or “weight loss” or “lose weight” in the description section were considered for this study. Each app was downloaded, tested, and coded. The instrument for collecting the data was developed based on studies done earlier and

other relevant information gathered from previous studies. This instrument consisted of 65 items that were categorized into two distinct areas: information available on the description section of the app, and information available within the downloaded app.

This instrument has eight research questions that fall in the two distinct areas mentioned. The coding instrument was adapted from previous studies, which are clearly mentioned at the end of each question.

RQ1: What types of weight loss apps are available through Android and Apple iOS (Azar et al., 2013; Abroms et al., 2011)?

RQ2: What are the distinct characteristics of popular, free weight loss apps in Android and Apple iOS (Breton et al., 2011; Abroms et al., 2011)?

RQ3: How do popular, free weight loss apps make use of interactivity as part of their applications (Witherspoon, 2001; Stout et al., 2001)?

RQ4: To what extent do popular, free weight loss apps use evidence-informed practices issued by the CDC, FDA, and USDA (Breton et al., 2011)?

RQ5: To what extent do popular, free weight loss apps adhere to NIH clinical 10-step guidelines on treating obesity and overweight (NHLBI, 2002)?

RQ6: To what extent are the content and quality of health information provided in popular, free weight loss apps credible based on Health on the Net (HON) standards (Boyer et al., 2007)?

RQ7: What user engagement and stages of change, as identified by the Transtheoretical Model, are most frequently used in popular, free weight loss apps (Sama et al., 2014)?

RQ8: To what extent are popular, free weight loss apps subject to FDA regulation and oversight (West, 2013)?

Codebook

A coding sheet is the fundamental prerequisite for conducting content analysis (Riffe, 1998). It has been documented in many scholarly articles that the coding sheet must conform to certain criteria. It must be exhaustive and inclusive, meaning that every variable relevant to this study is coded. Care should be taken not to overlap codes in terms of both the definition and meaning. Another important criteria for coding is the need to base it on previous studies. Since the area of mobile app research is still in its early stages, there were not enough studies to use as a base for all the research questions, and so these were supplemented by literature that focused on health communication in general.

A codebook was created based on the available body of research on mobile health apps. The coding instrument depended mostly on studies conducted by Breton et al. (2011), Sama et al. (2014), Stout et al. (2001), Azar et al. (2013), and Abroms et al. (2011). The final codebook consisted of two distinct sections. The first section of the instrument consisted of 15 items to address the first three research questions and deals with the criteria for gathering details to address the types and characteristics of apps. The second section of the instrument consisted of 50 items to address the five research questions and deals with the criteria for gathering details for interactivity, adherence to evidence-informed practices and national health guidelines, credibility of health information, and stages of change and user engagement. The following is a listing of the operational definitions employed for the coding of each item within the codebook.

Focus of the App (RQ1)

App focus was categorized as primary and secondary, based on the emphasis placed on certain topics within the app. The primary focus was defined as the intent of app functionality as mentioned in the first paragraph of the description section. The secondary focus was defined as

the intent of app functionality that is mentioned in subsequent parts of the description section found in the weight loss app. Ten areas of weight loss were identified (Appendix A). The following is a brief listing and was assigned codes 1 to 10.

- Diet or diet tracking: Does the app give dietary information, focus on food, or offer diet tracking?
- Weight tracking or weight loss: Is the app used for losing weight, tracking weight, or information about weight loss?
- Yoga: Is the app used for losing weight through yoga?
- Fitness/Training: Is the app used for losing weight through workout and fitness training?
- Meditation: Is the app used for losing weight through meditation?
- Surgery/pharmacotherapy: Is the app used for losing weight through surgery or diet pills?
- Hypnosis: Is the app used for losing weight through hypnosis?
- Recipes: Is the app used for losing weight by giving recipes for healthy cooking?
- Calculator: Does the app just calculate steps (e.g., pedometer) for losing weight?
- Combination: Does the app have a blend of more than two approaches for weight loss?

Items Defining Interactivity (RQ3)

Interactivity was operationalized as the ability of an individual to communicate with app developers through e-mail, access resources for information regarding the functionality present in the app, connect and chat with other users, and personalized features.

- Was the app developed by a professional health unit or health organization?
- Does the app have links to contact medical professionals?
- Does the app have e-mail links or contacts like telephone or address of app developers?

- Are features of connecting with others using social media platforms present within the app?
- Does the app have instructions or video tutorials?
- Does the app have features to connect with other people using the apps, sending messages, etc.?
- Does the app collect personal health data information of height, weight, and sex?
- Does the app have an online community or discussion board or message postings or newsfeed options?

(Adapted from Witherspoon, 2001; Stout et al., 2001)

Evidence-Informed Practices among Popular Weight Loss Apps (RQ4)

Adherence to 13 evidence-informed practices as laid down by the Centers for Disease Control and Prevention (CDC), the Food and Drug Administration (FDA), and the United States Department of Agriculture (USDA). These 13 practices are common to all the organizations and were developed to address the growing concern of overweight and obesity. The aim was to identify the extent to which popular, free weight loss apps incorporated these features in the app architecture.

- Assess one's weight: Does the app have provisions to calculate BMI?
- Eat a diet rich in fruits and vegetables: Does the app recommend an amount of fruits and vegetables?
- Regular physical activity: Does the app recommend physical activity?
- Drink water: Does the app recommend daily servings of water?
- Maintain calorie balance: Does the app calculate calorie needs of the user based on their height and weight?

- Weight loss of 1 to 2 lbs a week: Does the app recommend weight loss of 1 to 2 lbs a week?
- Portion control: Does the app illustrate portion size to eat?
- Nutrition labels: Does the app have options to scan nutritional label readings?
- Track weight: Does the app have a means of tracking the weight of the user over a period of time or log user weight?
- Physical activity journal: Does the app have provisions to track workout or fitness activity?
- Plan meals: Does the app have features to search for recipes or plan meals?
- Seek social support: Does the app feature the ability to connect with other users through message boards or forums?
- Food diary: Does the app have features to log in food intake?

(Breton et al., 2011)

Adherence Scale for 10 Steps to Weight Loss (RQ5)

The National Heart, Lung, and Blood Institute along with the National Institute of Diabetes and Digestive and Kidney Diseases released the 10 steps to treating overweight and obesity in their clinical guidelines report (NHLBI, 2002). This report provided useful tools like the 10 steps to manage weight based on inputs from various specialty doctors and health experts. The aim was to identify the extent to which popular, free weight loss apps integrated these 10 steps to lose weight.

- Height and weight to estimate BMI: Does the app calculate BMI?
- Measure waist circumference: Does the app calculate waist circumference?

- Assess co-morbidities: Does the app have provisions to assess the history of any diseases or conditions of the user before using weight loss app?
- Assessment to treat the patients: Does the app have provisions to assess the treatment options based on the user information before using weight loss app?
- Is patient ready and motivated: Does the app have provisions to evaluate the readiness of the user to lose weight?
- Diet recommendations: Does the app have provisions to recommend daily intake of food and calorie consumption?
- Discussing physical activity: Does the app have provisions to take a step-by-step approach to working out for losing weight?
- Review weekly food and activity: Does the app have provisions to review the weekly activity of the user's food and fitness activity?
- Give the patient copies of the dietary information: Does the app have provisions to retrieve information about diet and related information for weight loss?
- Enter patient information and reminders: Does the app have provisions to keep track of user goals to lose weight and provide gentle reminders for action?

(NHLBI, 2002)

Credibility of Health Information Based on HON Standards (RQ6)

The credibility of health information provided in popular, free weight loss apps was based on eight principles developed by the Health on the Net Foundation instrument. The extent to which these eight principles were incorporated in the app was examined

- Authority: Are the materials cited given references or due acknowledgments?
- Complementarity: Does the app mention that it cannot replace health professionals completely?
- Confidentiality: Does the app mention that the information of the users will be kept confidential?
- Attribution: Does the app mention the date and source of the content?
- Justifiability: Does the app have balanced and objective claims?
- Transparency: Is the app very clear with regard to revealing information about the developer's contact details?
- Financial disclosure: Does the app give details about the funding of their sponsors?
- Advertising: Does the app distinguish advertising from editorial?

(Boyer et al., 2007; Health on the Net Foundation, 2013)

Engagement Methods of Popular Weight Loss Apps Based on Transtheoretical Model (RQ7)

This study identified the most common forms of user engagement and stages of change found in popular, free weight loss applications on both iOS and Android, based on the Transtheoretical Model. The stages of change and user engagement were conceptualized as follows. This study adapted the instrument designed by Sama et al. (2014)

- Consciousness raising: Does the information provided increase awareness about the causes of obesity, consequences of obesity, and the remedies available to lose weight?
- Changing personal environment: Does the app have provisions to modify the environment to encourage the desired behavior?

- Facilitating social support: Does the app have provisions to connect with like-minded people or with similar conditions to lose weight through online forums or groups?
- Goal setting: Does the app have provisions to set specific goals for losing weight through diet, workout, or activity?
- Progress tracking: Does the app have provisions to assess the individual's progress with regard to reaching their goals over a period of time?
- Reinforcement tracking: Does the app have provisions to help users get reminders based on their information to help them pursue their weight loss goals?
- Self-monitoring: Does the app have provisions to track their behavior with no reference to a specific goal?
- Social presentation or announcement: Does the app have provisions to announce the progress of the users through social media?

Stages of Change

- Contemplation: Does the app provide tips and advice for weight loss?
- Preparation: Does the app encourage users to start weight loss by setting achievable goals?
- Action: Does the app encourage the individual to pursue current weight loss goals?
- Maintenance: Does the app incorporate new regimen and balancing to continue the regimen?
- Combination of stages: Does the app have more than one of the four stages of change?

(Sama et al., 2014)

Categorization of Apps Based on FDA Guidelines (RQ8)

The United States Food and Drug Administration (FDA) issued guidelines concerning the regulation of mobile medical applications in 2015. Based on their guidelines, we used these three categories to examine popular, free weight loss apps that warrants FDA regulation.

- Category 1: Apps that are intended to be utilized as reference materials and are not intended for use in the diagnosis of disease or other conditions. Apps are not subject to FDA scrutiny.
- Category 2: Apps that help patients self-manage their disease or conditions without providing specific treatment or treatment suggestions; provide patients with simple tools to organize and track their health information. Apps may be subject to FDA oversight.
- Category 3: Apps that are an extension of one or more medical devices by connecting to such devices and have the ability to display, store, analyze, transmit patient medical data, or suggest treatment options. Apps are subject to FDA oversight.

(West, 2013)

Inter-Coder Reliability

Inter-coder reliability, also known as inter-coder agreement, is an integral component of content analysis. It represents the extent to which two independent raters arrive at the same coding results in evaluating the characteristics of messages (Lombard, Snyder-Duch, & Bracken, 2002). Neuendorf (2008) analyzed many aspects of inter-coder reliability and found that when the resulting coefficient is equal to or greater than 0.90, the reliability is high, that is, the results are acceptable to all coders; a coefficient of 0.80 implies acceptable reliability, and anything below that indicates great disagreement.

The coding instrument was constructed based on relevant literature and previous studies in the areas of health communication, content analysis, and mobile applications. Before starting the main data collection, four PhD graduate students in science and engineering pretested the instrument. Based on their critique and feedback, the codebook was revised to include language that was unambiguous and clear.

Two coders were trained and assigned for coding Android and iOS separately to ensure inter-coder reliability. They were given the coding and style sheet and trained over multiple sessions for a few weeks between December 2014 and January 2015. They were asked to provide input and feedback for the instrument while coding, which led to further discussions until consensus was reached among the coders. Once the coders agreed on most of the issues that were raised, the coding instrument, including the style sheet, was revised to reflect the changes (Appendix A) for the final version of the instrument.

Eleven apps from Android and 10 apps from iOS platforms were identified and distributed to the coders. The coders individually coded each of these apps. Each rater was given a codebook and a stylesheet with detailed instructions to evaluate. They recorded their data using Excel workbook; this data was later transferred to SPSS. Cohen's Kappa was used to measure inter-coder reliability. The Cohen's Kappa value for coders who analyzed Android apps was 0.960, and it was 0.935 for iOS apps. These results were considered a strong agreement between the raters.

Table 3

Inter-Coder Reliability for iOS apps

Measure of agreement	No.of Cases	Value	Asymp. std Error	Approx.T
Kappa	*590*	*0.935*	*0.014*	*29.650*

Table 4

Inter-Coder Reliability for Android apps

Measure of agreement	No.of Cases	Value	Asymp. std Error	Approx.T
Kappa	*682*	*0.960*	*0.010*	*33.291*

CHAPTER 4

RESULTS

This study analyzed the content of 89 popular, free weight loss apps available through Android and iOS for their general characteristics, focus of the app, adherence to national health guidelines, credibility of information, and user engagement. There were 49 apps from Android, 40 from iOS, and 14 apps that were common to both platforms. However, this study considered the 14 apps found in both platforms as independent apps. The data was entered into SPSS version 21.0 for analysis. Missing data, outliers, and logical checks were performed initially, and then accuracy of the data was ensured by comparing the instrument against the SPSS data. Using the descriptive statistics mode of SPSS, frequencies and percentages were calculated for the categorical variables. This chapter presents the findings of the research questions discussed earlier.

RQ1: What types of weight loss apps are available through Google Android and Apple iOS?

The analysis looked at the primary and secondary foci of weight loss apps. The primary focus was defined as the intent of the app as mentioned in the first paragraph of the description section. The details of this section explain the features present in the app to inform the user about losing weight through diet, fitness, or tracking. The secondary focus was defined as the features that are mentioned in subsequent parts of the description section. Ten areas of weight loss were identified (Appendix A), and each app was categorized for its primary and secondary focus (Table 5).

Table 5

Primary Focus of Weight Loss Apps

Focus	iOS	Android	Total
Diet	25	16	20
Weight loss/tracking	13	14	14
Yoga	3	2	2
Fitness/training	53	53	53
Hypnosis	3	0	1
Recipes	-	1	2
Calculator	5	10	8
Meditation	-	-	-
Combination	-	-	-
None	-	-	-

Note. *N* denotes the percentage of apps.

Of all the weight loss apps analyzed from both Android and iOS platforms, "Fitness/training" topped the primary focus category with 53%, followed by "Diet" with 20%, and "Weight loss/tracking" with 14%. Interestingly, unconventional methods to lose weight like hypnosis and yoga were also featured in the health and fitness category.

Table 6

Secondary Focus of Weight Loss Apps

Focus	iOS	Android	Total
Diet	6	20	15
Weight loss/tracking	27	33	66
Yoga	-	-	-
Fitness/training	5	6	11
Hypnosis	-	-	-
Recipes	-	-	-
Calculator	-	1	2
Meditation	3	-	1
Combination	3	-	1
None	1	2	3

Note. *N* denotes the percentage of apps.

The secondary focus of the app was mainly on “Weight loss/tracking” with 66%, followed by “Diet” with 15%, and “Fitness/training” with 11%.

RQ2: What are the characteristics of popular, free weight loss apps in Google Android and Apple iOS?

The general characteristics present in the 89 popular, free weight loss apps were summarized. This included the number of reviews, star ratings, content ratings, size of the app, rank of the app, updated software, log-in criteria, website link, and privacy policy.

Table 7

Characteristics of Weight Loss Apps

Number of reviews	iOS	Android	Total
<10,000	83	14	53
10,000+	9	11	21
50,000+	-	27	15
100,000+	3	10	7
250,000+	5	2	3
500,000+	-	2	1

Note. *N* denotes the percentage of apps.

User reviews and star-rating features indicate the popularity of an app among users. The provision to rate the experience of their interaction with the app is an effective tool for helping other users to understand the functionality and drawbacks in the application, and it also serves as a positive or negative reference point for new users interested in downloading the app.

From Table 7, it is evident that the majority of the apps (53%) had fewer than 10,000 reviews, followed by 21% of the apps with reviews of between 10,000 and 50,000, and 15% of the apps with reviews of between 50,000 and 100,000.

Table 8

Star Ratings of Weight Loss Apps

Star ratings	iOS	Android	Total
2 Stars	5	-	2
3 Stars	18	14	16
4 Stars	60	84	73
5 Stars	13	-	6

Note. *N* denotes the percentage of apps.

In the category of star ratings, 73% of the apps analyzed had four stars, followed by 16% with three stars, and only 6% had five stars. Five percent of the apps had only two stars. But iOS had five apps that had five-star ratings, whereas none of the apps in Android had five stars. Android featured 41 apps that had four-star ratings, but iOS had only 24 apps with four stars. Both platforms had seven apps with three-star ratings. iOS had two apps with two stars. Two apps from iOS did not have any star rating. It is also interesting to note that an app with practically no stars was listed in the popular category. This implies that iOS has a different set of algorithms for listing apps in their popular category. Table 8 points out that all the Android apps had only three- and four-star ratings, whereas iOS featured apps that were rated in all the star categories.

Table 9

Content Ratings of Weight Loss Apps

Content ratings	iOS	Android	Total
Everyone	83	51	65
Low maturity	5	31	19
Medium maturity	8	18	14
Mature audiences	5	-	2

Note. N denotes the percentage of apps.

From Table 9, it can be inferred that 65% of the total apps that were tested had content that was suitable for everyone, followed by low maturity content with 19%, and medium maturity content with 14%. However, only 2% of the apps were rated as an app with mature content. Even though Android and iOS have different content rating mechanisms, this study ensured that the differences were addressed and were coded appropriately. It was found that 51% of Android apps had content ratings that were suitable for everyone, whereas it was 83% in iOS apps. Low mature content was found in 30% of Android apps, whereas it was only 5% in iOS apps. Medium mature content was found in 18% of Android apps and only 3% in iOS. The concept of branding the apps with mature content helps users to understand whether it is appropriate for them to install the app.

Table 10

Size of Weight Loss Apps

App size	iOS	Android	Total
Less than 20 MB	25	74	52
20+	20	14	17
30+	13	20	16
50+	25	-	11
75+	10	-	5

Note. *N* denotes the percentage of apps.

Table 10 illustrates the size of the applications and reflects the storage capacity needed for an app required to function in a smartphone platform. Most of the apps (52%) had sizes less than 20 MB, and this was followed by apps with 20+, 30+, and 50+ MB size capacities, which were 17%, 16%, and 11%, respectively. However, only 5% of the apps present in iOS had app size capacity greater than 75 MB. It is evident that the majority of the apps in the Android platform tend to take up less space than iOS apps.

Table 11

Last Update of Weight Loss Apps

Last updated	iOS	Android	Total
< 1 month	45	63	55
1–3 months	23	22	23
> 3 months	33	14	23

Note. *N* denotes the percentage of apps.

The reason for incorporating this table was to understand the nature of the update feature present in popular, free weight loss apps. The constant updating of apps helps to address some of the software issues concerning the app. It was found that 55% of apps had very recent updates, and in some cases the update was even greater than six months.

Table 12

Mention of Privacy Policy in Weight Loss Apps

Privacy policy presence	iOS	Android	Total
Yes	90	33	69
No	10	49	32

Note. *N* denotes the percentage of apps.

The above table shows the percentage of apps providing information about privacy policy. From Table 12, it is evident that the majority of the apps mentioned privacy policy. However, mention of privacy policy was high in the iOS platform with 90% of apps, but it was only 51% in Android apps.

Table 13

Presence of Web URL in Weight Loss Apps

Web URL link presence	iOS	Android	Total
Yes	37	45	92
No	-	14	8

Note. *N* denotes the percentage of apps.

Table 13 indicates the percentage of apps providing a link for websites. From this table, it is clear that the majority of the apps had mentioned URL links.

Table 14

Log-in Criteria for Weight Loss Apps

Log-in criteria	iOS	Android	Total
None	35	47	42
Create log-in	23	18	20
Combination	43	35	38

Note. *N* denotes the percentage of apps.

Table 14 illustrates that the option to log into the app without any credentials was the most preferred form of log-in (42%), followed by a combination of e-mail and social media to log in(38%), and the use of only e-mail to login (20%). While 47% of Android apps can be used without any log-in, it was 35% for iOS. In the category of creating e-mail to access an app, iOS had a slightly higher percentage than Android. Twenty-three percent of iOS apps had this feature, compared to 18% for Android apps. For the category of combination of e-mail and social media to access an app, it was 43% for iOS and 35% for Android. The reason for integrating this criterion in the instrument was that log-in methods are employed by app developers to collect relevant information on users. The data can be used to customize the user experience as well as for other, various purposes.

RQ3: How do popular, free weight loss apps make use of interactivity as part of their applications?

This study focused on the interactivity elements present in weight loss apps as identified in the studies done by Witherspoon (2001) and Stout et al. (2001) on health-related websites. Results indicate that users can reach any app developers via e-mail for every weight loss app that was analyzed.

Table 15

Interactive Features in Weight Loss Apps

Features	iOS	Android	Total
Contact details of app	100	100	100
Website of app	100	86	92
Input personal health	75	67	71
Built-in tutorials	33	29	30
Connect with other users	44	27	34
Message boards	35	20	27
Users to connect with	15	18	17
Email of app developers	0	2	12

Note. *N* denotes the percentage of apps.

Table 15 illustrates that apps in Android and iOS gave priority to interactive features by providing the e-mail of app developers and links to the app developer website, and allowing the input of personal health data. All the apps in iOS provided links to the app developers' websites, whereas only 86% of the apps in Android did so. None of the apps in iOS had specific links to medical professionals or health practitioners, but Android featured one app that had provided a means to contact fitness experts. Many Android apps featured phone numbers and physical addresses of app developers, which were completely missing in iOS. This study indicates that popular, free weight loss apps in Android and iOS were not fully incorporating the interactive features. There is much potential to enhance communication between app developers and app users.

RQ4: To what extent do popular, free weight loss apps use evidence-informed practices issued by the CDC, FDA, and USDA?

Research studies have shown that evidence-informed practices are essential for policymakers and health practitioners (Evidence-Based Medicine Working Group, 1992). Collaboration between researchers and policymakers has been fruitful in the development of many useful policies and projects benefitting the community (Innvær, Vist, Trommald, & Oxman, 2002). This study aimed to find the presence of 13 evidence-informed practices in weight loss apps suggested by the CDC, FDA, and USDA.

Table 16

App Design Based on Evidence-Informed Practices

Evidence informed practices	iOS	Android	Total
Track physical activity	60	51	55
Calculation of calories needed	35	45	40
Means to track weight	40	39	39
Apps to connect or forums	45	31	37
Plan meals or search recipes	25	25	25
Nutrition label readings	15	22	19
Has food journal entry	25	22	24
Provision to calculate BMI	10	16	14
Daily water needs	8	14	11
Daily fruit/veg servings	13	10	11
Recommends weight loss goals	5	10	8
Recommends physical activity	8	6	7
Illustrates portion size	3	2	2

Note. *N* denotes the percentage of apps.

Table 16 presents the percentage of evidence-informed practices present in popular, free weight loss apps in Android and iOS. The most common evidence-informed practice was the provision to track physical activity (55%). The next most common strategy included in the apps was calorie balance. Forty-five percent of apps in Android provided "calculation of calories needed," and 35% of iOS apps did so. While 31% of the Android apps had provisions for "users to connect through forums or message boards," 45% of iOS apps had these provisions. Less than 20% of the apps had provisions for BMI calculation, weight loss goals, daily servings of fruits and vegetables, and portion size.

Table 17

Frequency of the Presence of Evidence-Informed Practices

Evidence-informed practices	Frequency	Percent
0	14	15.7
1	17	19.1
2	15	16.9
3	11	12.4
4	13	14.6
5	6	6.7
6	4	4.5
7	3	3.4
8	2	2.2
9	3	3.4
10	1	1.1

Table 17 shows that 16% of weight loss apps did not feature even a single evidence-informed practice in its content. Of the 89 apps analyzed, only one app in Android had 10 evidence-informed practices. However, many of the apps tracked physical activity, calories, and weight. Based on these data, we can conclude that the majority of the weight loss apps do not

incorporate evidence-informed practices as laid down by the CDC, FDA, and USDA, and the majority of apps incorporated features to track physical activity.

RQ5: To what extent do popular, free weight loss apps adhere to NIH clinical 10-step guidelines on treating obesity and overweight?

Obesity is one of the most common, expensive health problems, and it is a key risk factor for many chronic diseases and debilitating conditions (Lau, Douketis, Morrison, Hramiak, Sharma, & Ur, 2007). Few studies have shown that mobile technologies are useful in promoting healthy behavior changes and weight management (Riley, Rivera, Atienza, Nilsen, Allison, & Mermelstein, 2011; Stephens & Allen, 2013). To address this growing obesity crisis, the NHLBI released a practical guide to manage obesity and overweight. Based on input from health professionals and experts, this report provided useful tools, including the 10 steps to lose weight.

Table 18

Adherence to NIH 10-Step Guidelines for Obesity and Weight Loss

Recommendations	iOS	Android	Total
1. Recommends BMI	13	26	15
2. Ideal waist circumference	3	9	5
3. Assesses history	-	3	1
4. Treatment algorithms	-	-	-
5. Evaluations for individual	-	11	5
6. Daily diet and calorie intake	23	29	19
7. Step-by-step for workout	10	6	6
8. Provisions for weekly review	90	63	6
9. Access all dietary information	7	6	5
10. Track goals, gentle reminders	37	37	27

Note. *N* denotes the percentage of apps.

Table 18 presents the percentage of Android and iOS weight loss apps with regard to adherence to the 10 steps to address obesity and weight loss. From the table, it is evident that 26% of Android apps and 13% of iOS apps had provisions for BMI calculation. This study found that only 3% of Android apps and 9% iOS apps had provisions for calculating waist circumference, and there is no "treatment algorithm" feature. However, 29% of Android apps and 23% of iOS apps had provisions for recommending daily diet and calorie consumption. Likewise, 63% of Android and 90% of iOS apps had provisions for weekly review. This was the most common step found in both platforms. Around 6% of Android and 7% of iOS apps had the provision to access all the dietary information. Based on the data, we can conclude that except for the provision of weekly review in apps, the majority of the weight loss applications do not adhere to the NIH clinical 10 steps for treating obesity and overweight.

RQ6: To what extent are the content and quality of health information provided in popular, free weight loss apps credible, based on Health on the Net (HON) standards?

Health on the Net (HON) Foundation guidelines on quality of information have been used in the evaluation of many websites (Health on the Net, 2013), and they are widely used to assess the credibility of online health information. HON promotes eight ethical standards for quality and presentation of online health information (Silberg, Lundberg, & Musacchio, 1997; Stout et al., 2001).

Table 19

Adherence to Credibility Standards

Eight standards	iOS	Android	Total
Names of authors	14	18	16
Replacing health professional	-	13	6
Respect their privacy	71	98	83
Cite the sources and dates	4	-	2
Backed by scientific evidence	-	3	1
Valid contact information	100	100	100
Details of funding	-	-	-
Distinguish advt and editorial	2	-	1

Note. *N* denotes the percentage of apps.

From Table 19, it is evident that only 16% of the apps mentioned the names of the author in the content: 14% in iOS apps and 18% in Android apps. None of the iOS apps mentioned that the app cannot be replaced by health professionals, while 13% of Android apps mentioned that the app cannot replace health professionals. The majority of the apps in both platforms mentioned user privacy. Almost all the apps coded in Android do not cite the sources and dates of medical information and details of funding. However, 4% of the apps in iOS cited sources and dates, while 3% of Android provided content backed by scientific evidence. Only one app in iOS had features such as distinguishing advertising from the editorial content. None of the apps in both platforms mentioned anything about details of funding. However, all the apps analyzed provided valid e-mail details. Based on the data, we can infer that except for providing valid contact details and mention of privacy policy, most of the apps failed to meet Health on the Net Foundation standards for online health information.

RQ7: What user engagement and stages of change as identified by the Transtheoretical Model are most frequently used in weight loss apps?

Many studies done in the field of mobile health have proved that apps are designed with no sound theoretical framework and that many of the app developers had little or no understanding of health evaluated programs (Cowan et al., 2012; Sama et al., 2014). The instrument for this question was adapted from the study done by Sama et al., which was based on the Transtheoretical Model. The Transtheoretical Model posits that an individual behavior progresses through many stages of change (Lin et al., 2006). This study sets out to find the most-used stages of change component and user engagement based on the TTM in weight loss apps (Appendix A).

Table 20

Engagement Methods of Popular Weight Loss Apps Based on Transtheoretical Model

Engagement method	iOS	Android	Total
Awareness of weight loss	-	4	2
Modify the environment	6	2	3
Group or online forum	53	33	38
Facilitates goal setting	61	56	53
Logs the user's progress	78	69	66
Assign reinforcements	42	20	27
Self-monitoring	53	58	51
Announcement via social media	29	29	30

Note. *N* denotes the percentage of apps.

Table 20 shows the percentage of the most-employed engagement methods, based on the Transtheoretical Model. From this it is clear that 4% of Android apps had features for awareness

of weight loss, compared with none of the apps in iOS. While only 33% of Android apps assisted users in creating a group or online forum, 53% of iOS apps did so. In terms of setting up weight loss goals, 56% of Android apps and 62% of iOS apps facilitated the user in setting weight loss goals. This study found that 69% of Android apps and 78% of iOS apps had provisions for tracking the progress of users. There were 29% of apps both in Android and OS that provided announcement via social media. This study found that the provision to log the user progress was the most employed user engagement (66%). Facilitating of goal setting (53%) and self-monitoring (51%) were the other top user engagement methods found among popular weight loss apps based on the Transtheoretical Model.

Table 21

Stages of Change User Engagement

Stages of action	Android	iOS	Total
Contemplation	12	-	7
Preparation	88	100	93

Note. *N* denotes the percentage of apps.

Table 21, based on the Transtheoretical Model, shows the most employed stages of change. This study found that the majority of apps in both platforms incorporated preparation as the most employed stage of change, followed by contemplation.

RQ8: What proportion of popular weight loss apps is subject to FDA regulation and oversight?

The growth and use of smartphones and the dramatic rise in the use of health apps prompted the United States Food and Drug Administration (FDA) to issue guidelines concerning the regulation of mobile medical apps (MMA, 2013). To date, there has been no documented proof or record of anyone that has been harmed because of the use of health apps (Buijink, Visser, & Marshall, 2013). Nevertheless, health authorities do not want to take this risk and have

issued guidelines regarding the regulatory process for mobile medical apps in the United Kingdom and United States. This study aimed to find out whether any weight loss apps warranted FDA certification and were evading the regulatory process (Appendix A).

Table 22

Subject to FDA Guidelines

FDA Guidelines	iOS	Android	Total
Yes	3	-	1
No	5	-	2
Maybe	93	100	97

Note. *N* denotes the percentage of apps.

From Table 22, it is evident that most of the free weight loss apps fall under the "may be subject to FDA regulation" category. We found only one app that is subject to FDA at this time but they have evaded the regulatory process. This study found that Health Mate—Step Tracker and Life Coach, developed by Withings, was the only app that warrants FDA regulation but has slipped the regulatory process.

DISCUSSION

A content analysis of popular, free weight loss applications in iOS and Android available in February 2015 was undertaken to determine their general characteristics and whether they adhere to recognized national health guidelines for weight loss, credibility of health information, interactivity, and user engagement. The coding instrument developed can be divided into two distinct categories: (a) data gathered before the installation of the app and (b) data gathered after installation. The general characteristics of the app such as its ranking, name, name of the developer, number of reviews, star ratings, content rating, size of the app, updates, and contact details of the app developers were retrieved before the installation of the app. Data such as evidence-informed practices based on official guidelines, clinical 10-step guidelines for weight loss, credibility of health information, and user engagement were found after the installation of the app. Understanding this data is vital in analyzing the overall features of an app. This study was guided by eight research questions and was intended to contribute to the emerging research literature on mobile health apps for weight loss.

Based on our criteria, we identified 89 weight loss apps out of 300 popular, free apps from the Health and Fitness category in Android and iOS. Of all the apps analyzed for the study, none of them in both platforms performed well in terms of adherence to evidence-informed practices and nationally recognized guidelines. There is minimal involvement of health professionals in the design and development of weight loss apps, and the majority of apps failed to meet credibility standards for health information.

Focus of Weight Loss Apps

There are many traditional options for people interested in losing weight. Weight loss can be achieved through diet, fitness training, pills, surgery, or through a combination of approaches. This study explored the primary and secondary foci of apps designed for assisting people to lose weight. The coding instrument created had a total of 10 approaches predominantly found in apps for weight loss. All the data gathered were entirely based on the description of the app in the app's description section. A majority of the apps in both platforms had fitness and training as their primary focus (53%), followed by dietary information and food intake (20%) and weight tracking (14%). Earlier studies predominantly focused on popular apps that focused on weight tracking, food intake, and calorie consumption (Breton et al., 2011; Pagoto et al., 2013). Even though many of the apps present a combination of fitness and diet approaches, there is a notable emphasis on physical activity and fitness training. In this study, the top 10 apps in both platforms had fitness and training approaches to weight loss as their primary focus. Fitbit, Runkeeper, Runtastic Pedometer, Workout Trainer, and Noomwalk apps were in the top 10 list in both the platforms. These names indicate that there has been a considerable shift away from dietary approaches toward fitness and physical training approaches. This can be attributed to the availability of built-in sensors and wearable gadgets in smartphones, which allow technology-assisted strategies like computing fitness statistics, monitoring the number of steps taken by an individual, and recording physical activity.

Analysis of the secondary focus of the apps revealed that weight tracking was the predominantly used feature, followed by apps for diet and fitness features. One interesting point in the secondary focus of apps was the presence of the meditation approach for losing weight.

This might be the starting point of incorporating complementary and alternative medicine along with conventional approaches to weight loss within the app architecture.

There were a handful of apps based on yoga, hypnosis, and meditation for weight loss. Daily Yoga Fitness from Android and Daily Yoga were the two yoga apps for losing weight that had four-star ratings. Weight Loss Hypnosis was the only hypnosis app meant for weight loss in this study. Despite the low number of these apps, their presence is noteworthy because it indicates that people are ready to adopt unconventional methods to lose their weight. Even though there is no scientific evidence that complementary and alternative medicine like yoga and hypnosis can contribute to weight loss (Sharpe, Blanck, Williams, Ainsworth, & Conway, 2007), mobile app stores have potentially become platforms for showcasing complementary and alternative medicine via these specialized apps.

Pharmacotherapy is a commonly used approach for weight loss in the traditional clinical setting, and that was the reason for including this approach in the coding sheet. Many people in the United States use pills, drugs, and supplements to lose weight (Blanck, Khan, & Serdula, 2001). Late-night television was a hotbed of faddish weight-loss products, which were promoted especially in infomercials. Pills and supplements with exaggerated claims endorsed by super models are common on the majority of television networks. Sensa which boasted that people could lose weight by sprinkling their product on food; L'Occitane, which claimed that its skin cream could slim the body; and a few other companies that promoted acai berry for weight loss on television are now returning millions of dollars to consumers after the intervention of the Federal Trade Commission for misleading advertisements (FTC, 2014). In contrast, there was not even a single app in either platform that recommended drugs or supplements for weight loss. And although surgery is an effective treatment approach for obese people to lose weight in the

clinical setting (Maggard, Shugarman, Suttorp, Maglione, Sugerman, Livingston, & Shekelle, 2005), none of the apps that were examined focused on surgery as an option. There are many apps available for weight-loss surgery both in Android and iOS, but none of these were found in the popular category of Health & Fitness.

Lose It was the only app in iOS that had multiple types of approaches in its design. Its blend of different weight-loss approaches might be one of the reasons that it is often mentioned in the mainstream media and social media. The ability to convey the essence of app features in an effective and succinct way in the description section is another important factor in app adoption. This study has shown that there has been a considerable shift in the focus of apps toward fitness and training for weight loss and an emerging trend of complementary and alternative medicine approaches in the weight-loss apps category.

Characteristics of Apps

The general characteristics of apps included the number of reviews, star ratings, content ratings, size of the app, rank of the app, software updates, log-in criteria, website link, and privacy policy.

Reviews and feedback by users operate similarly to word-of-mouth communication (Vasa, Hoon, Mouzakis, & Noguchi, 2012); feedback also acts as a point of reference to understand the views of the consumer (Khalid, Shihab, Nagappan, & Hassan, 2014). Feedback is useful for both the community as well as the app developer. For instance, positive feedback enhances the image of an app and motivates others to install it, while negative feedback cautions other users and informs the app developers to address those concerns (Tan & Vasa, 2011). Many users are very hesitant to install apps that crash or have bugs.

In this study, Calorie Counter, developed by MyFitnessPal, was the only app in Android that had close to a million reviews. This number reflects the number of reviews registered for this particular app; however, all those who use the app do not necessarily rate the app or write a review. Reviewers essentially want to share their experiences so that others can benefit from their feedback. At the same time, Calorie Counter in iOS registered 438,744 reviews. This app ranks within the top three apps in both platforms. Even though it would be interesting to analyze these thousands of reviews in depth to understand user experience, such analysis is beyond the scope of this dissertation. Calorie Counter is the only app in both platforms to have such a massive user review base, and this can be attributed to its ability to cater to the needs of people interested in losing weight. In comparison, Lose It has 36,269 user reviews in Android and 354,062 reviews in iOS, showing that this app is more popular with the users of iOS than Android. In data analysis of the same app on both platforms, most of the features remain the same except for content ratings and the weekly recommended weight loss suggestion.

Reviews and star ratings are crucial factors in an app's success (Mudambi & Schuff, 2010). The success of an app can be measured both in terms of influencing the consumer decision to download the app and also in terms of revenue generation. Most of the studies done earlier on mobile apps mention that the star rating is a very clear indicator of the popularity of an app among the users (Cowan et al., 2012; Breton et al., 2011). Interestingly, all of the apps with five stars and two stars were found only in the iOS platform, whereas most of the apps in Android had either four or three stars. Apps like Sworkit Lite Personal Trainer, My Diet Coach Weight Loss Motivation, Fitloss Personal Trainer, Fooducate Healthy Weight Loss, and Daily Workout Free Personal were given five-star ratings in iOS. However, it should be noted that these apps were not among the top 10 apps in iOS, and their reviews numbered fewer than

10,000. Unlike Android, iOS does not mention the number of downloads for a particular app. The only professional health unit to have an app for weight loss was found in iOS, and it was one of the two apps to receive a two-star rating. Calorieking Food Search was the only other app to have a two-star rating in iOS. This is a classic example of how even a professional health organization involved in the design and delivery of apps failed to meet the expectations of the smartphone users who want to lose weight. And yet, apps designed by people with no professional knowledge of health manage to get a higher ranking and star rating. This is the predicament we are faced with in online environments—the ease of use can sideline the quality of the content. Studies have even shown that people don't pay much attention to authorship of the source (Eysenbach & Kohler, 2002), but they pay attention to the design (Fogg et al., 2002).

App developers with no prior knowledge about health intervention are able to create thousands of apps available for mass consumption. To develop apps with so little exposure to health is surprising; at the same time, it is reassuring to know that app developers at least have the potential to produce apps with superior functionality and interface with the input of expert health professionals. The presence of thousands of apps in app stores indicates that there is a considerable demand for health apps. Instead of regulating or enforcing disciplinary action, just guiding app developers to health resources backed by evidence-informed practices would be beneficial. Instead of taking efforts to regulate the app sphere, the time is now to educate app developers to integrate health components in app architecture.

Seventy-three percent of the overall apps had a four-star rating, which is an indication that a considerable number of users are satisfied to an extent with their app experience. Even though this study did not look into the content of the user reviews, a quick glance of the reviews done during the study indicates that they can be quite influential in the user's decision to either

download or not download an app. Illustrating the flip side of technology, in which people misuse it for personal and professional gain, there are instances of many app developers manipulating the system to boost their app's ranking and popularity list (Zhu, Xiong, Ge, & Chen, 2013). Star ratings and user reviews are still considered a reliable estimate of the functionality and usefulness of an app. The data also found that while Android users were keen to use the review platform, iOS users made the most of the star-rating features.

Of the 89 apps analyzed for content ratings, 58 had content that was suitable for everyone. There were only two mature apps from iOS, and there were no mature apps in Android. Apple iOS users are required to enter their password every time they install an app, but there is no such requirement in place for Android apps. The content ratings of apps in both platforms use different methods, but the differences were adapted for this study. For instance, Apple iOS has content ratings that were expressed as "4+, 9+, 12+, 17+," whereas Android content ratings were expressed as "everyone, low maturity, medium maturity, and maturity." The rating for content is done by the app developers and not by app stores (Warner, 2012). While apps in iOS clearly states the content rating on the very first page of the app, Android apps mention the content rating in its "Read More" description section of the app.

Many reviews reflect users' frustration with the apps' consumption of battery life, even though the users like the app content. There could be many reasons for the high levels of power use, but experts say that poorly written apps can account for 30% to 40% of battery drainage (Jha, 2011). There is also extensive research to improve the battery performance for smartphones, by designing mobile devices that consume less energy and perform more (Mittal, Kansal, & Chandra, 2012). So, the intimidating size or storage load of an app can sometimes dissuade users from downloading an app. One of the reasons for including size of the app in the

coding instrument was to determine which platform had apps that were smaller in size. Smaller sized apps takes up less memory space and help reduce consumption of battery power. None of the apps in Android exceeded 50 MB, but 14 apps in iOS exceeded more than 50 MB.

People are very reluctant to share their personal or health information, and they are also very wary about how their information is used by those who collect it (Whiddett, Hunter, Engelbrecht, & Handy, 2006). This study found that 68% of the apps had a privacy policy in place. Of the iOS apps, 90% had their privacy policy mentioned very clearly, whereas only 51% of Android apps mentioned their privacy policy in detail. There was an item termed "permission details" in a few apps in Android; however, this study looked specifically for apps mentioning a privacy policy on their app page. In both platforms, privacy-policy information runs to several pages, and it can take a considerable amount of time to pore over these extensive clauses and details. The legal nature of these clauses and the small fonts on the smartphone display are not conducive to understanding privacy policies. In the future, privacy policies must have a simple layout or pointers regarding their use of personal health information.

In terms of privacy policies, contact details, website links of the apps, and software updates, both Android and iOS had these provisions integrated in the majority of their apps. These general characteristics point out that apps are continually expanding their features, capabilities, and functionalities.

Interactivity in Weight Loss Apps

There has been extensive research on the content of websites and the interactive features present in them (Bucy, Lang, Potter, & Grabe, 1998). To date, very few studies have examined interactive features in mobile apps. This study found that e-mail addresses of the app developers were present in all 89 popular, free weight loss apps of Android and iOS. None of the apps in

iOS mentioned phone numbers of the app developers, but a few of the Android apps included both the physical address as well as phone numbers in their app description section. However, the presence of e-mail does not necessarily imply that there will be communication or a guaranteed reply. It is just a sign or an indication that the developers can be reached for any queries or complaints.

Of the 89 weight loss apps analyzed, with the exception of one app in Android, none offered e-mail links to specific doctors or other health practitioners. There are potential advantages of incorporating e-mail links of health practitioners: users can communicate and remain anonymous, and e-mail allows users a means of clarifying related queries based on their app experience and also to understand health issues. Even the app developed by the only health organization, the Mayo Clinic, did not offer links to connect with their doctors or health professionals. Runkeeper, developed by Fitnesskeeper, Inc. in Android, was the only app to connect their professional trainers with the user. When people are following the recommendations for food and physical activity to lose weight, a mechanism to connect with experts or medical professionals can be a great interactive tool to enhance the image of an app as well as give moral support to the individuals.

The presence of a website link for app developers in iOS was 100%, but only 86% of the app developers in Android had links to their websites. The presence of websites can assist the individual to know more about the app developers and their area of expertise. Apple app developers seem to have their e-mail links and website details readily available for their users.

A traditional approach to any health-related behavior like weight control, smoking cessation, physical activity, and improving nutrition is individual counseling. There is a growing demand to address counseling through tailoring and customization in the field of online health

communication (Kreuter, Farrell, Olevitch, & Brennan, 2013). So, health information that is tailored and relevant to the user is a key factor in ensuring that the app is received well by the user. To understand the tailored interactive component in an app, the study used the input of personal health data as a standard. This study found that 71% of the weight loss apps offered the ability to input user weight and personal details like name, age, and sex. Many apps had features to welcome the user by their first name and options for profile images and avatars to make them feel warm and welcome while using an app.

Even for those familiar with technology, sometimes navigating around an app and learning its functionality can be time consuming or annoying. There are varying degrees of understanding of digital technology, based on users' economic and social background (Hargittai, 2010). The study wanted to look at apps that had the facility for users to understand the app features and functionality through either video tutorials or the frequently-asked-questions (FAQs) menu as an interactive component. We found that only 30% of the apps analyzed had these features incorporated to assist the user. The iOS apps had more of these features, but only slightly more than Android. App developers need to consider expanding this option of tutorials and FAQs so as to ensure that everyone, irrespective of their technical expertise or digital savviness, is able to navigate the various features of the app without any hesitation. Support systems for app issues, navigation, and queries should be integrated into apps. At the same time, this study also observed that many of these interactive features were reserved for premium apps.

Studies have shown that online support groups and friends with similar goals are more likely to achieve their goals together because of motivation factors (Ma, Chen, & Xiao, 2010). This study found that the interactive feature of the ability to connect with other users and friends in apps was only 34%. Only 27% of the total apps had message boards or discussion forums,

and less than 20% of the apps had social media links. With the increasing usage of apps worldwide, connecting users through apps will definitely help in nurturing an online community (Hwang, Ottenbacher, & Lucke, 2011). As of now, there appears to be a big gap in terms of incorporating these features in weight loss apps. App developers need to tap this social network aspect to promote their app for weight loss or any chronic health condition. Features such as a location-based awareness component in an app can connect local users to encourage them to start walking, running, or participating in a sporting activity.

Of the 89 weight loss apps analyzed, only one had a feature that allowed the user to connect with a health expert. Runtastic, developed by Fitness Keeper Inc., was the only app to incorporate the ability to contact their professional trainer. This can be an effective tool for clarifying any doubt or query about the app or the weight loss program. Mayo Clinic Diet, developed by Everyday Health, was the only weight loss app in iOS backed by a health organization, and yet, even this app did not feature the concept of connecting with their health professionals. Even though it has only a two-star rating as of now, there is a lot of space for this app to develop into one of the most popular apps in the Health & Fitness category in the near future. This is also a cue for other health organizations to enter into the field of mobile medical apps, which can benefit their organization as well as the community.

Evidence-Informed Practices

This study found that 16% of the total weight loss apps analyzed did not meet even a single evidence-informed practice listed by the FDA, CDC, and USDA. Tracking physical activity, calculating calories needed, planning meals or searching for recipes, and finding social support through forums were some of the popular evidence-informed practices found in popular, free weight loss apps. Illustration of portion size was found to be the least used evidence-

informed practice. Overall, popular, free weight loss apps do not adhere to evidence-informed practices issued by the FDA, CDC, and USDA.

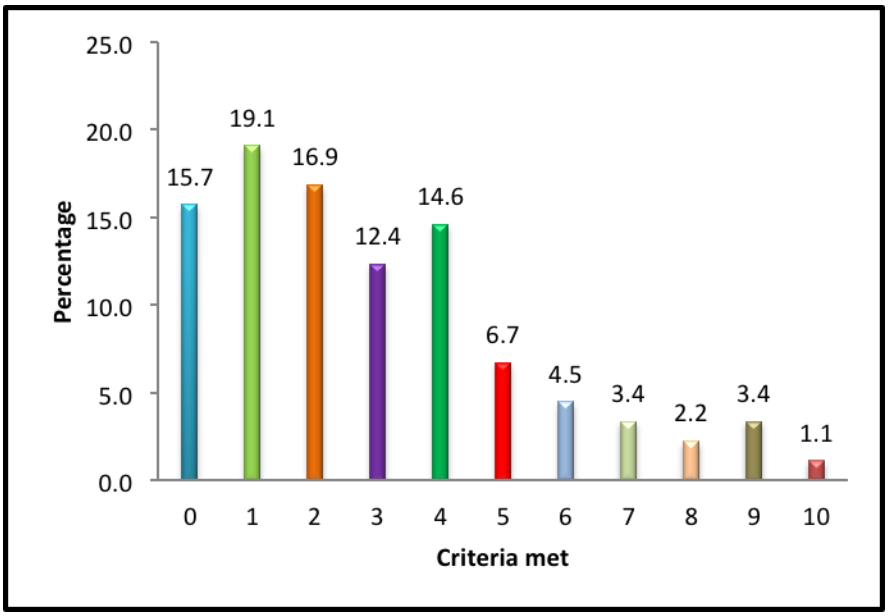

Figure 2 Evidence-informed practices found in weight loss apps

The Android apps Calorie Counter by MyFitnessPal, which is the highest-ranking app in Android, and MyNetdiary Calorie Counter Pro by Mynetdiary.com, and the iOS apps Calorie Counter and Diet Tracker by About.Inc and Calorie Counter and Weight Loss by Sparkpeople had 9 of the 13 evidence-informed practices present in their apps. Calorie Counter by Caloriecounter.com for Android was the only app to have 10 evidence-informed practices. This study found that 60% of the apps analyzed have 4 of the 13 evidence-informed practices integrated in their app design. In the study done by Breton et al. (2011), one or two evidence-informed practices were found in the majority of apps. This is a sign that apps are slowly incorporating some of the evidence-informed practices in app design and development.

An earlier study on free and paid weight loss apps in iPhone by Breton et al. in 2011 found that food journal entry had the highest percentage of evidence-informed practice, and social support was the least found practice. This study found that tracking physical activity in a

journal had the highest percentage of evidence-informed practice, and illustration of portion control was the least found practice. In a span of a few years, apps are now geared more toward fitness and training than diet. At the same time, many of the fitness apps fail to recommend the amount of physical activity that an individual should do. These are some of the areas that app developers can pay attention to when incorporating these simple evidence-informed practices in their app design.

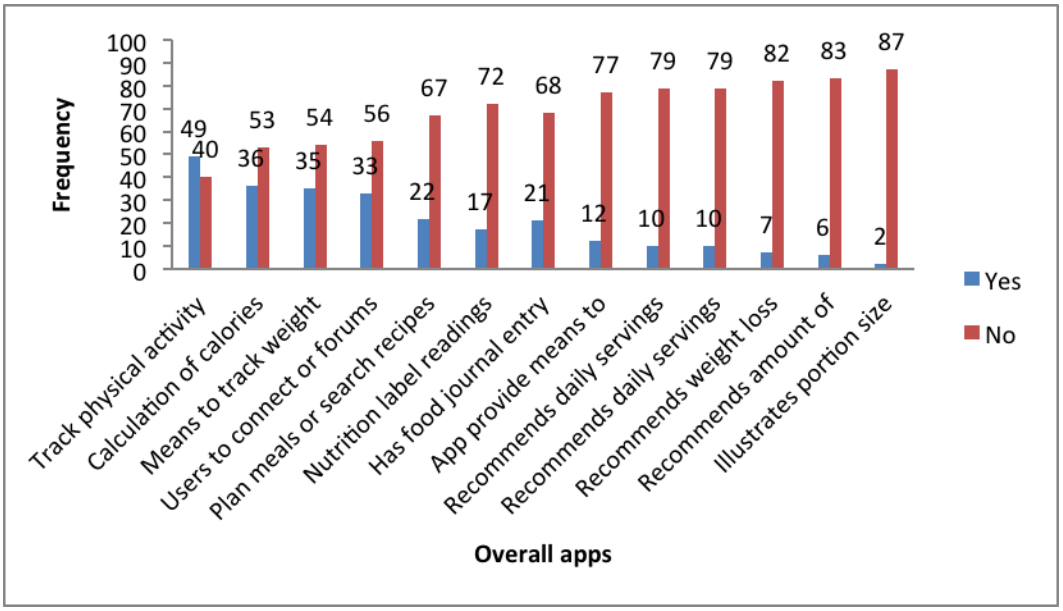

Figure 3 Frequency of 13 evidence-informed practices

Tracking physical activity in the study was categorized as the ability to track physical activity or the presence of a journal in an app. This was the most common evidence-informed practice found among popular, free weight loss apps, and the trend is continuing in the field of mobile weight loss apps. Studies done in the recent past showed that dietary apps were the dominant category in weight loss apps (Azar et al., 2012). Azar et al. analyzed 23 top-rated iOS free weight loss apps and found 12 apps that were categorized as diet apps. This current study has contributed to documenting the emerging trend of fitness-oriented weight loss apps, noting that diet apps have been pushed down to second place as of February 2015. The changes in

trends over a relatively short time period of three years characterize the dynamism of the mobile app landscape. Even while analyzing the Health & Fitness section for weight loss apps, the ranking of apps was fluctuating drastically during that particular period. During this analysis, the study found the highest-ranking app would be either Fitbit or Calorie Counter in both Google Android and Apple iTunes. The ranking list in the Health & Fitness category has a dynamic page and is constantly updated. Nobody knows the ranking system incorporated by these app giants.

Most Americans who want to lose weight understand that consuming fewer calories and less fat is an effective weight loss strategy (Kruger, Galuska, Serudla, & Jones, 2004), which is very much in line with the evidence-informed practice of calculation of calories needed for an individual. In this study, we found that this practice was the second most employed evidence-informed practice, followed closely by means to track weight, and then the provision of users to connect with other users within the app (37%). This is in sharp contrast with the results of Breton et al. (2011), showing that only 3% of apps provided features for social support. Illustration of portion size remained the least found evidence-informed practice out of all the 13 practices across the two platforms. Mayo Clinic Diet and My Diet Coach Weight Loss were the only two apps in Android to illustrate portion size in its app. Even though there have been a few studies done on weight loss apps, no study to date has found all the 13 evidence-informed practices present in any weight loss app. It is also unclear that the effectiveness of these evidence-informed practices in a clinical setting can be transferred to the online environment. This is something current app developers and future scholars should bear in mind as they explore the potential of and research possibilities in this field.

Ten Steps to Watch Weight

The National Heart, Lung, and Blood Institute, along with the National Institute of Diabetes and Digestive and Kidney Diseases, released the 10 steps to treating overweight and obesity in their clinical guidelines report (NHLBI, 2002). This report was done with the contribution and collaboration of multiple health agencies and health practitioners from the field of primary care, and it encompasses the fields of clinical nutrition, exercise psychology, psychology, physiology, and pulmonary disease. This study set out to find the two important components of weight loss: assessment, which encompasses height, weight, BMI, waist circumference, and co-morbidities; and management, which includes treatment algorithms and approaches for weight loss. The study analyzed whether the national clinical 10-step guidelines to treat overweight and obesity are incorporated in weight loss apps available on Android and iOS platforms. There have been very few studies to date with regard to the presence of National Institute of Health (NIH) clinical 10-step guidelines for weight loss in mobile weight loss apps. This study found that the majority of the apps in Android and iOS do not adhere to these guidelines. Weekly review was the only step commonly found across many of the apps in both Android and iOS. Tracking goals and gentle reminders were the next most common features present in many of the weight loss apps. The assessment part remained the most underutilized component in both platforms, and the evaluation step of treatment algorithms was completely missing.

Waist circumference is an indicator of abdominal fat, and people with waist circumferences of more than 35 inches are at a higher risk for diabetes and cardiovascular diseases (NHLBI, 2002). Studies have shown that waist circumference is better than BMI in terms of assessment of health risk (Zhu, Wang, Heshka, Heo, Faith, & Heymsfield, 2002;

NHLBI, 2002). We found that only 4 of the 89 apps analyzed provided a feature for calculation of waist circumference. Fitness Home and Gym Workouts, BMI Calculator for Weight Loss, and My Netdiary Calorie Counter Pro in Android and Fitter Fitness Calculator in iOS were the only apps that featured calculation for waist circumference. The Noom Coach Weight Loss app in Android had a waist circumference recommendation, but it was reserved only for paid users.

Another matter of concern is that although there were numerous apps for physical fitness and training aimed at losing weight, very few of them had a step-by-step approach for workouts. A handful of apps advise the user about the importance of step-by-step approaches toward their weight loss program and training, including Workout Trainer, Dreambody Workout Plan, and 7 Minute Workout from Android, and Fitness Buddy Free Workout and Quick 4 Minute Workout from iOS. Tracking goals and gentle reminders were found in 24 apps out of the 89 apps under study. The reminder function of an app is an important component for persuading individuals to follow up with their weight loss goals. The top four apps in both Android and iOS had a reminder feature integrated in their design. This feature is also subject to personal preference; some individuals might appreciate the constant reminders, while others can be annoyed by them. Calorie Counter, Fitbit, Lose It, and Water Your Body from Android, and Fitbit, Calorie Counter & Diet Tracker, 7 Minute Workout Quick Fit, and Lose It from iOS had provisions for users to track their goals and receive gentle reminders.

Credibility of Health Information in Apps

We looked at eight best practices for credibility of online health information and found that all the apps had integrated a practice of transparency in which app developers were readily accessible, and the majority of apps had the practice of respecting the privacy of users. However, other practices such as listing qualifications of authors, citing the sources and dates of

information, and backing claims with scientific evidence were scored very low. Of the 89 apps analyzed, only 7 in both platforms had authors mentioned in their content. We found that few of the apps mentioned author names in their blogs or articles section. This study found that most of the weight loss apps failed to meet conventional credibility standards.

Previous studies have shown that most mobile health apps lack theory, do not adhere to evidence-informed practices, and have no professional health practitioner involvement (Breton et al., 2011; Sama et al., 2014; Abroms et al., 2011; Visvanathan et al., 2012; Stevens et al., 2013). There has been extensive research on the quality and credibility of health information online and on websites (Pant, Deshmukh, Murugiah, Kumar, Sachdeva, & Mehta, 2012; Corritore, Wiedenbeck, Kracher, & Marble, 2012). However, very little literature focuses on the credibility and quality of health information available on health-related apps. Many scholars have expressed serious concerns about the need to evaluate apps because of their potential to improve public health and delivery of health care (Boudreaux, Waring, Hayes, Sadasivam, Mullen, & Pagoto, 2014). This study is one such attempt, albeit a small one, to fill the need to evaluate apps based on credibility of health information.

Studies have shown that readers like to read articles and blogs that are presented by experts or professionals in their particular field (Winter & Kramer, 2012). It is conceivable that people who want to lose weight can relate better to the information when it's from health professionals. Unfortunately, the majority of apps did not give the qualifications of authors for most of the information in the weight loss apps. Even the app that was developed with input from Mayo Clinic health professionals did not give the authors' qualifications or cite the sources and dates of information. Only two of the total apps analyzed cited the sources and dates of medical information: Fooducate Healthy Weight and MSN Health & Fitness. None of the apps in

iOS attributed the information provided. Especially with regard to health information, the mentioning of dates is important because the relevance of information is crucial, and any outdated information can be misleading and potentially harmful in certain cases (Washington, Fanciullo, Sorensen, & Baird, 2008).

None of the apps in Android specifically mentioned that the weight loss app cannot replace health professionals, but five apps in iOS mentioned that apps exist only as a complement and cannot replace health professionals. None of the apps in Android and iOS provided details about sponsorship or funding of the app. Fooducate was the only app from Android that clearly distinguished its content from advertising. Some of the apps under study had some unsubstantiated and exaggerated claims in terms of helping people lose weight. One Android app—Diet Plan—Weight Loss in 7 Days by Gamebaby—claimed to help people lose 8 kgs or 17.6 pounds in a week. The recommended or suggested weight loss by health organizations is 1–2 lbs per week (NHLBI, 2002), but this app claims to help people lose around 18 lbs in one week. Regardless of the seemingly exaggerated claims, this particular app has more than 100,000 downloads, and 1,473 users rated the app with five stars. A perusal of the review section showed there was no negative feedback except for problems like pop-up ads. Many users claimed that they have lost 18 or 19 pounds within a week by religiously following it. However, health experts warn people to stay away from any diet plan or weight loss program that promises weight loss of more than 3 lbs per week (Zelman, 2008). People want instant gratification, and they are ready to adopt any means, especially those who intend to lose a lot of weight. With the proliferation of the Internet and technology, access to these short-cut diet plans and programs is unrestricted. Unfortunately, many of the users are not aware of the consequences of losing weight in such a short span of time. Judging from the number of

downloads and user ratings, this app has impacted several thousand users. Only an in-depth interview with some of the reviewers of this app as a follow-up can explain the rationale behind their drastic weight loss and long-term impact. If there were a regulatory mechanism in place to ensure the quality and credibility of apps, the apps with exaggerated claims would never get listed in any of the app stores. Unfortunately, with no authorities to check the content, the proliferation of health apps with exaggerated claims is inevitable.

Technologists, app developers, health practitioners and professionals, and app store owners should come together to standardize the content and to ensure the quality and credibility of information presented on mobile app platforms. The thrust and momentum that was applied to evaluate the standards and credibility of online websites for information on health is somewhat absent on mobile applications. Technology has provided a level playing field for anyone with a background in app development to create a product for mass consumption. Although this is a welcome sign, incorporating an app with sound features with health expert interventions in terms of uniformity of content and credibility can increase the likelihood of app adoption and ensure the safety of the users.

Stages of Change and User Engagement

The current analysis aimed to analyze the content of 89 popular, free weight loss apps in Android and iOS for the presence of stages of change and user engagement based on the Transtheoretical Model. The study found that the stage of preparation, defined as encouraging the users to set specific weight goals, was the main stage of change present in popular, free weight loss apps. This was followed by contemplation, in which apps present simple tips and advice for weight loss. Logging the user activity to track progress and self-monitoring were the two most found user engagements in the majority of apps. This finding is very much in line with

the study done by Sama et al. (2012), but the only difference is that this study found tracking the user progress and facilitating goal setting as the dominant user engagement, whereas Sama et al. found self-monitoring and tracking the user progress as the major user engagement. Also, there were multiple user engagement approaches present in many of the apps. The finding of this study has reconfirmed that there is a dearth in the presence of theory-driven components in health apps (Sama et al., 2011; Cowan et al., 2012; Azar et al., 2013).

Pedometer, developed by Pacerworks from Android, and Argus Pedometer, developed by Azumio in iOS, were the apps incorporating most of the user engagement in their app architecture. One of the reasons for the spike in the number of tracking and self-monitoring features is the ubiquitous nature of technology and the availability of built-in sensors. The 24/7 connectivity and simplicity of these tools have drastically changed the process of tracking physical activity without any labor-intensive manual entry.

In our "information age," it is ironic that only 2 out of 89 weight loss apps provided information about the causes of obesity, its consequences, and the remedies available. Dreambody Workout Plan and My Diet Coach were the two apps from Android that had detailed information for weight loss. When all the apps were analyzed for weight loss only two apps were found to have in-depth information that helped in increasing awareness about the importance of losing weight.

Calorieking Foodsearch, Mayo Clinic Diet, Weightwatchers Mobile, 7 Minute Workout, Ideal Weight-BMI, and 7 Minute Workout did not feature even a single user engagement in their design. Even an app designed with health professional input like Mayo Clinic failed to have a single user engagement. The free version of WeightWatchers Mobile in both platforms practically has no features because they have allotted all the special features to the paid version.

This study points out that all the weight loss apps analyzed fell under some of the stages of change of the Transtheoretical Model. The TTM has shown to be an effective theoretical framework for behavior change with regard to weight management and weight loss (Riebe, Blissmer, Greene, Caldwell, Ruggiero, Stillwell, & Nigg, 2005). At the same time, a study has also concluded that TTM-based customized feedback is an effective tool to improve healthy eating and weight management (Johnson et al., 2008). Even though this study found that preparation was the main stage of change present in apps, it is also equally important to have a tailored approach in the app design based on the individual stage of change. Instead of one size intervention that fits all, app developers should consider incorporating features of stages of change in apps that cater to individual stages of change. So, persuading the individuals to change their health behavior through app content is essential, but at the same time, helping individuals to progress along the stages of change is equally important.

Another important point related to the Transtheoretical Model is that app designers need to consider incorporating features and activities that emphasize the processes of change associated with each stage of change. For instance, an app user who is in the contemplation stage must have components like specific tips, strategies to incorporate change in behavior, confidence-building measures, and ideas to lose weight. App designers need to be educated about the various stages of changes and processes of change while designing apps for weight loss that can considerably improve the efficiency of these apps. This can happen only when health professionals and app designers collaborate and develop products that are theory driven.

Stages of change in the TTM may be its most notable feature, but there is also a transition that occurs between the stages of change that is dictated by a set of independent variables, including decisional balance (pros and cons of change) and self-efficacy (confidence in the

ability to change under stress). Genetic, environmental, social, and psychological factors can also pose problems when addressing change in a problem behavior. We noted in this study that app developers are preoccupied with just preparing the user to set specific achievable goals, but if they incorporate features such as giving cues to the user to change the problem behavior, the app can be more productive. For instance, messages that tell the user that walking for a mile can burn 100 calories and eating a bag of chips can add 100 calories can prompt the user to decide the best option to help him or her reach personal goals.

The other most important factor is to customize or tailor information based on user needs. Delivering content and a package based on the user needs for their weight loss goals can be more fruitful than a single approach that is expected to work for everybody. If an app is able to identify the stage of individual readiness to change problem behavior, suggest workouts based on the user's needs, and help the user navigate from one stage to the next, the app can be an effective tool to address weight loss. Weight loss apps seem to be designed for individuals who are ready for change and are action-oriented users, but not everyone is ready to implement changes for a healthy lifestyle overnight. For example, an individual who is in the stage of action can use and benefit from a weight loss app, whereas an individual who is in the stage of contemplation or just thinking of losing weight can be overwhelmed by the content. Eventually, they will drop out or discontinue the use of the app because it is not in sync with their expectations.

The concept of apps is itself an emerging phenomenon, and it is too early to expect app development to incorporate theory or health behavior constructs in its design or content. Apps are literally flooding the markets, and it is estimated that people are spending on average about two hours a day just with their apps (Lessin & Ante, 2013). This is a definite cue that social

scientists should focus on evaluating the content of these apps. Also, it is an important signal for app developers to create theory-driven health apps to make a meaningful difference in the lives of people. Sensitizing app developers to integrate health behavior theories can be a viable option, but as of now, it still remains in theory.

Regulating Apps

The proliferation of apps has become so great that their numbers increase with each passing day. Even though there might not be a spike specifically in the number of health apps, there is definitely a large following and demand for it. Keeping count of apps is a huge task by itself. Recently, the FDA came up with a set of guidelines in an effort to streamline the growing industry. This study found that many of the popular, free weight loss apps fall under the "may be subject to FDA" category. Yet, only one app was identified—from iOS—that was subject to FDA regulation: Health Mate—Step Tracker and Life Coach, developed by Withings. Of the 89 apps analyzed, only one app requiring oversight or regulation may not be a significant number. This is an indication that there are probably many more apps that warrant oversight of the United States Food and Drug Administration in the Health & Fitness category.

The FDA stated in its February 2015 guidance report for mobile medical applications, which superseded its earlier guidance report, that if a software program transforms a mobile platform into a regulated medical device, then that app falls under the category of apps that must come under the FDA's regulatory oversight (MMA, 2015). This study found that the app Health Mate uses camera sensors to measure the user's heart rate. The app can calculate the heart rate when the user places a finger over the camera for a few seconds, thus transforming the smartphone platform into an electronic stethoscope. There are also features in this app that can transfer all the data collected, like heart rate, daily steps, and sleep patterns.

Thousands of apps are introduced everyday with brilliant features across many categories that can make our life easier in many ways. App development requires a high level of coding and technical capabilities, but it is a level playing field in which anyone with the knowledge and technique can create and publish apps for the entire world to use. This is definitely a welcome sign that must be encouraged and appreciated. However, when it comes to health apps, care should be taken to ensure that people are not misled by erroneous information. In traditional health-care delivery, when health professionals are at fault, patients can use the legal system for redress, but no such mechanism is currently in place for mobile health care. And there is a growing desire to streamline health apps in particular.

Many of the apps in Android come with a stamp of approval with a tagline of "Editors' Choice and Top Developer."

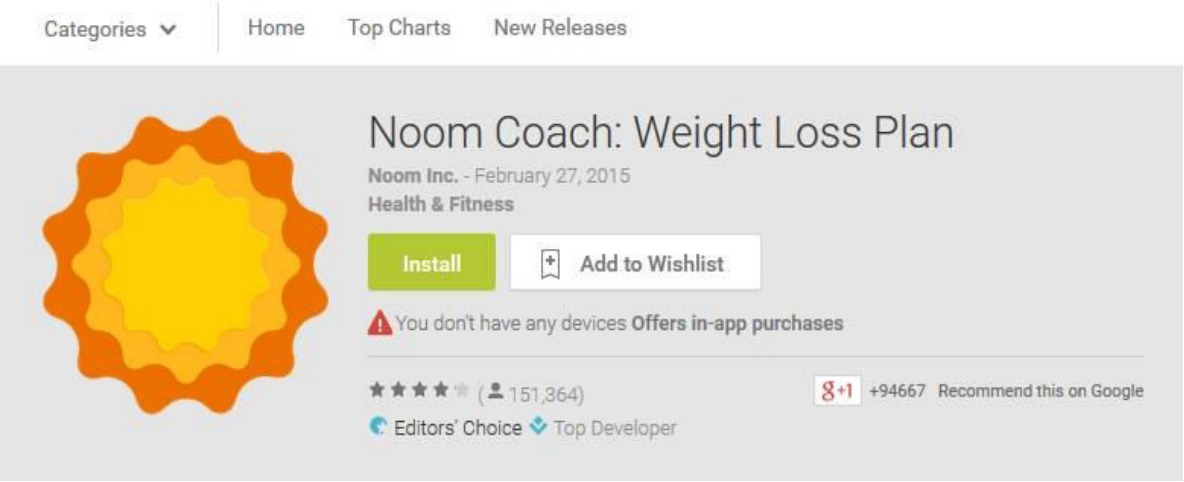

Figure 4 Screenshot from Android app store "Noom Coach as the Editors Choice" (March 5, 2015)

Such distinctions or acknowledgments from app stores could boost the confidence among users to download the app without hesitation. A stamp of approval from health authorities can

instill a sense of confidence among the users. A mechanism of this nature might be appreciated and well received by health app users.

"There's an app for that"—a buzzphrase in mainstream and social media—points to the quantity and diversity of available apps, but there are also many harmful apps available for download. In a study done by Bindhim et al. (2014), researchers found that tobacco companies are trying to promote tobacco products through smartphone apps. Since the app sphere is unregulated, and with a global reach, many companies are exploiting the app platform to promote products like tobacco and unhealthy behavior like smoking. There have been cases of erroneous health apps being recalled from the market because they were misleading users about assessment of a disease (Buijink et al., 2012). For instance, app marketer acneapp launched an app on iOS, claiming it can cure acne. The users have to install this app, which emits light waves. The claim is that consumers need only to hold their phones against their face every day for a few minutes to solve their acne problems. Eleven thousand users bought this app, only to waste their time holding their phone in front of their face, and they even paid $1.99 for installing it. The authorities in the United Kingdom were quick to fine the app marketer and recalled the app (Sharp, 2012). The issue is that there are still thousands of dubious apps available online for mass consumption, and many more are in the pipeline.

Many people are not even aware that they are duped by apps and simply continue to use them. At the same time, there are many apps that make people's lives easier, empowering them to confront their problems and talk to their physician with a better understanding of medical conditions. There are free and paid apps that monitor fitness levels, blood sugar, and blood pressure, as well as promote smoking cessation and other healthy behaviors. And there are functions featured in many apps where the data can be recorded, transmitted, or forwarded to

health-care professionals (Mulvaney, Rothman, Dietrich, Wallston, Grove, Elasy, & Johnson, 2012). There are good and bad aspects of using these myriads of apps. At the moment, the need of the hour is guidance by the right authorities or health professionals and regulation both in online and mobile media.

Even though the Federal Trade Commission has been monitoring the situation posed by the drastic growth in the field of mobile technology, they are yet to announce or enforce any kind of legislation to protect the privacy of mobile users. There has been a growing concern about the collection of personal information and health data by various apps and how data is being utilized. The current need is to ensure the safety and privacy of mobile app users, which is completely in the hands of the FDA and FTC. Even though these organizations are trying to be proactive by issuing guidelines and monitoring the potential dangers involved in telehealth technologies, policy decisions must be implemented to safeguard the users. Regulation of the app market by these organizations is an excellent idea, and the welfare of the users should be the top priority. Ironically, not even health professionals and government authorities are ready to tackle the hurdles posed by technological barriers and legal frameworks (Gupta & Saot, 2011). There should be more coordination among app developers, health-care professionals, government agencies, and other stakeholders involved to standardize the mushrooming field of mobile health.

CHAPTER 5

IMPLICATIONS

The phenomenal growth of mobile health apps in the recent past and their global reach is mind-boggling. The effectiveness of these apps for individual users is a subject that is slowly receiving more scrutiny among research scholars; the findings of this study can help lay the foundation for design and development of evidence-informed apps that incorporate interactive features with credible health information. Results from this study demonstrate the paucity in the involvement of health professionals in the development of health apps. At the same time, there is a need for professional health organizations to venture into the field of mobile health care, and there is a wide space for health organizations to explore the potential and opportunities for delivering health care.

The presence of millions of users just for weight loss alone is proof that individuals are ready to adopt technology to address weight loss issues. It is also well documented that Americans are growing heavier with each passing day, and the prevalence of obesity is spinning out of control. Obesity not only affects the health of the individual but also that of the entire nation. The global reach of mobile apps and the widespread adoption of smartphones offer a great opportunity for optimizing and delivering affordable health care to all. At the same time, there is still a considerable section of the population who either don't have access to technology or are not tech savvy. Many people are hesitant to switch to smart devices because of the ease with which personal information can be accessed and shared.

Authorities are aware of the situation, and the FDA has set clear guidelines for the launch of health apps. The results from this study point out that app developers can find a way to bypass these guidelines and regulations. Even though the FDA and FTC are playing a pivotal

role to keep the mobile health technology situation under control, a comprehensive federal policy will be the best solution to address this issue in the long run.

Overall, the findings of the study have several implications for health apps and, specifically, for weight loss apps. One of the fundamental findings of this study is that the majority of weight loss apps do not adhere to evidence-informed practices and nationally recognized health guidelines. This study has only reinforced the existing vacuum documented by previous studies and the need to develop apps with components of evidence-informed practices. The study intends to stimulate healthy discussion among the various stakeholders in the field of mobile health apps.

It is important to note that the findings of this study are also applicable to the general area of health apps. The potential to explore the concept of interactivity features through apps could guide app developers in general to integrate these components to enhance user experience. The need to develop apps based on a strong theoretical framework was emphasized in this study. The intention of the app developers to focus on the development of health apps must be appreciated, but these must be backed by sound health interventions, which are vital for change in health behavior. The complete lack of credibility in the majority of apps is an eye opener that should spur improvements in the overall quality of future health apps. This would not only standardize the content of health information available on apps but also give confidence to the user. Even though many steps have been taken by authorities to streamline mobile health apps, this study pointed out the existing loopholes that exist in the regulatory framework.

The findings of this study have direct implications for initiating efforts to improve the features of health apps. These findings are compelling for app developers, to take note of the wide gap that exists in the domain of health app development. There is much room for app

developers to apply the findings of this study to improve interactivity, evidence-informed practices, theory-driven content based on health behavior change, and credibility of health apps. App developers, health professionals and agencies, avid app users, nongovernmental organizations, and policymakers must come together and create a policy that addresses some of the major issues mentioned in this study.

CHAPTER 6

LIMITATIONS

This study was a content analysis of popular, free weight loss applications for Android and iOS platforms. There were many limitations to this study, but the first one was the decision to study only free weight loss apps. Studies have shown that free apps are downloaded more than premium apps (West et al., 2012). And people always experiment with free apps to become familiar with the features and functionality. The reason for studying free apps was that these were the ones that were being downloaded and used by many users. Instead of analyzing every single app listed, focusing on apps that were popular added value and significance to the study.

Weight loss apps evaluated for this study were identified from the Health & Fitness category in Google Android and Apple iOS. We focused on free weight loss apps that were listed only in these two platforms. However, when we searched the Google Play app store with a search query for "weight loss," it was found that this study analyzed 7 of the top 10 search results. But three potentially popular weight loss apps suggested by the app store were not analyzed because of our study criteria. There were weight loss apps even in the games category in Android. An app called Eat Smart teaches kids and adults to make healthy food choices in a fun way, and the Fat No More—Lose Weight app lets users become trainers to help their favorite cartoon characters lose weight. Weight loss apps are spread across many categories, and our current target was limited to the Health & Fitness category in the two major app stores. The decision to study weight loss apps from the Health & Fitness category was also based on an earlier scholarly approach for studies done on weight loss apps. There were many platforms for mobile health apps like Windows Mobile, BlackBerry, and Symbian, but we decided to focus on

Google's Android and Apple's iOS because they were the two major stakeholders in the app market as of 2015.

This study used the iPhone 4s and Samsung Galaxy S3, but there are currently versions such as iPhone 6 and Galaxy S6, which have better capabilities. The latest iPhone has iOS 8, super-fast processors, Near Field Communication, built-in sensors, high-resolution cameras, high storage capacity, and connectivity to wearable gears, which are not present in the current phones under study. Moreover, our criteria excluded apps that required these upgrades or premium features.

The study wanted to identify the interface, design, navigation, speed, color, font, display, images of people, advertisements, and multimedia capabilities present on these platforms. The limited time available to analyze the possibilities restricted the scope of this dissertation. Another important aspect is the dynamic nature of the app market which is constantly changing at a fast pace. The app market is so competitive that ranking the app becomes crucial for its presence in the app market. Even our evaluation of these apps can be obsolete because newer, enhanced apps are replacing the current standard of apps. At the same time, this dissertation can at least contribute in a small way to the existing literature on mobile apps and to enrich overall app experience. The study intends to lay a strong foundation for future health applications to consider the importance of incorporating evidence-informed practices, adherence to recognized national health guidelines, and to focus on the credibility of online health information.

During the analysis, especially after the installation of the app, the researcher looked at some of the components of the app, exploring the menu option and general features present in the app. For each app evaluated in this study, about 30 to 45 minutes were required to code the various categories based on our coding instrument. To understand the complete technicalities

and functionalities present in an app, user interactions must be evaluated over an extended period of time. Given the constraint of time and the quantity of apps for analysis, only a superficial overview for coding was possible for this study. It's possible that the researcher overlooked a couple of features that were present in an app.

All the apps analyzed for this study were installed on smartphones using campus Wi-Fi and not with regular phone data. Downloading an app via phone is dependent on the telephone service provider, the type of smartphone, and the allotted bandwidth or data plan. There is a visible difference in terms of using the phone data plan and using Wi-Fi.

CHAPTER 7

FUTURE RESEARCH

Despite the fact that a considerable portion of the population is using mobile health apps, research on this area is in its infancy and is fairly limited. The study only took into consideration free weight loss apps in the two major smartphone platforms, whereas other platforms and premium weight loss apps should also be considered for future research. The next logical extension would be the impact of the use of weight loss apps by mobile users. This will introduce the human dimension and shed further light on the merits and demerits of weight loss apps from the user's perspective.

Weight loss apps are growing in popularity, and with the release of thousands of apps, it is necessary to keep pace with the latest trends and technology. Future research should be conducted to assess the incorporation of evidence-informed practices, interactive features, and credibility of health information. More in-depth qualitative research should be conducted on how weight loss apps are impacting the lives of people and there should be more research on the design and development of the apps.

This study has only analyzed the content of popular weight loss apps in the two major smartphone platforms and has set the stage for the continuation of this work in both mobile communication and human mobile interaction. While this study has provided a bird's-eye view of the present trend and status of popular weight loss apps, more research is needed.

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APPENDICES

APPENDIX A

Code Sheet

Data gathered from app information page

Rank of the app in the Health and Fitness Category

Name of the app (RQ2):

Operating System (RQ2): iOS – 1, Android – 2

Name of the company (RQ2):

Is this app intended for weight management or weight loss? Yes – 1, No – 0

Number of Reviews (RQ2):

500,000+	5
250,000+	4
100,000+	3
50,000+	2
10000+	1
<10000	0

Star Ratings (RQ2):
Android

5 stars	5
4.0-4.9	4
3.0-3.9	3
2.0-2.9	2
1.0-1.9	1

App Focus (RQ1) – Primary

Diet or Diet Tracking	1
Weight loss/Tracking	2
Yoga	3
Fitness/Training	4
Meditation	5
Surgery/pharmacotherapy	6
Hypnosis	7
Recipes	8
Calculator	9
Combination	10
None	0

(Mention primary focus first)(Followed by secondary focus)

Date app last updated (RQ2): 1. In the last one month
2. More than a month but less than 3 months
3. More than 3 months

Rank of app: Mention the app ranking from the top free categories based on its position.

Contact Details (RQ2):

Yes – 1
No - 0

Content Rating (RQ2):

(For iOS)	(For Android)	
1 - 4+	Everyone	1
2 - 9+	Low maturity	2
3 - 12+	Medium Maturity	3
4 - 17+	Maturity	4

Size of app (RQ2):

75+MB or more	5
50+ upto 75 MB	4
30+ upto 50MB	3
20+ upto 30MB	2
<20 MB	1

Privacy Policy (RQ2): Yes – 1, No – 0

URL or Website address (RQ2): Yes – 1, No – 0

<u>Data gathered from app after installation:</u> Signup Options (RQ2):

Create login	1
Social media	2
Combination	3
None	0

Items Defining Functional Interactivity (RQ3)

Item	Yes	No
App developed by professional health unit or organization	1	0
Email links to specific medical professionals readily available	1	0
Contact details of app developers are readily available	1	0
Provisions for users to connect with social media	1	0
Built-in tutorials available for users	1	0
Provisions to connect with other users to share tips/advice	1	0
Provisions to input personal health data	1	0
Provisions for message boards/ discussion forums /challenges	1	0

(Adapted from Witherspoon, 2001; Stout et al, 2001)

13 evidence-informed practices for weight loss

Yes – 1 and No – 0

Assess one's weight – Whether app provide means to calculate BMI
Eat a diet rich in fruits and vegetables – Whether app recommends daily servings
Regular physical activity - Whether app recommends amount of physical activity
Drink Water instead of beverages – Whether app recommends daily servings of water
Maintain Calorie Balance – Whether app allows calculation of calories needed
Weight loss of 1 to 2 lbs a week – Whether the app recommends weight loss goals
Portion control - Whether app illustrates portion size
Nutrition labels – Whether app recommends nutrition label readings
Track weight - Whether app provides means to track weight
Physical activity journal – Whether app provides journal to track physical activity
Plan meals – Whether app recommends ways to plan meals or search recipes
Seek social support – Whether app allows users to connect or forums or message boards
Keep food diary – Whether app has food journal entry

Adherence scale based on (NHLBI, 2002) for ten steps to weight loss and their approach to address obesity and weight loss

Yes – 1 and No -0

Height and Weight to estimate BMI – Whether app recommends BMI
Measure Waist Circumference – Whether app recommends waist circumference
Assess co-morbidities – Whether app assesses the history of CVD, diabetes, sleep apnea etc. ,
Assessment to treat the patients – Whether app has the provision of treatment algorithms
Is patient ready and motivated – Whether app has evaluation provisions for individual readiness to lose weight, previous attempts to lose weight, attitude towards physical activity, time availability, potential barriers etc.,
Diet recommendations – Whether app recommends daily diet and calorie consumption.
Discussing physical activity – Whether app provides information about the pros and cons of physical activity and gauges their users to step by step approach to workout.
Review weekly food and activity – Whether app has provisions for weekly review.

Give the patient copies of the dietary information – Whether app has the provision to access all the dietary information.
Enter patient information and reminders – Whether app has the provision to keep track of their goals, gentle reminders and follow up.

Health information best-practice principles adapted for prescriptive content within smartphone apps

Yes-1, and No-0

	Authority
Principle 1	Give qualifications of authors
	Complementarity
Principle 2	Does the app mentions about not completely replacing health professional
Principle 3	**Confidentiality** Mention of how the information about the user will be handled and respect their privacy
Principle 4	**Attribution** Cite the sources and dates of medical information
Principle 5	**Justifiability** Justification of claims / balanced and objective claims, backed by scientific evidence
	Transparency
Principle 6	Accessibility, provide valid contact details
Principle 7	**Financial disclosure** Provide details of funding
Principle 8	**Advertising** Clearly distinguish advertising from editorial.

(Adapted from Boyer et al. , 2007; Health on the Net Foundation, 2013)

User engagement of popular weight loss apps based on Transtheoretical Model (RQ4)

Yes -1 and No – 0

Consciousness Raising – It involves increased awareness about the causes, consequences and remedies for weight loss. Interventions that can increase awareness include education materials and tips for weight loss.

Changing personal environment: whether the app suggest to modify the environment to encourage the desired behavior (eg, white or ambient noise, or images for meditation);

Facilitating social support: whether the app assists in creating a group or online forum to connect with others for social support

Goal setting, the app facilitates goal setting (eg, weightloss target, fitness goal);

Progress tracking, the user identifies a goal and the app creates subsidiary goals or tasks based on the user-defined goal and logs the user's progress;

Reinforcement tracking, the app allows a third party to assign reinforcements based on information collected by the app regarding the user's health or health behaviors;

Self-monitoring, the user tracks his or her behavior in the app with no explicit reference to a goal, the app is simply a tracking tool (eg, pedometer);

Social presentation or announcement: whether the app provides implicit social reinforcement, for example, by announcing an action, achievement, or process via social media or an app tool; and

Contemplation, Preparation, Action, Maintenance

(Adapted from Sama, Eapen, Weinfurt, Shah, & Schulman, 2014)

Categorization of Apps based on FDA guidelines (RQ5)

Category 1: Apps that **do not** meet the statutory definition of a device, and thus are not subject to FDA oversight.

Category 2: Apps that **may** meet the statutory definition of a device, but present such a low risk of patient harm that the FDA is not going to exercise oversight at this time.

Category 3: Apps that **do** meet the statutory definition of a device **and** the above definition of a "mobile medical app," and that present potential patient risks warranting FDA oversight this time

(FDA, 2015)

APPENDIX B

Android apps	iOS apps
Calorie Counter	MyFitnessPal
Fitbit	Fitbit,Inc
Loseit	Fitnow, Inc
Water Your Body	Northpark.Android
Weight Watchers Mobile	Weightwatchers International
7 Minute Workout	Abishkking
Runkeeper-GPS Track Run Walk	Fitnesskeeper.Inc
Runtastic Pedometer Step Count	Runtastic
Pedometer	tayutau
My Diet Coach - Weight Loss	InspiredApps Ltd
Workout Trainer	Skimble Inc
Noom Walk Pedometer	Teer Studios
Calorie Counter & diet tracker	Sparkpeople
Fooducate Healthy Weightt	Fooducate Ltd
Runtastic Running & Fitness	Runtastic
MSN Health & Fitness	Microsoft Corporation
Underarmour Record	Under Armour
Pedometer	Pacer Works
8 Minutes Absworkout	Passion4Perfection Apps
Daily Yoga - Fitness On	IMOBLIFE Co. Ltd
Monitor your weight	Husain Al-Bustan
Squats Workout	Northpark.Android
Noom Coach Weight loss plan	Noom Inc
Calorie Counter by Fatsecret	Fatsecret
calculator & tracker for weight	Matt Donders
Fitness-Home & Gym Workouts	Virtuagym
Jefit Workout Exercise Trainer	Jeftit Inc
Ideal Weight(BMI)	mmapps mobile
7 Minute Workout - Weight Loss	Ego360
BMI Calculator-Weight Loss	Appovo
Atkins Carb Tracker	Atkins Nutritionals
Total Fitness - Gym & Workout	Total Fitness Blue Corner
Sit Ups Workout	Northpark.Android
MyFitness Calculator BMI IIFYM	abhinav Singh
Walklogger pedometer	walklogger
Calorie Counter	Caloriecounter.com
Accupedo Pedometer	Corusen LLC
Diet Plan - Weight Loss in 7 days	Gamebaby
Fitness Buddy - 300+ Exercises	Azumio, Inc
StrongLifts 5x5 Workout	StrongLifts
Calorie, Carb & Fat Counter	Virtuagym
Pumpup-Fitness Community	Pumpup
Chest Workout	Passion4Profession Apps

MyNetdiary Calorie Counter Pro	Mynetdiary.com
Dreambody Workout Plan	Workout Routines
My Diet Diary Calorie Counter	MedHelp, Inc
Pedometer 2.0	DSD
Runtastic Six Pack Abs Workout	Runtastic
Bodybuilding workout	Blake Apps LLC

Apps present in both Android and iOS
Calorie Counter
Fitbit
Loseit
Weight Watchers Mobile
Runkeeper-GPS Track Run Walk
Runtastic Pedometer Step Count
My Diet Coach - Weight Loss
Workout Trainer
Fooducate Healthy Weight
Underarmour Record
Calorie Counter by Fatsecret
Atkins Carb Tracker
Fitness Buddy - 300+ Exercises
Runtastic Six Pack Abs Workout

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