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The Use of Mobile Applications in Preventive Care and health-Related Conditions: A Review of the Literature

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THE USE OF MOBILE APPLICATIONS IN PREVENTIVE CARE AND HEALTH-RELATED CONDITIONS: A REVIEW OF THE LITERATURE

by

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ABSTRACT

The purpose of this review of literature was to understand the role of mobile device applications in health related conditions and to analyze their effects on health outcomes related to the management of chronic illnesses. Implications for future use of applications in client-centered care and interpretation of the data by health care providers was also explored. Peer-reviewed, English-language research articles published from 2008 to present were included for synthesis. Study results revealed positive outcomes when health-related mobile applications were used in practice and support clinicians' use of mobile applications as a tool for monitoring symptoms and communicating with individuals. The literature indicated nurses play a significant role in providing feedback, which reinforces self-care strategies and adherence, with the potential for improving outcomes. Additional research is needed to evaluate the long-term effects of applications on patient outcomes, nurses' perspectives, and feasibility of implementation into practice.

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INTRODUCTION

Client-centered care is rapidly evolving as new technologies emerge with the potential to increase communication, efficiency, and accessibility with health care providers. Smart phones, in particular, integrate many technological functions into one device that is capable of changing the delivery of health care (Putzer & Park, 2010). Increasingly, clients and providers are using smart phones and tablet computers in daily health care practice (Sevetson & Boucek, 2013). Smartphone owners who use health-related applications (apps) can readily track and manage their health care encounters and needs (Fox & Duggan, 2012). Health-related apps can be used to engage individuals and providers in their goals to support the communication and information technology Healthy People 2020 initiatives by providing individualized self-management tools and resources necessary to improve health and well-being (United States Department of Health and Human Services, Healthy People 2020, 2010).

A Pew Research Center study shows that 58 percent of American adults now own smartphones (Pew Research Center's Internet & American Life Project, 2014). Smartphone ownership is most prevalent among 18 to 29-year-old adults, followed by 74 percent of 30 to 49-year-old adults, nearly half of 50 to 64-year-old adults, and approximately 19 percent of adults over the age of 65 (Pew Research Center's Internet & American Life Project, 2014). Further analysis indicates more Hispanic adults own smartphones, followed by African-American and White adults (Pew Research Center's Internet & American Life Project, 2014). In an analysis of the leading causes of deaths among Americans, chronic conditions were the most prevalant among older adults, yet heart disease, diabetes mellitus, and cerebrovascular disease remained among the top 10 causes of deaths of adults ages 25 to 34 years old (Heron, 2013). Fox and Duggan (2012) found people most likely to participate in mobile health activities to be those living with chronic health conditions or those seeking preventive health strategies. In 2012, 19 percent of smartphone users had at least one health-related application on their phone (Fox & Duggan, 2012). Among the most popular apps were exercise, diet, and weight management (Fox & Duggan, 2012).

PROBLEM

The number of health-related, mobile applications focusing on chronic disease management, such as diabetes, heart disease, and asthma, is expected to greatly increase until 2018 as consumer demand and the incorporation of client data trending into health-related outcomes becomes a performance based, reimbursement incentive for health care providers (Blake, 2008). However, there is a paucity of research that explores consumer's use of mobile, health-related applications and their integration into the healthcare setting. This review of literature will establish a better understanding of how clients use health-related apps to track their health status and their progress towards health improvement, which is meaningful to future trends in individualized care. Mobile device technologies have great potential as a basic means for tailoring client-centered care to preventive and chronic condition management that can improve individual health outcomes (Kratzke & Cox, 2012).

PURPOSE

The purpose of this study is to review current research examining the use of health-related, mobile device applications in health care. This review will provide better understanding of how health-related apps can be implemented into the management of chronic disease conditions to prevent, maintain, or improve an individual's health status. It is proposed that health-related apps are convenient and useful tools for individualizing interventions that improve self-management of chronic illnesses and health behaviors (Kratzke & Cox, 2012). The secondary purpose of this review will be to discuss potential future research that focuses on the integration of mobile technology into client education that improves individualized health initiatives.

METHOD

A search of published literature was carried out using the EBSCOhost, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Education Information Resource Center (ERIC), MEDLINE, and PsychINFO databases (Figure 1). Searches were limited to peer-reviewed articles published between 2008 and 2013. Dates were limited by the relatively recent innovation of mobile technology and applications. An initial search using the keywords health, application, tech, and mobile revealed 162 results. Twenty-eight articles were selected for further review, with the inclusion of two relevant studies in this review of literature. Inclusion criteria extended to primary and secondary research articles written in the English language, articles pertaining to application use or feasibility in health care practice, chronic condition management, and health promotion. Exclusion criteria extended to studies in which the full-text article was unavailable, psychiatric-related diagnoses, interventions that did not focus on chronic conditions, interventions that did not involve uses of apps, and articles describing apps used only among clinicians. Additional searches using the keywords smartphone, smart phone, app, and disease were conducted. An additional 17 studies and articles were selected from the same databases for synthesis. A total of 19 articles were included in this review of literature. A study by Verwey et al. (2014) did not meet inclusion criteria of published dates of 2008 to 2013 but was included because the intervention included use of a smartphone application and an accelerometer, nurse-to-client feedback, and outcomes included nurses' perspectives.

BACKGROUND

Mobile Device Applications

Mobile device applications, also known as end-user software applications, became available to the public in 2007 with the first-generation Apple iPhone (Purcell, 2011). Apps have become a fundamental feature of smartphones, tablets, or other handheld devices as clients have moved from traditional computers to mobile computing (Purcell, 2011). A Pew Research Center study shows app downloads doubled from 2009 to 2011 (Purcell, 2011).

Mobile device applications present many opportunities for health care professionals to interact in a real-time environment with individuals engaged in self-care routines outside the traditional health care setting. The portability of mobile devices allows clients to track their health statuses in a variety of settings, including locations outside of the health care environment or away from the clients' homes. Apps are unique tools for wellness and disease management because they are readily available to individuals and clinicians, are capable of storing data locally and uploading to the Internet, and can also utilize the device camera, speakerphone, or other built-in features (Aungst, Clauson, Misra, Lewis, & Husain, 2014).

Self-management of Chronic Illnesses

Clinicians face many challenges in caring for clients with complex chronic illnesses. Strategies to help clients contend with physical and psychosocial aspects of living with a disease process often involve client-centered, self-management activities. Clinicians promote self-management by communicating and coordinating appropriate plans that involve clients as active decision-makers in their care (Schulman-Green et al., 2012). Living with a chronic illness is a dynamic process with shifting needs and outcomes (Schulman-Green et al., 2012). Tailoring interventions to support self-management provides holistic care (Schulman-Green et al., 2012).

Knight and Shea (2014) propose the Empowerment Informatics framework in which health-enabling technology, including mobile devices and apps, strengthens the collaborative relationship between clients and healthcare providers in the management of chronic illnesses. Client-driven goals are incorporated into care plans to increase self-management behaviors and, as a result, client outcomes. Mobile devices and apps are tools to facilitate self-management behaviors through education, monitoring, feedback, and support (Knight & Shea, 2014).

Clinicians who seek to implement health-related apps into practice face many challenges due to wide-ranging quality-control measures. The United States Food and Drug Administration (FDA) regulates a small portion of apps on the market, including mobile devices or apps operating as a blood glucose meter (FDA, 2013). Apps allowing clients to track health information or communicate with providers do not require FDA review or approval prior to market release (FDA, 2013). Therefore, individuals and clinicians must be diligent in choosing appropriate and effective health-related apps in the growing plethora of apps. Aungst et al. (2014) propose clinicians use peer-reviewed literature, online resources, or a trial-and-error selection method to identify appropriate healthcare applications for practice.

Other limiting factors stem from technical issues related to a slow Internet connection and varying performance capabilities of the many device models available to clients (Zakas, 2013).

Chronic Illnesses

Chronic diseases are among the most common and costly of all health problems in the United States (Centers for Disease Control and Prevention, 2012). In 2010, heart disease, malignant neoplasms, chronic lower respiratory diseases, and stroke were the four most common causes of deaths in the United States (Heron, 2013). Diabetes was the seventh most common cause of death (Heron, 2013). Chronic conditions such as heart disease, stroke, diabetes, and obesity may be preventable by modifying health behaviors related to physical activity, nutrition, tobacco use, and alcohol consumption (Centers for Disease Control and Prevention, 2012). Current research outlines the manner in which adults use health-related apps to manage factors contributing to chronic illnesses.

Physical activity has major health benefits for all populations, including healthy individuals, clients who are at risk for developing chronic diseases, or clients who may have current disabilities and chronic diseases (United States Department of Health and Human Services [HHS], Office of Disease Prevention & Health Promotion, 2008). The Physical Activity Guidelines for Americans recommends a total of 150 minutes of moderate-intensity physical activity, such as brisk walking, per week to improve overall health and prevent some adverse health outcomes (HHS, Office of Disease Prevention & Health Promotion, 2008). Smartphone technology, including apps and native software, promoted physical activity by allowing individuals to set goals, review real-time feedback, and receive social or expert support on their devices (Bort-Roig, Gilson, Puig-Ribera, Contreras, & Trost, 2014). In particular, step counts helped track individual progress and measured outcomes of physical activity interventions as documented in the systematic review by Bort-Roig et al. (2014).

In addition to physical activity, maintaining a balanced diet is important for reducing obesity and improving health (United States Department of Agriculture, 2010). The Dietary Guidelines for Americans, 2010 makes several recommendations including limiting dietary consumption of solid fats and refined sugars, increasing consumption of fruits and vegetables, and reducing sodium to 1,500 mg per day for adults over 51 years old (United States Department of Agriculture, 2010). Direct entry or selection of food items from an existing database appeared to be common functionality in nutrition apps for mobile devices (Lieffers & Hanning, 2012). The majority of clients using these apps were overweight or obese Caucasian females ages 30 to 50 with higher income status (Lieffers & Hanning, 2012).

Tobacco use contributes tremendously to the burden of disease and death in the United States (National Center for Chronic Disease Prevention and Health Promotion, 2014). Smoking is a major cause of chronic obstructive pulmonary disease (COPD) in the United States and increases the risk of diabetes and many cancers (National Center for Chronic Disease Prevention and Health Promotion, 2014). Efforts to end the tobacco abuse epidemic are hindered by the inability to fully implement interventions to prevent the startup of tobacco product use and to treat tobacco dependence. A major barrier to tobacco cessation efforts rests with the use of increasingly potent chemicals to enhance the physiologic addiction of tobacco products and the tobacco industry’s continued efforts to market cigarettes and tobacco products (National Center for Chronic Disease Prevention and Health Promotion, 2014). Health care professionals can play a significant role in advancing smoking cessation by establishing a reliable standard of care (National Center for Chronic Disease Prevention and Health Promotion, 2014). However, the majority of smoking-cessation apps failed to connect users with a hotline or prompt them to follow up with healthcare providers but touted interactive features including calculators, rationing, and tracking mechanisms (Abroms, Westmaas, Bontemps-Jones, Ramani, & Mellerson, 2013). Hypnosis apps were the second-most downloaded category in a content analysis of popular iPhone and Android smoking-cessation apps (Abroms et al., 2013).

Excessive alcohol consumption is another potentially unhealthy lifestyle behavior that can cause or worsen many chronic conditions such as liver disease, high blood pressure, heart attack, stroke, and some cancers (Centers for Disease Control and Prevention, 2011). The Dietary Guidelines for Americans, 2010 recommends one alcoholic drink per day for women and two drinks per day for men (U.S. Department of Agriculture, 2010). Despite recommendations on alcohol consumption, more than 500 apps available in the iTunes store promoted alcohol consumption through drinking games or other entertainment (Cohn, Hunter-Reel, Hagman, & Mitchell, 2011). The majority of alcohol-intervening apps used motivation, feedback, and 12-step strategies to help clients reduce alcohol intake (Cohn et al., 2011).

Summary

A coordinated approach in which health care professionals engage clients, families, policymakers, and other interdisciplinary professionals is needed to modify health behaviors and outcomes (U.S. Department of Agriculture, 2010). Mobile device technology can be part of the strategy of combating chronic diseases by allowing health care professionals to educate, remind, and engage clients to modify health behaviors (Weaver, Lindsay, & Gitelman, 2012). Mobile device technology allows clients to become partners in their care (Weaver et al., 2012).

RESULTS

Sixteen studies related to mobile communication devices and applications were included in this review of literature. An additional three articles provided follow-up data on previously conducted studies. All studies were published in the past six years. Five randomized controlled trials were included. Five articles included were pilot studies. Fifteen studies included a questionnaire or survey related to app use in health monitoring. Four studies included interviews. Two studies included focus groups. One randomized controlled trial and subsequent secondary analysis did not include such qualitative data.

Application Uses and Related Outcomes

The literature reviewed revealed major themes pertaining to the use of health-related, mobile device apps. Studies described self-reported data trends and outcomes related to chronic health conditions such as pain, diabetes, physical activity, diet, and other potential uses.

Pain

Three studies focused on the use of applications by clients experiencing pain.

Fibromyalgia clients in a feasibility study rated their symptoms three times per day for seven days on an iPod Touch diary application, which generated and sent emails to a registered nurse for review and feedback (Vanderboom, Vincent, Luedtke, Rhudy, & Bowles, 2013). The study concluded the majority of participants found a pain diary application valuable, useful, and easy to use (Vanderboom et al., 2013). Participants perceived interactions with the nurse to be valuable in providing feedback and reinforcing self-management; thus, interactions had the potential to influence outcomes (Vanderboom et al., 2013). The study demonstrated positive user attitudes toward the application and the nurse's feedback but was not designed to examine improvements in pain.

Participants in a randomized controlled trial were instructed to write three smartphone-based diaries per day for four weeks regarding their chronic pain (Kristjánsdóttir et al., 2013b). The study authors, with backgrounds in nursing or psychology, responded with personalized feedback (Kristjánsdóttir et al., 2013b). The results suggested that participants had significantly improved pain immediately after the 4-week period, followed by moderate results at 5 months, and no significant difference at an 11-month follow up of the randomized controlled trial.

In a related study, adolescents used an iPhone-based game application to record pain intensity and location twice daily during a two-week feasibility phase. The app included a reward system in which users gained rank as they completed pain assessments, which led to high compliance (Stinson et al., 2013). Adolescents reported they enjoyed the app, found it easy to use, and did not find it intrusive on daily life, which led researchers to conclude mobile apps have the potential to improve pain management and quality of life (Stinson et al., 2013). Specific health care provider roles were not discussed in the study.

Diabetes

Six studies involved clients with type 1 or type 2 diabetes mellitus.

Type 1 diabetic clients in a randomized controlled trial used an iPhone application to upload blood glucose levels, insulin dosages, medications, diet, and physical activity; a certified diabetic educator provided feedback on a periodic basis (Kirwan, Vandelanotte, Fenning, & Duncan, 2013). Participants had significantly decreased HbA_{1c} over nine months; however, the results of the research did not identify a significant relationship among app engagement, text messages, and the change in HbA_{1c}. One proposed reason for the improvement was a higher baseline HbA_{1c}, which allowed more potential for improvement (Kirwan et al., 2013).

A randomized parallel-group multicenter study by Charpentier et al. (2011) utilized the Diabeo smartphone app for recording self-monitoring plasma glucose, diet, and insulin treatment. Participants in the group using the Diabeo app and receiving telephone consultations had significantly lower HbA_{1c} (8.41 $\pm$ 1.04%) compared to the control group (9.10 $\pm$ 1.16%), which used a paper log and in-person consultations (Charpentier et al., 2011). Participants in the second group used a combination of smartphone application and in-person consultations and resulted in HbA_{1c} levels of 8.63 $\pm$ 1.07% (Charpentier et al., 2011).

In a pilot study, a smartphone app transferred blood glucose readings from a meter to the smartphone of participants (Nes et al., 2012). Healthcare providers tailored feedback to participants based on the data and on participants' diary entries pertaining to diet, physical activity, medications, and emotions (Nes et al., 2012). $HbA1_c$ levels were set as a measurement of behavioral change in type 2 individuals with diabetes (Nes et al., 2012). Participants demonstrated a decrease from mean $HbA1_c$ levels of 7.39 percent prior to intervention to a mean of 6.9 percent at the end of intervention, but the results concluded by measuring $HbA1_c$ alone was not indicative of behavioral change (Nes et al., 2012). Most clients reported the experience of using an app for monitoring diabetes trends to be meaningful and motivational, with nurse-supplied feedback reinforcing strategies to manage their diabetes (Nes et al., 2012). Nurses reported clients lacked knowledge of diabetes (Nes et al., 2012).

In a separate pilot study, type 2 diabetic clients were evaluated for their use of a smartphone application, Wii videogame console, and interactions with a nurse manager. Participants uploaded glucose readings and collaborated with the nurse manager, who wrote care plans, sent feedback, and conducted clinic visits. Researchers concluded participants were frustrated with the smartphones but nurse interactions had potential to influence self-care behaviors (Lyles et al., 2011).

In an integrative, prospective, randomized study of hypertensive diabetic individuals monitoring blood pressure, participants used Bluetooth-enabled sphygmomanometers to transmit data to a BlackBerry application, which could generate and send critical alert messages to providers when blood pressure levels exceeded predetermined thresholds (Logan, 2013). Participants who used a smartphone application at home in conjunction with automated self-care messages had significantly decreased mean daytime ambulatory systolic blood pressure (SBP) and mean 24-hour SBP (Logan, 2013). Fifty-one percent of the intervention group and 31 percent of the control group reached the target goal of less than 130/80 mm Hg blood pressure (Logan, 2013).

Physical Activity

Four studies reviewed described the use of mobile device apps related to physical activity, diabetes, COPD, and cardiovascular disease.

The Verwey et al. (2014) pilot study evaluated performance, acceptance, and satisfaction of a smartphone app paired with an accelerometer to log physical activity in clients with type 2 diabetes or chronic obstructive pulmonary disease (COPD). Health care providers, who were predominately nurses, were involved in the recruitment process, helped establish client goals, and provided feedback. On average, participants increased the average physical activity from 29 minutes per day in the first two weeks to 39 minutes per day during the final two weeks (Verwey et al., 2014). Health-related quality of life scores increased from a mean index score of 0.76 to

0.84 on the EuroQOL five dimensions questionnaire (EQ5-D), in which 0 represents death and 1 represents a perfect health state (EuroQOL Group, 1990; Verwey et al., 2014). The study indicated the smartphone app helped to improve participants' self-efficacy in order to achieve their goals (Verwey et al., 2014).

Nguyen, Gill, Wolpin, Steele, and Benditt (2009) conducted a randomized repeated pilot study that compared efficacy of a web-based program, which included a PDA app, and face-to-face dyspnea self-management program in COPD participants at zero, three, and six months. Nurses made baseline assessments, educated participants, reviewed data, and gave feedback. The study utilized the Chronic Respiratory Questionnaire-Dyspnea subscale. Results for both groups demonstrated improvements in dyspnea with activities of daily living; a six-minute walk test improved in the web-based group but declined in the face-to-face group (Nguyen et al., 2009). All participants in the web-based group agreed or strongly agreed they received nurse-guided, health-related, support despite technical difficulties with the web-based and PDA-based apps (Nguyen et al., 2009).

A smartphone application was found to be conducive to participation in a two-arm, matched, case controlled trial to measure potential of the iStepLog smartphone app that was designed to improve health behaviors (Kirwan, Duncan, Vandelanotte, & Mummery, 2012). The study found application group usage to be 71 percent compared to the matched group utilizing a website resource which had 29 percent usage (Kirwan et al., 2012). Participants, who self-selected into the intervention group, described the smartphone app as usable and useful overall (Kirwan et al., 2012).

A convergent, validation study was reviewed to help determine validity of app-based programs for health-related tracking. The study evaluated the validity of an application-based physical activity questionnaire to a self-recall questionnaire in clients with cardiovascular disease (Pfaeffli et al., 2013). Participants wore an accelorometer and responded to two daily questions on an Android-based application for one week (Pfaeffli et al., 2013). The study concluded that an application-based questionnaire was relatively reliable and valid in measuring and tracking physical activity, which supported the use of mobile devices to assess physical activity regardless of cardiac rehabilitation attendance (Pfaeffli et al., 2013). Health care provider interventions and feedback were not discussed in this instance.

Diet

Three studies were brought forth from the literature that discussed interventions related to diet. The effects of health care provider interventions and feedback were not discussed and are therefore unknown in these instances (Burke et al., 2011; Carter, Burley, Nykjaer, & Cade, 2013; Welch et al., 2013).

Welch et al. (2013) conducted a randomized pilot study to analyze a smartphone application that allowed individuals undergoing hemodialysis to scan Universal Product Code labels on food packages or select food icons from the existing database to track their diets. Researchers concluded use of a smartphone application had no effect on weight gain between hemodialysis sessions and no statistical significance on improvements in diet or self-efficacy (Welch et al., 2013). The intervention group had significantly increased perceived control immediately after the study, but perceived control returned to baseline at eight weeks (Welch et al., 2013). In an article describing user perceptions, eleven participants stated the app caused them to change diets, and 17 participants stated the app caused them to think about changing their diets (Connelly et al., 2012).

In a three-arm, randomized, controlled trial, adherence to diet was measured by usage of a smartphone application, paper diary, and weight-loss website over six months (Carter et al., 2013). The smartphone group had significantly higher adherence and decreases in BMI and percentage of body fat compared to the other two groups (Carter et al., 2013). Participants in both smartphone and paper diary groups had significant weight loss although some participants reported use of another weight-loss related intervention in addition to the one assigned (Carter et al., 2013).

A separate randomized controlled trial regarding diet found adherence to be more important than the method used to achieve weight loss (Burke et al., 2011). Participants using a PDA-based Dietmate Pro app in addition to health care provider feedback had small, statistically significant weight loss ($p=0.02$) when compared to participants using only the PDA application or participants using only a paper diary (Burke et al., 2011). Overall, PDA use resulted in greater adherence (Burke et al., 2011). A secondary analysis of the study found that health care provider feedback significantly increased adherence, with the potential for mobile technology to enhance adherence (Turk et al., 2013).

Other Potential Uses

There are many other uses for health-related apps to improve overall health and well-being in individuals. Dennison, Morrison, Conway, and Yardley (2013) examined adult perspectives on the potential use of apps in health behavior modifications. The study design did not include an intervention in which participants used a smartphone application; rather, participants discussed their attitudes on how smartphones could be used to monitor diet, exercise, and medications, or as an adjunct to psychological therapy (Dennison, Morrison, Conway, & Yardley, 2013).

DISCUSSION

The studies reviewed in this work provide insight into clients' use of health-related mobile device applications. Research findings revealed the role and potential use of mobile device technology in managing chronic conditions. While the reviewed literature showed mixed results, the use of mobile device apps exhibited several positive effects on client outcomes. The literature also suggested that applications allow clinicians to communicate with clients and help to monitor progress, which may result in modifying clients' health behaviors.

Use of Apps in Managing Chronic Conditions

Clients with chronic conditions may benefit from the use of mobile device applications (Kratzke & Cox, 2012. The literature reviewed provided examples in which clients implement mobile device applications into their daily lives. The majority of mobile device applications discussed in the studies reviewed allowed clients to input, upload, track progress, and receive feedback on pain symptoms, blood pressure, HbA_{1c}, physical activity, and diet. These results were expected given the portability and function of mobile devices in general. Mobility may provide convenience for clients who wish to input data as it occurs in real-time; however, the studies did not examine how portability influences adherence or health-related outcomes.

While several studies had positive outcomes, findings were not linked directly to applications and their uses (Burke et al., 2011; Carter et al., 2013; Charpentier et al., 2011; Kirwan et al., 2013; Kristjánsdóttir et al., 2013b; Logan, 2013; Nguyen, 2009). Two groups of type 1 diabetic clients using a smartphone application had improved end-point HbA_{1c}, but one group received telephone feedback while the other did not (Charpentier et al., 2011). Thus, it cannot be concluded that the application itself rather than the method of feedback was responsible for decreased HbA_{1c}. Further analysis of the study by Nguyen et al. (2009) suggests the method of intervention may have little effect on improving dyspnea in COPD clients, yet an intervention providing support and feedback may be linked to improved outcomes.

A study by Logan (2013) suggests diabetic clients with uncontrolled systolic blood pressure may benefit from care that includes smartphone application, but the study was not designed to examine the direct role of the application.

Relationship between Feedback and Apps

Research describes the use of mobile device applications solely or in conjunction with feedback, yet the relationship among feedback, applications, and positive outcomes is unclear. Use of an application in conjunction with feedback resulted in more weight loss when compared to use of an application alone (Burke et al., 2011). Clients with chronic pain who wrote pain diaries on a smartphone application and received therapist feedback reported less pain immediately; however, the study did not analyze the relationship of feedback and outcomes (Kristjánsdóttir et al., 2013a; Kristjánsdóttir et al., 2013b). According to Vanderboom et al. (2013), nurse feedback provided valuable reinforcement and the potential to positively influence outcomes of clients who used a pain diary application. However, Kirwin, et al. (2013) did not find a relationship between feedback and improved outcomes in diabetic clients' HbA_{1c} levels. Despite the mixed results of multiple studies, clients may benefit from applications that provide automated or clinician-generated feedback.

Barriers to Implementation

Current hardware technology limits mobile device applications by requiring the use of accessory devices to manage certain health conditions. In the literature reviewed, clients utilized additional devices such as Bluetooth-enabled sphygmomanometers and accelerometers. The need for secondary devices poses a challenge for clients due to the need for more training and the responsibility for multiple devices.

Other barriers to implementation are technical difficulties and a lack of usability or usefulness in the mobile device application. Technical difficulties caused participants frustration with the application and led to one study ending early, yet participants found nurse support to be helpful and showed improvements in symptoms (Nguyen et al., 2009). While results suggest nurses may help mitigate technical difficulties with client support, it does not solve the underlying technical issues and places the burden of responsibility on the nurse. Thus, clinicians should seek to circumvent these issues by addressing the reliability of an application and how technical issues are to be handled prior to implementation.

Useful applications may be a key factor in engagement and may indirectly influence outcomes (Kirwan et al., 2012). The Dennison et al. (2013) findings that usefulness of an application depends on clients' existing motivation to change health behaviors suggests clients will not benefit from the use of an application if they do not have a foundation of knowledge regarding their health and its implications. Results are limited in generalizability due to the sample size of 19 participants who self-selected into the study.

Determining relevant and usable applications is another challenge to implementation. Methods include reviewing current research and existing app store databases for appropriate applications (Aungst et al., 2014). The literature suggests outcomes such as client adherence, engagement, or perceived value of the app are useful for evaluating application feasibility or potential; however, clinicians are limited by inconclusive findings. Conclusions from a feasibility study and subsequent analysis that participants who used a diet-related application had no significant improvements and provided limited data does not provide substantial evidence to draw conclusions about the the feasibility of the application (Connelly et al., 2012; Welch et al., 2013).

Although not discussed in-depth in literature reviewed, financial barriers must be considered for successful implementation. Healthcare organizations may have to take on the financial burden of application development, while clients may be responsible for the initial investment of the device and payment of an Internet-access carrier plan in order to launch applications.

LIMITATIONS

Several limitations were noted in this review of the literature. Initial search results revealed numerous findings on keywords health, application, tech, and mobile; however, fewer original research articles remained relevant to the purpose of this investigation. Only two initial results met inclusion criteria for this review of literature. Search terms were expanded to include keywords, including smartphone, app, and disease, in order provide more relevant search results. This limitation may be an indication of the relative novelty of mobile apps and an indication for the potential for future research. Inclusion and exclusion criteria are subjective in nature, and thus limit this review of literature.

Many of the studies were limited by timeframe and location and small sample sizes. Only one study collected data from multiple sites over 1.5 years (Charpentier et al., 2011). The majority of studies included small but targeted populations, which limits generalizability of findings. The largest sample size (n=210) was limited by a population of mostly educated and employed Caucasian females (Burke et al., 2011). The majority of studies were descriptive in nature, with four studies including power analyses (Charpentier et al., 2011; Kirwan et al., 2013; Kristjánsdóttir et al., 2013b; Logan, 2013).

Response rates and retention of participants in two studies further limits findings. In one study, researchers experienced a withdrawal rate of 30 percent from the intervention group, followed by a response rate of less than 70 percent to follow-up questionnaires (Kristjánsdóttir et al., 2013b). Burke et al. (2012) retained 86 percent of its study participants. It is not uncommon in projects to find poor retention rates when data collection extends over a longer period of time.

RECOMMENDATIONS FOR HEALTH-RELATED APP USE

Implementation of Health-related Apps

Mobile technology is a tool that allows healthcare professionals to modify an individual's health behaviors and outcomes (U.S. Department of Agriculture, 2010). As part of the healthcare team, nurses play a significant role in the implementation of mobile device applications into practice.

Communication with individuals seeking to manage their health-related conditions was a common topic among the studies reviewed. Mobile technology is a vehicle for communication and enhances daily feedback, which in turn increases self-monitoring adherence (Turk et al., 2013). The literature suggests an individual's motivation is a key factor in successfully implementing mobile device applications (Dennison et al., 2013). The use of applications to educate and reinforce health behaviors can motivate a person with a chronic condition that requires self-monitoring to maintain current health status and potentiate positive outcomes. Thus, communication between nurses and individuals who seek health-related interventions promotes self-care.

Another strategy to improve health outcomes is through education (Weaver et al., 2012). Mobile devices provide the functionality and convenience for individuals to track their health through the use of applications. Nurses can educate clients how to implement applications into daily living. Furthermore, nurses can use mobile device applications as a delivery tool for succinct and tailored educational messages.

Research

Further research is needed on practicality and perspectives of nurses related to uses, implementation, and outcomes of mobile device applications. Verwey et al. (2014) found nurses dedicated more time to counseling on technical issues rather than study objectives. Nursing resources and time allocation affect the feasibility of implementation; therefore, future research on issues that impact the nurse workforce are important to better understanding efficiency and effectiveness.

Research reviewed during this investigation revealed perceptions of clients but lacked substantial data on nurses' viewpoints. One study concluded nurses perceived data gained from the application helped to assess clients and communicate barriers and facilitators to change (Verwey et al., 2014). Studies are needed to evaluate nurses' perspectives in order to understand why applications are beneficial and how applications can be implemented into practice.

The review uncovered a lack of long-term, large-scale research studies related to chronic conditions. Four studies included lasted at least one year, but only one study was conducted at multiple research sites (Charpentier et al., 2011; Kristjánsdóttir et al., 2013a; Logan, 2013; Stinson et al., 2013). Nurses perform a variety of vital roles, including recruiting participants and managing application-generated data, in research studies. Therefore, nurses are in a position to foster commitment to future research and to carry out investigations.

Education

Education of nurses is essential for nurses to successfully implement mobile device applications into practice and provide quality care. The literature findings suggest clients' first-line communication occurs with nurses on issues ranging from technical difficulties to health behaviors. A foundation of knowledge is needed to understand the overall goals and functions of applications. Nurses who will communicate with clients or handle application-generated data should have fundamental knowledge on how to troubleshoot technical issues.

Nurses must be knowledgeable about which apps are appropriate for their clients as nurses may be expected to make recommendations. Aungst et al. (2014) proposes clinicians use mobile app store databases to first identify apps in accordance with needs. Clinicians who use this method will depend on taxonomy determined by the mobile app stores or by the app developers, which may not reflect medical expertise. Clinicians may find searching online databases dedicated to health-related, medical apps to be more efficient in selecting apps for their clients (Aungst et al., 2014).

Nursing Practice

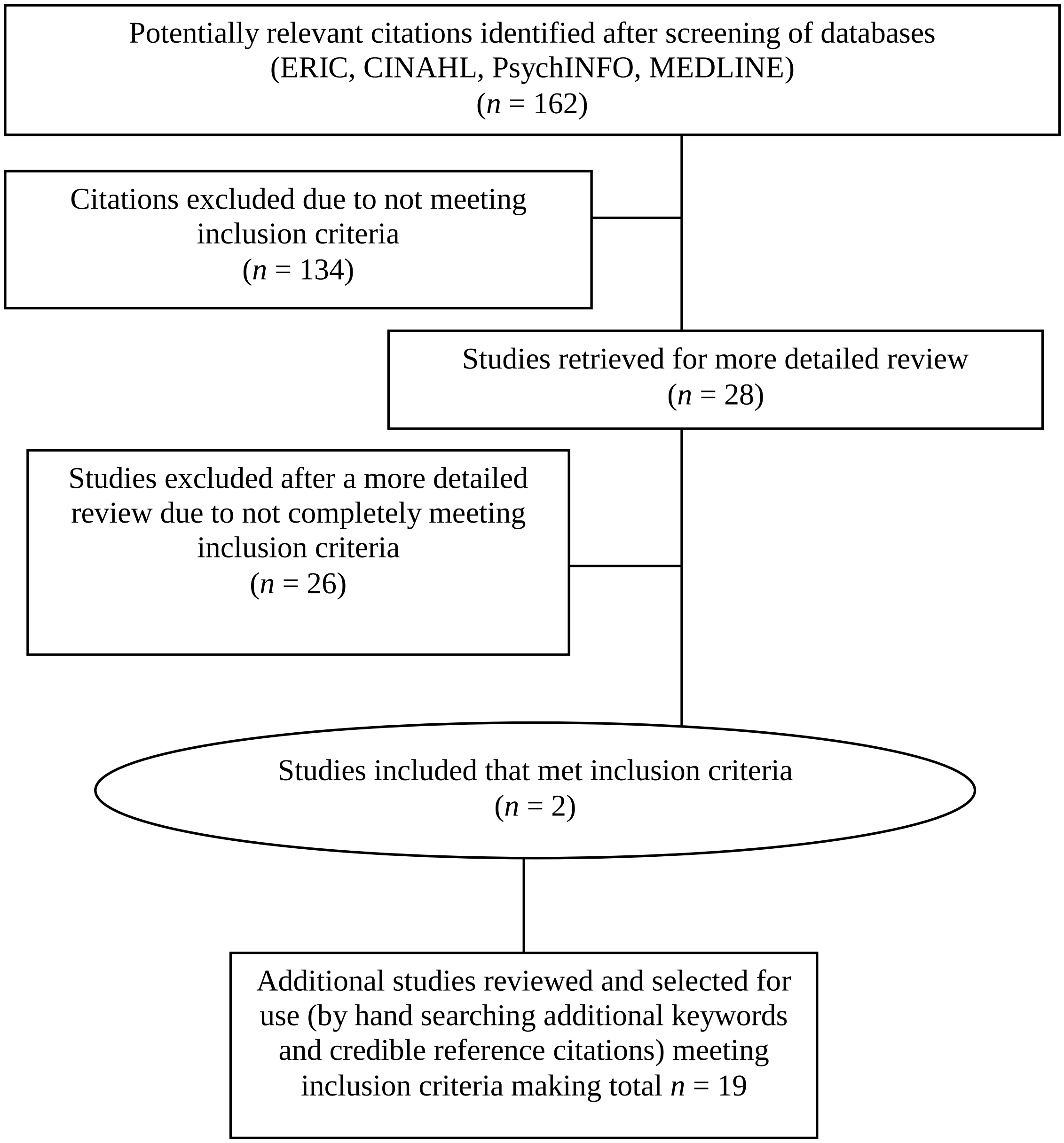
Research findings have many implications for nursing practice. Part of the commitment to evidence-based practice is for nurses to be knowledgeable about current research and to disseminate information in their healthcare organizations. Nurses are expected to make decisions based on sound evidence and judgment. In addition to direct patient care, nurses are involved in organizational initiatives to contribute to changes in healthcare practice. Nurses can help develop protocols and best practices for integration of mobile device applications by becoming workplace leaders.

Applications may help nurses tailor patient care. The literature suggests principal functions of applications are to allow clients to input and track symptoms, diet, weight, or screening measurements. Nurses have the ability to monitor data linked from clients' devices and to send feedback based on nursing judgment or preset goals. The feedback mechanism, which provides the opportunity to educate and reinforce self-management strategies, is a significant factor in tailoring care.

Conclusion

Mobile device technology has the potential to influence nursing practice. Nurses' roles may include choosing apps to implement, monitoring trends in client-generated data, and providing individualized-feedback to increase clients' motivation and knowledge regarding their health statuses. The literature suggests clients' knowledge and motivation influence health outcomes (Dennison et al., 2013; Kirwan et al., 2012). However, it is unclear whether the apps or nurses who utilize the apps are the key component in improving clients' motivation. Apps may be used as tools for increasing adherence, which has the potential for improving self-care among clients with chronic conditions. Clients using apps may have greater adherence, which may be associated with improved health-related outcomes (Burke et al., 2012; Carter et al., 2013; Charpentier et al., 2011; Kirwan et al., 2012).

APPENDIX A: FIGURE



Key Search Terms = health AND application* AND tech* AND mobile
Limiters = English language, peer-reviewed, published between 2008-2013

Figure 1: Selection Method of Literature

APPENDIX B: TABLE

Table 1: Table of Evidence

Author(s) Year Location	**Study Design and Purpose**	**Sample Size**	**Intervention Protocol**	**Screening Measures**	**Outcome Measures**	**Key Findings and Limitations**
Burke et al. (2011) United States	Prospective, randomized controlled trial Evaluate the relationship of feedback and adherence to self-monitoring and weight loss.	n=210 Paper diary (PD) (n=72) PDA (n=68) PDA + feedback (FB) (n=70)	All received reduced energy intake and attended intervention meetings PDA = Dietmate Pro software Daily feedback for PDA+FB; others weekly/biweekly	Recruited from community between 2006-2008; 18-59 years old; BMI 27-43 kg/m2; agree to randomization; recorded dietary intake for 5 days during screening; no major medical or psychiatric conditions.	Primary: Percentage weight change at 24 months. Significant weight loss for PDA+FB ($p=0.02$) but equaled out after 24 months. No difference between PDA and PDA+FB groups ($p=0.49$) Secondary: Adherence to self-monitoring over time	Adherence to self-monitoring associated with short-term and long-term weight loss; adherence more important than method. Mobile technology has potential for reducing burden of self-monitoring. PDA use resulted in greater adherence. Adherence to self-monitoring more important than the method used to self-monitor for sustained weight loss. Daily feedback enhanced outcomes, which indicates technology may play a role in weight loss. Limitations: 86% retention rate; 21% minority representation
Carter et al. (2013) United Kingdom	3-arm parallel group randomized controlled trial Test acceptability and feasibility of MyMealMate (MMM) app	n=128	Baseline height, weight, percentage of body fat measurements and self-completed questionnaires. Smartphone group given HTC with pre-downloaded MMM app. Website group given voucher for 6-months access to weight loss resources website. Food diary group given paper diary, calorie-counting	BMI > 27 kg/m2; 18-65 years old; employed by large Leeds employer; willing to commit; Internet access; read and write English; willing to be randomized; never had surgery for weight loss; not pregnant or planning pregnancy; not breastfeeding; not taking anti-obesity medications; not taking insulin for	Primary: Adherence to trial and frequency of use at 6 months Usage compared between smartphone group and website group and paper diary group ($p<0.001$) Satisfied/very satisfied with equipment: 86.6% smartphone users compared to other groups at 6 weeks ($p=0.02$); 63.2%	Smartphone group had significantly higher adherence than other groups. Usage declined by 6 months with 16% of smartphone users recorded dietary intake every day and none recording in other groups. Smartphone and diary groups had significant weight loss ($p<0.01$). Smartphone group had significant decrease in BMI and body fat percentage. Diary and website groups had significantly higher attrition rates than smartphone group ($p<0.001$). Limitations: Mostly white female sample; 20 people reported using intervention in addition to assigned one; unequal dropout rate, with dislike of study equipment most

			book, and calculator. Evaluation questionnaire given at 6 weeks and 6 months	diabetes; not taking sertraline.	smartphone users compared to other groups at 6 mos. (p=0.05) Adherence of smartphone group vs. other groups at 6-month follow up (p=0.001) Secondary: Anthropometric	cited reason.
Charpentier et al. (2011) France	Randomized open-label parallel-group multicenter study Demonstrate Diabeo smartphone software combined with telesupport significantly improves HbA1C in poorly-controlled type 1 diabetics	n=180 G1 (n=61) G2 (n=60) G3 (n=59)	Control (G1) paper log, follow up at 3 mos. and 6 mos. in person Smartphone with Diabeo (G2) without teleconsultation option, follow up at 3 mos. and 6 mos. in person Smartphone with Diabeo (G3), teleconsultation every 2 weeks and 6-mos. follow up; plasma glucose, diet, insulin data uploaded from smartphone to website; consultation focus on insulin adjustment and support.	Recruited from 17 French hospital sites Inclusion: 18 years or older; T1DM for at least 1 year; treated with basal bolus insulin for at least 6 mos. with MDI or pump; HbA1c ≥8.0% Exclusion: Participant of diabetes educational program within 3 months; clinical condition requiring more frequent follow up than scheduled quarterly visits	Primary: HbA1c levels at end point at 6 mos. G1 = 9.10 ± 1.16% G2 = 8.63 ± 1.07% G3 = 8.41 ± 1.04% Secondary: Change in the HbA1c level from baseline to end point. Proportion of participants reaching target < 7.5% HbA1c. Change in self-monitoring plasma glucose frequency (SMPG). Change in quality of life (QOL). Satisfaction based on Diabetes Health Profile and Diabetes QOL questionnaires. Time spent	Diabeo led to 0.9% decrease in HbA1c compared with control. G3 had significantly lower 6-mos. mean HbA1c compared to G1 (p=0.0019). 17% of G3 reached target goal of HbA1c <7.5%. Diabeo had impact on economic status due to G1 and G2 losing more than half a work day (nearly 5 hours); G3 saved time and money traveling but spent same amount of time in consult. Main advantage of Diabeo was correct interpretation of SMPG data and calculation of recommended insulin dose Limitations: Two groups received Diabeo software to show results of software and results of frequency of contact; participants had history of poorly-controlled T1DM

Connelly et al. (2012) United States	Continuation of Welch et al. (2013) Describe DIMA design and evaluate usage and user perceptions	n=18	Participants took PDA with DIMA home to record intake. Research assistants met with participants at each subsequent dialysis session to download food logs, voice recordings, and charge PDAs. Administered questionnaires at end of self-monitoring intervention.	Same as Welch et al. (2013)	Frequency of use. Use of individual features. 27-item post-intervention usability questionnaire: DIMA use caused them to change diet (n=11); caused them to think about how to change diet (n=17). 33-item post-intervention on usability and context of specific features	Two-thirds able to and continued to use DIMA to monitor food and fluid intake. Participants recorded average of 56% of fluid intake. Participants generally unable to successfully scan items but could use icon interface. All participants felt feedback applicable to them. Limitation: Difficulty obtaining consumption data; proxy used for literacy
Dennison et al. (2013)	Qualitative, inductive thematic analysis Explore adult perspectives on apps and changes in health behavior	n=19	4 focus groups discussions lasted 55-70 min. One researcher facilitated discussion and presented images showing health-related apps to trigger discussion. Second researcher took notes.	18-years-old; recruited from university campus; answered online questionnaire for demographic, lifestyle, and smartphone data	Analyzed themes generated from focus groups	App usefulness and appeal depends on user's existing motivation to change health behavior. Participants liked apps that help monitor attempts or changes to improve health behavior. Apps suited for those with chronic conditions who need to monitor diet and exercise, elderly who need med reminders, or those who undergo psychological therapy. Limitations: Small, self-selected sample; retrospective accounts of app use or hypothetical discussion of app us
Kirwan et al. (2012) Australia	2-arm matched case control trial Determine potential of app to improve	Intervention group (n=50) Matched group (n=150)	Intervention group given instruction on how to download and install iStepLog app, then allowed to use app or website to log steps. Intervention group given questionnaire	Recruited participants of 10,000 Steps program via email. Inclusion criteria: Access to iPhone or iTouch. Matched with comparable	Usage: Daily steps logged =11,140.22 Number of days logged = 62.06 Steps logged in app vs. website = 2210/3103 (71.22%) Total time spent on	App assisted participants in staying engaged with program. Matched (control) group had significant decline in frequency and steps logged during study. High proportion of usage (71% smartphone app vs. 29% website) suggests convenience, usefulness, and usability. Limitations: Matched-case; small sample;

	health behaviors in members of physical activity program		immediately following study on usability and usefulness of app.	ages, gender, membership length, average number and frequency of steps logged in past 3 months.	app for each participant = 11.1 min (3.74 SD) Time spent on app per occasion = 9.33 sec (3.21 SD) 5-point Likert scale on usability and usefulness: Mean usability = 4.35 (0.67 SD); 89% agree or strongly agree (39/44). Mean usefulness = 4.33 (0.75 SD); 84% agree or strongly agree (36.8/44).	short duration limits generalizability. Intervention group not representative of wider population. Intervention group self-selected and may have been more self-motivated than control group. Participants knew they were part of a study.
Kirwan et al. (2013) Australia	2-group randomized controlled trial Evaluate effectiveness of app and feedback in improving glycemic control of type 1 diabetics	n=72 Intervention group (n=36) Control group (n=36)	Both groups continued usual care from diabetes PCP every 3 months. Intervention group used Glucose Buddy iPhone app to upload blood glucose levels, insulin dosages, medications, diet, and physical activity to iPhone app. Certified diabetic educator provided feedback.	Inclusion: Age 18-65; diagnosis of type 1 diabetes > 6 months; HbA1c > 7.5%; multiple daily injections or insulin pump treatment; smartphone (iPhone) ownership	Primary: HbA1c change Secondary: Self-efficacy using Diabetes Empowerment questionnaire; self-care behaviors using Summary of Diabetes Self-Care Activities; Diabetes Quality of Life scale; Number of logs in iPhone app; number of text messages with certified diabetic educator	Intervention group had significant decrease in HbA1c ($p<0.001$) over 9 months. Control group had non-significant increase. No significant differences between groups for all other outcomes No significant relationship of text message and app engagement and HbA1c change Limitations: Intervention group had higher HbA1c at baseline; small sample; short study period; patient dropout; group differences in glycemic control and gender at baseline; possibility of some control group participants using self-care mobile app during study

Kristjánsdóttir et al. (2013b) Norway	Parallel group, randomized controlled trial Evaluate efficacy of smartphone intervention following inpatient program for chronic pain	Intervention group (n=70) Control group (n=70)	1-hour face-to-face session with nurse; 3 diaries per day on smartphone. Therapist gave feedback daily for 4 weeks, excluding weekends. Provided 4 audio files with mindfulness exercises.	Referred by practitioner at rehabilitation center. Inclusion criteria: Female; 18 years or older; participant in chronic pain multidimensional rehabilitation program; chronic pain > 6 months with or without fibromyalgia diagnosis; not participating in another research project; use of smartphone; not having a profound psychiatric diagnosis.	Primary: Pain catastrophizing scale; 13-item questionnaire with scores of 0-52, higher scores reflecting higher catastrophizing Other: Chronic pain acceptance questionnaire; general health questionnaire; chronic pain values inventory; visual analog scale; fibromyalgia impact questionnaire; short form health survey; single questions for smartphone intervention feasibility	Intervention participants immediately reported less catastrophizing than control participants ($p<0.001$). At 5-month follow up, intervention participants reported more moderate results. Limitations: 30% withdrawal rate from intervention group. Participants who completed tended to be younger, have less pain, less sleep disturbance, and better baseline function. Response rate less than 70% for follow-up assessment questionnaires.
Kristjánsdóttir et al. (2013a) Norway	11-month follow up to randomized controlled trial Evaluate long-term effects of original study with smartphone intervention with therapist feedback in	Intervention (n=39) Control (n=43)	Kristjánsdóttir et al. (2013b)	Kristjánsdóttir et al. (2013b)	Primary: Catastrophizing self-reported questionnaires Secondary: Daily function; symptom levels; acceptance of pain; emotional distress	No significant differences of catastrophizing, acceptance, functioning, and symptom level between intervention and control groups was evident ($p>0.10$). More improvement within intervention group of catastrophizing scores when compared to control group ($p=0.045$). Small positive effect ($d=0.33$) on catastrophizing from baseline to 11 months in intervention group; no change in the control group. Positive effect on acceptance found within intervention group ($p<0.001$) but not in control group. Limitations: Response rate less than 70%. Those who did not complete follow-up

	chronic widespread pain					questionnaires had generally more symptoms at inpatient admission to than those who completed follow-up questionnaires
Logan (2013) Canada	Prospective, open, randomized primary end-point controlled trial Compare measures to lower blood pressure (BP) hypertensive diabetic patients and examine effects self-care promotion	n=110 Self-care support group (n=55) Control group (n=55)	Self-care group taught to use BlackBerry app and Bluetooth-enabled home BP. monitoring device. Instructed to take smartphone to all primary care provider (PCP) visits. PCP indicated high-low values for critical alert messages and allowed to change values. Researchers did not contact participants or PCPs during study.	Inclusion: Familiar with computers; access to Internet. Exclusion: Severe or end-stage organ disease; diabetic ketoacidosis; illness with survival expectancy < 1 year; severe mental illness; disability; significant cardiac arrhythmia; symptomatic orthostatic hypotension; pregnancy; unsuitable based on PCP opinion; not fluent in English.	Primary: Change in mean daytime ambulatory SBP. 51% self-care group reached targeted <130/80 mmHg BP vs. 31% of control group ($p<0.05$) Secondary: Changes in 7 days of home BP readings; psychological questionnaire responses; prescribed anti-hypertensive medications HADS anxiety at 12 mos was non-significant ($p=0.75$); depression at 12 mos. was significant ($p=0.014$) ASI anxiety at 12 mos. was non-significant ($p=0.56$) Comfort with BP self-monitoring at 12 mos. was significant ($p=0.001$)	Primary outcome significantly decreased only in self-care group. No significant changes in control group. Decline in number of BP readings per week despite reminder messages. Better control when patient-BP monitoring allows for their engagement in decision-making. Limitations: Interventions not masked; doesn't examine detail mechanisms of support group that led to better outcome; Doesn't measure adherence to home BP measurement schedule in control, record office BP readings, or analyze weight or HbA1C changes.

Lyles et al. (2011) United States	Qualitative, randomized pilot Evaluate disease management program in type 2 diabetics	Intervention group (n=8) Control group (n=6)	Smartphone and web browser on videogame console used to upload glucose readings via Bluetooth interface and smartphone app. Nurse coordinated care plans and phone meetings, provided feedback, saw patients in clinic for scheduled visits. Semi-structured interviews at end of study for 15-40 minutes.	Inclusion: Type 2 diabetes; at least 1 visit between 2007-2008; HbA1C > 7% in past year; 18-75 years old	Average glucose readings per patient during trial = 92.5, 8.4 batch uploads. Questionnaires on connection with nurse practitioner, ease of uploading, frustration, focus on taking care of self, accesing Wii features	Increased self-awareness. Provider connection increased self-care behaviors. No value in accessing web-based elements Participants frustrated with smartphones. Some receptive to mobile communication services to manage diabetes. Development should take into consideration readiness to use technology. Limitations: Small sample size; limited comparison among age groups; technical literacy
Nes et al. (2012) Norway	Pilot study Develop and test feasibility of smartphone-based intervention to support self-management of type 2 diabetes	n=15	Smartphone with secure Internet connection, individualized nurse therapist-written feedback based on ACT, audio files with mindfulness and relaxation exercises, app to transfer blood glucose from meter to smartphone. Daily diaries with feedback for first month, then weekly after.	Recruitment through 2 general practitioners and social network of researchers for potential candidates. 5 women, 10 men ranging 49-71 years old.	Feasibility: 5-main areas questionnaire to assess experience on 5-point Likert scale and 2 semi-structured interviews Diary response rate average 67% HBA1c for behavioral change Average HBA1c the week before inclusion was mean 7.39% (SD = 1.11%) and mean 6.9% (SD = 0.8%) at end of intervention	Most perceived experience to be supportive, meaningful, and motivating. Most rated high satisfaction with content of feedback; feedback helped reinforce coping strategies to manage diabetes. Majority found smartphone user-friendly; main issues were display; size too large; Internet connection. HBA1c itself not enough to indicate behavioral changes. Nurse felt participants were not knowledgeable about diabetes. Limitations: Small sample; time-consuming in beginning; lack of nonverbal communication

					BMI ADDQoL-19 (Audit of Diabetes Dependence Quality of Life) Problem Areas in Diabetes (PAID)	
Nguyen et al. (2009)	Randomized, repeated pilot study Compare web-based and face-to-face dyspnea programs	eDSMP intervention (n=26) fDSMP control (n=24)	Nurse completed consultations, assessments, trained web group on how to record symptoms and exercise on Blackberry PDA. Reviewed submissions, provided feedback, reinforced strategies. Educated both groups on SOB symptoms and interventions. Face-to-face group did not receive PDA	COPD diagnosis and clinically stable for at least 1 month; spirometry results of at least mild obstructive disease; ADL limited by dyspnea; internet use and checking email at least 1x/wk with Windows OS; O2 sat < 85% on room air or < 6L/min nasal cannula after 6-min walk test.	Primary: Dyspnea with ADL measured with CRQ-Dyspnea subscale and rated on 7-point Likert scale 0-3 months: fDSMP +3.3 points eDSMP +3.5 points 6 months: fDSMP +4.0 points eDSMP +2.5 points Secondary: Stage of motivational readiness for exercise; exercise behavior; exercise performance; health-related QOL; acute COPD exacerbations; knowledge; self-efficacy; perception of support; program preference; usage; satisfaction	Both groups showed meaningful improvement in dyspnea with ADL and at 0-3 mos and at 6 mos. 6-min walk test declined in fDSMP and improved in eDSMP with marginal group by time difference ($p=0.05$). 100% eDSMP agreed or strongly agreed they received nurse support. HRQOL improved over time for both groups ($p<0.001$). Limitations: Technical difficulties led to ending study early; subjective self-reported primary outcome; participants may have wanted to impress researchers with favorable self-reported measures

Pfaeffli et al. (2013) New Zealand	Convergent validation study Determine validity of mobile phone physical activity (MobilePAL) questionnaire against accelerometry cardiovascular disease (CVD) clients and compare MobilePAL to self-recall questionnaire (IPAQ)	n=30	Demographics questionnaire and 6-minute walk test at first visit. Smartphone with MobilePAL questionnaire preloaded on Android app for responding to 2 questions daily for 7 days, while wearing accelerometer for 7 days. Follow-up visit after 1 week to return equipment and complete IPAQ	Adults 49-85 years old recruited from exercise-based cardiac rehabilitation clinic. Inclusion: Documented CVD history, current participant of cardiac rehab, and could safely exercise.	6-minute walk test = mean 570 meters Statistical analysis using SAS version 9.2 and R version 2.15.0 Average daily physical activity: MobilePAL = mean 1.77 (SD 0.1) Acc_CPM (daily counts per min) = mean 313 (SD 140) Acc_METs (average daily metabolic equivalent derived from Acc_CPM) = mean 1.69 (SD 0.1) Acc_PAmin (daily minutes of lifestyle, light, moderate, or vigorous physical activity) = mean 302 (SD 74) IPAQ_met (minutes per day measured by IPAQ) = mean 531 (SD 468) IPAQ_PAmin = mean 149 (SD 131)	App-based questionnaire relatively reliable and valid measure of physical activity and as good as existing self-report measures. Good association between MobilePAL and Acc_CPM. Findings support use of mobile phone questionnaire to assess physical activity in CVD clients irrespective of cardiac rehab attendance. Little within-day variability for mobile phone questionnaire. Middle-aged to older adults were able to use app successfully. Limitations: Small sample; mostly New Zealand European men

Stinson et al. (2013) Canada	Qualitative usability testing and thematic analysis Design and test smartphone pain app for adolescents with cancer	Low fidelity phase (n=15) High fidelity phase and content validity (n=18) Feasibility phase (n=14)	Interviews for usability testing to refine iPhone Pain Squad app. 2-week feasibility trial with users alerted to record pain intensity and location in game-based app twice daily, rewarded with ranks. Participants completed importance-rating surveys. Compliance and satisfaction data collected after trial.	Adolescents recruited from hematology/oncology center. Inclusion: Read and speak English; 9-18 years old; diagnosed with cancer; inpatient or outpatient of oncology team; self-reported pain at least 1x in last week Exclusion: Severe cognitive or co-morbid illness	Phase 1: User design based on pain assessment questionnaire and qualitative interviews. Content validity rated on 4-point Likert scale = 88% of pain assessment questions rated as important/very important by > 50% of adolescents. Phase 2: Clinical feasibility, compliance of pain assessments - 81%, SD 22%. No significant differences in mean compliance between morning and evening (p=0.77) or gender and treatment location (p=0.59) Satisfaction of app based on Pain Squad Evaluation Questionnaire on 4-point Likert scale = 86% liked it very much/liked it OK; 79% found app very easy/easy to fill out 2x/day.	App appealed overall to adolescents with minor revisions made for usability. Game-style app led to high compliance and satisfaction. Compliance remained high from week 1 to week 2 (p=0.55) due to notifications,in game reward system resulted in internal motivation. Some adolescents willing to use app for longer periods Pain diary has potential to improve pain management and QOL in adolescents with cancer. Limitations: Limited generalizability d/t user sample from one pediatric oncology program; app coded for Apple devices; small sample size.

Turk et al. (2013) United States	Secondary analysis of original study, Burke et al. (2011) Evaluate feedback frequency on weight loss and determine if effect was mediated by adherence to self-monitoring	n=210 Paper diary (PD) (n=72) PDA (n=68) PDA + feedback (n=70)	Same as Burke et al. (2011)	Same as Burke et al. (2011)	Significant higher adherence in PDA+FB vs. other groups ($p < 0.001$) Receiving daily feedback significantly increased self-monitoring adherence ($p=0.002$) Significant weight loss in PDA+FB mean loss of 7.0 kg vs. no feedback mean loss of 5.0 kg ($p < 0.05$) at 6 months Self-monitoring adherence significantly associated with weight loss ($p < 0.001$)	Daily feedback significantly increased self-monitoring adherence. Increasing the frequency of feedback through mobile technology has potential to enhance self-monitoring adherence. Limitations: Use of existing data for secondary analysis; sample of mostly educated, employed White females.
Vanderboom et al. (2013) United States	Feasibility, descriptive Evaluate mobile-device monitoring in fibromyalgia clients	n=20	Rated pain, fatigue, and activity 3x/day for 7 days on iPod Touch with My Pain Diary app. App-generated emails for RN review and feedback. RN encouraged self-management strategies.1-hour focus group at end of study.	Inclusion: Outpatients of fibromyalgia treatment program from 4/2011 to 7/2011	Use of mobile phones = 100% Use of smart phones = 60% Use of apps = 30% Use of text messaging = 70% Value for future use Interested in future mobile symptom tracker = 85% Prefer email communication with	Participants perceived interactions with R.N. to be valuable, served valuable role in providing feedback and reinforcing self-management strategies. Interactions have potential to impact outcomes. Limitations: Small sample size; lack of diversity of sample; limited technology used in study; relationship between time of diagnosis and level of knowledge for self-management.

					provider = 90% Text message communication with provider = 35% Frequency of use monitoring device over 7 days = 5.2 mean Overall, app easy to use = 80% Useful in managing condition = 75%	
Verwey et al. (2014) The Netherlands	Pilot study Test performance, acceptance, and satisfaction of app. Design future randomized controlled trial	n=20 COPD (n=10) T2DM (n=10)	Intervention based on model to support self-management in primary care. Participants given tool consisting of accelerometer and smartphone app to use in daily life. Nurses assessed baseline activity, helped patient set daily goal, provided feedback based on data from tool.	Nurses from two general practices recruited participants: 10 adults greater than 40 years old with Type 2 DM with BMI > 25kg/m2, 10 adults with COPD stage 2 or 3 according to GOLD criteria who would benefit from more physical activity. Exclusion: Complex co-medical conditions; insufficient Dutch language mastery; no Internet connection.	Participants and nurses interviewed for 30-60 min after each consultation about technical function, acceptability, and user satisfaction. 10-item General Self-Efficacy Scale; Exercise Self-Efficacy Scale; EQ5-D for quality of life and self-rated health: QOL scores increased from 0.76 to 0.84 (p=0.04). Mean physical activity significantly increased from first 2 weeks to last 2 weeks (10.6 min/day, p=0.02)	3 themes: Awareness of physical activity performance; stimulating effect of daily target goal; positive effect on self-efficacy Nurses spent more time counseling on technical issues than physical activity but stated tool was useful for obtaining objective data that would be hard to assess otherwise. Nurses stated it was easier to discuss facilitators and barriers when looking at data with patient. Once technical issues resolved, tool appears feasible in primary care Limitations: Small sample size; possible selection bias known by nurse to be cooperative; no control group; accelerometer had not been validated

(Welch et al., 2013) United States	Randomized, pilot study Examine feasibility of DIMA in randomized controlled trial and changes in weight gain, self-efficacy, perceived benefits and control	n = 44 Dietary Intake Monitoring Application (DIMA) Intervention (n=23) Daily Activity Monitoring Application (DAMA) Control (n=21)	Participants scanned Universal Product Codes from food packages or selected food icons from database. Feedback given relative to user's diet prescription. Research assistants collected app data at baseline, 6 weeks, and 8 weeks. Met participants 3x/week, recorded questionnaire responses.	Recruited from 2 urban dialysis centers. Inclusion: 18+ years old; alert and oriented; read and converse in English; receiving outpatient hemodialysis as primary treatment; receiving treatment for 3 months or longer; willing to use technology; self-reported difficulty following diet or fluid prescription.	Interdialytic weight gain (IWG) for pre- and post-weights (p=0.37, p=0.40) Diet self-efficacy based on Cardiac Diet Self-Efficacy Instrument; fluid self-efficacy based on Fluid Self-Efficacy Scale Perceived benefits based on Benefits of Sodium Adherence; Benefits of Fluid Adherence Perceived control based on 7-item mastery scale at 6 weeks (p=0.01) and at 8 weeks (p=0.55)	No effect on IWG based on group assignment. No statistical significance in improvements of diet or self-efficacy, but those who used app 50% of time had significant sodium reduction. DIMA group had significantly increased perceived control at end of study but returned to baseline at 8 weeks. DIMA use ranged 2-48 days during self-monitoring period. Attrition rate 25% overall. Limitations: Users did not enter data as instructed; small sample size; predominantly African American clients; lack of direct self-efficacy statements to DIMA group; potential interaction among control and DIMA during intervention.

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