SMARTPHONE APPLICATION USE PROMPTS AN EVIDENCE-BASED INTERVENTION TO IMPROVE MEDICATION ADHERENCE IN THE FAMILY PRACTICE OUTPATIENT SETTING

A PRACTICE INQUIRY PROJECT SUBMITTED TO THE GRADUATE DIVIDION OF THE UNIVERSITY OF HAWAI'I AT HILO IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

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ABSTRACT

Background: Medication adherence is defined as whether a person takes their prescribed medication at the frequency it is prescribed as well as whether it is continuously taken for as long as prescribed. Medication nonadherence is a complex and multidimensional public health challenge due to the increasing number of chronically ill individuals. Research has shown that average nonadherence rates for persons taking long-term medications for chronic conditions are between 25%-50%. Avoidable healthcare costs attributed to nonadherence account for $100 to $300 billion annually. Medication adherence can be improved at many different levels and points of contact in the healthcare system utilizing multidisciplinary and technology-based approaches. There is researched evidence that supports the use of smartphone applications (apps) to improve self-management and medication adherence rates in the United States. However, the use of such has not been studied in the State of Hawai'i.

Methods: A mixed methodology pilot study was conducted to evaluate the use of the Medisafe® Medication Management smartphone app on improving medication adherence rates of individuals from an outpatient Family Practice setting. The Medisafe® app was chosen for its comprehensive design that is intended for persons who are on multiple medications for chronic diseases who have a hard time complying with their medication regimen. Participants utilized the app as their primary reminder system for three consecutive weeks. Data before and following app use were collected via survey and statistically analyzed to determine if a medication reminder app is useful for persons in Hawai'i to improve medication adherence rates.

Results: Ten participants completed the 3-week intervention and completed the post-survey. Descriptive statistics evaluated pre- and post-survey results, which showed that medication adherence rates improved from 40% pre-intervention to 70% post-intervention and that the average number of days medications were missed was reduced with daily use of the Medisafe® app. Evaluation of participant experience indicated overall positive feedback: the app was easy to use, the app was useful, they were 100% "very likely" to continue use after the pilot study, and were "very likely" to recommend its use to others (90%). Feedback from the family medicine clinic providers and staff specified that participants seemed more likely to show interest in participation when the Primary Care Provider (PCP) themselves directly recommended or "prescribed" the app use as part of their treatment plan.

Conclusion: Data from this study are reflective of other previously conducted studies in that the use of smartphone medication reminder apps improves medication adherence rates. Individuals who utilize self-management tools to engage in health-promoting behaviors retain autonomy in realizing the outcome of their own goals towards their "ideal health." Clinicians are encouraged to recommend and support the use of smartphone medication reminder apps to patients to support the long-term goal of improving medication adherence rates population-wide and decreasing the incidence of adverse events related to nonadherence, including avoidable hospital admissions to ultimately lower total healthcare costs.

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Background

Medication adherence is defined as whether a person takes their prescribed medication at the frequency it is prescribed as well as whether it is continuously taken for as long as prescribed (Iuga & McGuire, 2014). Medication adherence is especially important as the number of medications a person takes increases and the complexity of disease states and associated comorbidities intensify.

Medication nonadherence is a complex and multidimensional public health challenge due to the increasing number of chronically ill individuals. Nonadherence can range from a person simply forgetting a dose, taking medications at altered times or doses other than as prescribed, stopping therapy sooner than recommended to intentional nonadherence or refusal. According to Hugtenburg et al. (2013), "a meta-analysis of 569 studies of medication adherence revealed an average nonadherence rate of 25%" (p. 676). Other research shows that average nonadherence rates for persons taking long-term medications for chronic conditions are between 25-50% (Centers for Disease Control and Prevention [CDC], 2017; Hugtenburg et al., 2013; Iuga & McGuire, 2014; Zaugg et al., 2018).

To add to the complexity of medication adherence, polypharmacy situations, or the concurrent use of multiple medications used to treat coexisting/comorbid conditions, have the potential to result in adverse effects such as medication interactions and new or worsening side effects (Rieckert et al., 2018). The more medications a person takes, even when taken exactly as prescribed, the higher the likelihood of medication interactions or other unintended consequences leading to harm. According to Abbass, Revere, Mitchell, and Appari (2017), nonadherence with pharmacotherapy can result in negative patient outcomes including increased morbidity and/or mortality as well as lead to increased healthcare costs overall.

Other factors including social determinants of health influence adherence rates as well. Abbass et al. (2016) identified socioeconomic factors including race/ethnicity, education level as well as income level have a significant association with adherence rates. Further details regarding the relationships between social determinants and medication adherence rates will be discussed later.

Statement of the Problem

Primary care practitioners as well as nursing leaders in collaboration with the individual clients typically take the lead in monitoring and maintaining a person's medication regimen, including medications prescribed by other providers or specialists. PCPs and nurses may utilize several different strategies including in-office medication reconciliation for promoting medication adherence. Medication reconciliation is the concept of healthcare providers collaboratively working with patients, their families, as well as other care providers to ensure that information pertaining to medications is accurately and comprehensively communicated during transitions of care as well as maintained between routine visits (U.S. Department of Health and Human Services, 2018a). However, most PCP and/or nurse-driven strategies for medication adherence have only a modest long-term effect, and despite determined efforts, there has been little progress in improving the healthcare problem of medication nonadherence.

With the advancement of technology, more and more people use or have access to a smartphone device. According to Holst (2019), there were an estimated 257.3 million smartphone users in the United States in 2018. A new and innovative approach to medication adherence now includes smartphone reminder apps that can be downloaded at little to no cost and provide a range of services to help remind patients to take their medication as well as serve as educational resources. Recent research has shown an increased rate of medication adherence when smartphone reminder apps are used daily (Burhenn & Smudde, 2015; Dayer, et al., 2014; Huang et al., 2019; Morrissey et al., 2018).

Aims and Objectives

The overarching aim of this project explored the use of smartphone medication reminder apps to improve medication adherence rates. Table 1 identifies the specific aims and objectives of this pilot project. The ultimate long-term goal of this project was to improve medication adherence rates population-wide and decrease the incidence of adverse events related to nonadherence, including avoidable hospital admissions to ultimately lower total healthcare costs.

Table 1

Aims and Objectives

Aims	Objectives
Aim 1: Identify top-rated, evidence-based medication reminder apps for both Android and iPhone Operating System (iOS) devices.	**Objective 1:** Identify the top-rated medication reminder apps for Android devices **Objective 2:** Identify the top-rated medication reminder apps for iOS devices. **Objective 3**: Compare and contrast medication adherence rates per app per device and chose a single app that can be used on either type of device.
Aim 2: Engage patients in the use of an appropriate medication reminder app.	**Objective 1**: Determine the current medication adherence rates of the surveyed population. **Objective 2**: Determine the individual educational needs of participants using the smartphone medication reminder app. **Objective 3:** Pilot a program using evidence-based guidelines to increase medication adherence rates of participants with the aid of using a smartphone medication reminder app.
Aim 3: Evaluate medication reminder app use and medication adherence rates after app use.	**Objective 1**: Compare and contrast medication adherence rates before and after using the app. **Objective 2**: Evaluate the participant's experience of using the medication reminder app. **Objective 3**: Based on evaluation results, provide practice-based change recommendations for improving medication adherence rates based on the use of the medication reminder app.

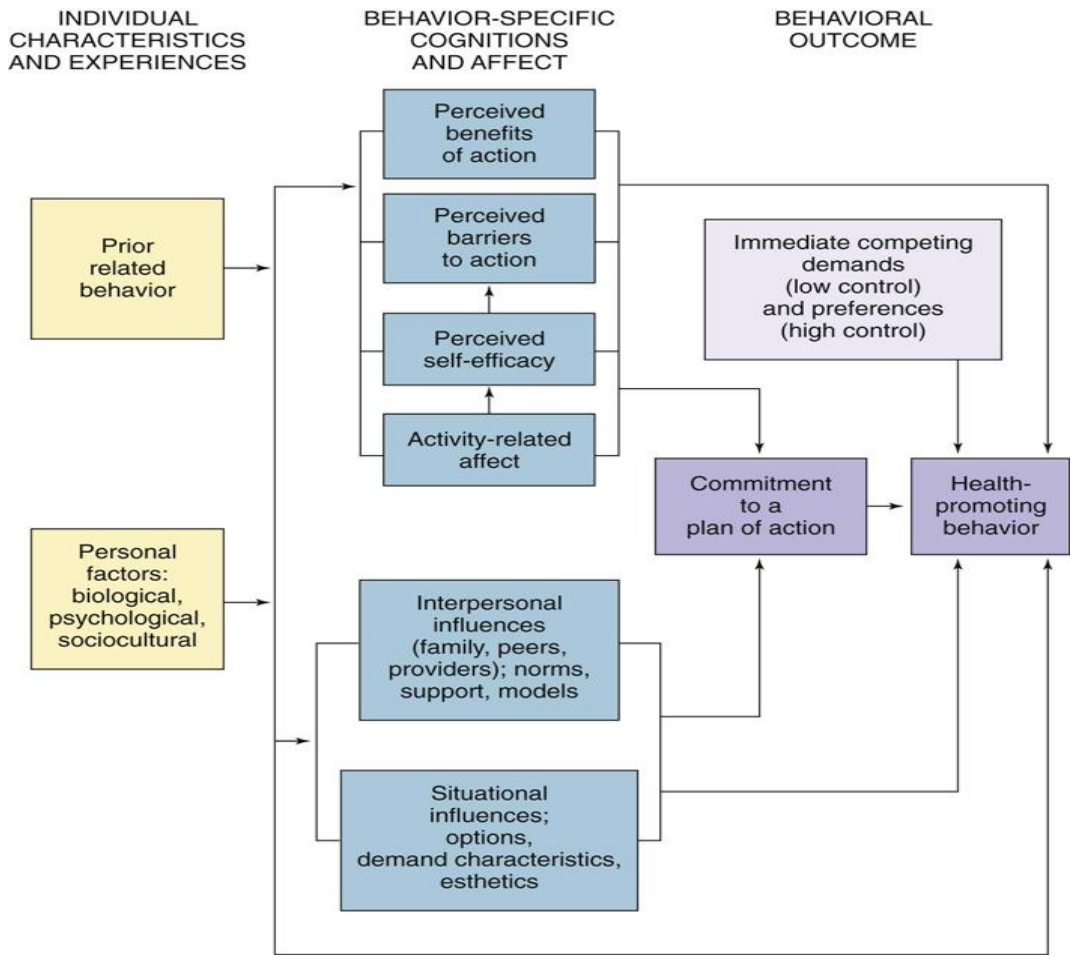
CHAPTER 2

Theoretical Framework

The Revised Health Promotion Model (RHPM) developed by Pender was utilized as the theoretical framework to guide this project. RHPM is used extensively for health-related research, education, and practice and focuses on helping people achieve higher levels of well-being. It describes the multidimensional nature of people as they interact within their environment (Petiprin, 2016). It also encourages healthcare professionals to provide resources to help patients achieve behavior-specific changes in pursuit of what the patient considers to be their definition of "ideal health." The RHPM focuses on 10 major concepts that provide a basis for exploration and determination of health-promoting behaviors. These 10 concepts can be summed up into three focus areas: Individual Characteristics and Experiences, Behavior-specific Cognitions and Affect, and Behavioral Outcomes (see Figure 1) and will be discussed in detail.

Figure 1

Revised Health Promotion Model



Individual Characteristics and Experiences

Individual Characteristics and Experiences involve two key concepts: Prior related behavior and Personal factors. Prior related behavior refers to the frequency of the same or similar behaviors that have happened to an individual in the past. Personal factors including biological, psychological, and sociocultural are predictive of specified behaviors and are influenced by the nature of the target behavior (Petiprin, 2016). Personal biological factors include variables such as age, gender, development, aerobic status, strength, and agility. Personal psychological factors include variables such as self-esteem, self-motivation, perceived health status, or definition of health and personal competence. Personal sociocultural factors include race, ethnicity, education, and socioeconomic status (Pender et al., 2002).

Behavior-specific Cognitions and Affect

Behavior-specific cognitions and affect include five key concepts: Perceived Befnefits of Action, Perceived Barriers to Action, Perceived Self-efficacy, Activity-related Affect, Interpersonal Influences, and Situational Influences. Perceived Benefits of Action are the anticipated positive outcomes that one believes will result from a health behavior. Perceived Barriers to Action are anticipated, imagined, or real personal costs of undertaking a health behavior. Perceived Self-efficacy is the personal judgment of one's own capabilities to organize and implement a health behavior and is inversely related to perceived barriers to action – higher self-efficacy results in lower perceived barriers. Activity-related Affect describes the subjective positive or negative feelings before, during, and after a heath behavior and is based on the stimulus properties of the behavior itself. Interpersonal Influences are the behaviors, beliefs, expectations, or attitudes of others (primarily family, peers, and healthcare providers) and include social norms, social support, and modeling of the target health behavior. Situational Influences are one's own personal perceptions and cognitions of any given situation that could facilitate or impede health behavior (Pender et al., 2002).

Behavioral Outcomes

Behavioral Outcomes encompass the final three key concepts: Commitment to a Plan of Action, Immediate Competing Demands and Preferences, and Health-promoting Behavior. Commitment to a Plan of Action is the notion of intention and identification of a planned strategy that leads to the implementation of the health behavior. Immediate Competing Demands and Preferences – Competing demands are alternative behaviors in which there is low control due to

environmental contingencies such as work or family care while competing preferences are alternative behaviors in which there is high control such as the choice of a snack (an apple versus ice cream). Finally, Health-promoting Behavior is the outcome of given actions which are directed towards achieving positive health outcomes such as well-being, personal fulfillment, and productive living – examples include eating a healthy diet, getting regular physical exercise, effectively managing stress, getting adequate rest, spiritual growth and building and maintaining positive relationships with others (Pender et al., 2002).

The RHPM and its encompassing focus areas and concepts were used for this project due to its direct relativity of promoting medication adherence through self-management techniques by way of a medication reminder smartphone app. As described by Petiprin (2016), the RHPM focuses on recognizing that individuals are primarily responsible for the outcome of their own behaviors, but that same outcome is also influenced by a multidimensional array of environmental and situational influences. The goal of the RHPM is blatantly stated in its name – health promotion – and a successful outcome can be measured by the individual's perception of the outcome as it relates to their individual sense of ideal health and well-being.

Literature Review

A comprehensive review of scholarly and researched-based literature was conducted to attain the most relevant, up-to-date information related to medication adherence and related smartphone applications. The following databases were used in the search: Cumulative Index to Nursing and Allied Health Literature (CINAHL), MEDLINE, EBSCO, and Google Scholar. The keywords used to retrieve articles included: medication adherence, medication nonadherence, medication compliance, medication noncompliance, medication synchronization, medication reconciliation, medication knowledge, medication education, medication and smartphone, medication reminder applications, medication apps, technology.

Several main themes were identified on the subject of medication adherence including: barriers to adherence, health literacy and communication, the influence of comorbidities on adherence, the social determinants of health that affect adherence, affordability and accessibility, influences of polypharmacy, the effects of non-adherence on the total cost of care, and finally multidisciplinary approaches for patient support and strategies for improvement.

Barriers to Adherence

An individual's reasons for nonadherence vary and can be grouped into two categories: unintentional and intentional nonadherence. Unintentional nonadherence refers to unexpected or inadvertent actions that result in not taking medication at the correct time, dosage, or strength of which it is prescribed. Intentional nonadherence refers to the conscious decision to not follow the prescribed medication regimen. This conscious decision may be the result of preconceived, possibly incorrect knowledge of how the medication works, misunderstanding of potential side effects or interactions with other medications, lack of trust in the medication or prescriber, or observations of friends or family who take the same medication (CDC, 2017; Hugtenburg et al., 2013). Additionally, using certain medications may be stigmatizing, or be a reminder that one's health is less than optimal.

Health Literacy and Communication

Health Literacy, as defined by the Patient Protection and Affordable Care Act of 2010, Title V is the "degree to which an individual has the capacity to obtain, communicate, process, and understand basic health information and services to make appropriate health decisions" (p. 437).

Heath literacy applies to both individuals who need health information as well as to those who provide health information. For an individual to make informed decisions about their health care, they must have the skills to obtain information and services, communicate their needs and preferences, process the meaning and usefulness of the information, and have the ability to decide on the information to match their needs (CDC, 2019c). Anyone who provides health information to others, such as a doctor, nurse practitioner, nurse, or other healthcare professional must have the health literacy skills to help people find information and services, effectively communicate about health and healthcare, understand and process what a person is explicitly and implicitly asking, understand how to provide useful information and services and to decide which information and services work best in different situations and for different people (CDC, 2019c).

Open, bidirectional communication with a person is of the utmost priority for clinicians when prescribing a medication, especially when prescribing a new medication, as this can be a time of heightened stress and anxiety for a person. According to Iuga and McGuire (2014), poor communication by the clinician leads to a 19% higher risk of nonadherence. With regards to

medication adherence, the person must have the ability to understand the purpose of the medication, the importance of the timing of doses, and ultimately the goals of the treatment plan. Clinicians must be able to effectively communicate the purpose of the medication and its dosing regimen, identify barriers and understand and respond to the individual's specific needs and overall healthcare goals. A trusting relationship between the individual and the clinician results in better communication and understanding, decreased barriers, and ultimately increased adherence (deGuzman et al., 2013).

Clinician training to improve communication skills in turn, leads to improved rates of adherence. Interventions and programs that increase a person's knowledge of their disease and treatment plan helps to address underlying concerns or fears and allows a person to self-identify barriers to medication adherence and to ask appropriate questions. Education should be tailored to meet the person's level of understanding (Hugtenburg et al., 2013). Adequate time must be taken to ensure understanding and address any concerns or questions.

Comorbidity Influence on Adherence

Data is conflicting when comparing adherence and comorbidities. Some studies indicate that there is a positive direct correlation between increased adherence and comorbidities (Abbass et al., 2017; deGuzman et al., 2013), while other studies show an inverse correlation between the two (Rasmussen et al., 2007). Some studies found that persons may be more likely to be nonadherent and forget to take medication entirely when they are taking only one or two medications (Iuga & McGuire, 2014). Opposingly, other studies found that persons taking five or more medications are more likely to be nonadherent due to the complexity of comorbid conditions as well as dosing schemes (Hugtenburg et al., 2013). In addition, individuals with comorbid or mental health disorders are typically less adherent to medications for other comorbidities such as cardiovascular disease and diabetes. (Abbass et al., 2016; Desai et al., 2014; Hansen et al., 2012; Nelson et al., 2011).

Social Determinants of Health Influencing Adherence

Social determinants of health (SDH) are the "conditions in which people are born, grow, work, live and age and the wider set of forces and systems shaping the conditions of daily life" (World Health Organization [WHO], 2019). These forces and systems include economic and social policies and systems, developmental agendas, and social norms.

Much research has been conducted on the individual influences of adherence rates, while less attention has been focused on the social determinants that influence adherence. Abbass et al. (2016) identified socioeconomic factors including race/ethnicity, education level as well as income level have a significant association with adherence rates.

There is conflicting research suggesting gender and age influencing adherence rates. Some studies indicate that there is little association between gender and age on adherence rates (Zaugg et al., 2018; Rieckert, et al., 2018), while other studies do show a positive correlation. For example, research by Abbass et al. (2016) indicate that males are 11% more likely to be adherent to statin therapy than females. In addition, an increase in age by one year is associated with a 3% increase in statin therapy adherence.

Individuals who come from traditionally disadvantaged social groups, those who have limited education or those living in neighborhoods that have a high proportion of households receiving economic public assistance are 8% more likely to be nonadherent (Abbass et al. 2016; Heath, 2019). Additionally, non-adherence rates among ethnic minorities, in particular, Hispanic and African American-dominated neighborhoods exceeded that of predominantly white neighborhoods (Abbass et al. 2016; Heath, 2019).

Affordability and Accessibility

The affordability, including out-of-pocket (OOP) costs of a medication, is an individual as well as a societal variable when determining adherence rates. Whether a person can afford their medication has a direct influence on if the medication regimen is followed, or if the medication is picked up from the pharmacy at all. Previous studies provide strong evidence of the linear correlation between OOP costs and adherence, even amongst those who are classified as having high income levels (Iuga & McGuire, 2014).

In a retrospective cohort study conducted by Abbass et al. (2016), 49,176 individuals, aged 18-64 years who were taking a statin were found to have a statistically significant correlation between OOP costs and adherence. The study found that a $10.00 increase in monthly OOP cost resulted in an approximately 7% decrease in the adherence rate.

According to Abbass et al. (2016), access to community-based pharmacies influences prescription refill behavior. Neighborhoods with higher pharmacy density typically have higher prescription refill rates. Likewise, when patients have a developed relationship with their clinician as well as a pharmacist or pharmacy staff, adherence rates rise (National Community

Pharmacists Association, 2013). In addition, enrollment with mail-order pharmacies is associated with higher adherence rates.

Influences of Polypharmacy on Nonadherence

Polypharmacy, or the use of multiple medications and the resulting complexity to medication dosing regimen as well as the need to manage potential drug-drug interactions has been associated with increased nonadherence rates. A study conducted by Rieckert et al. (2018) identified frailty, comorbidity, obesity, decreased physical and mental health status as risk factors for polypharmacy. According to the CDC (2017), 50% of Americans take at least one prescription medication, 23% take three or more prescription medications, while 11% take five or more medications. Research shows that polypharmacy, especially in older adults is associated with a number of negative health outcomes such as decreased functional and cognitive status, increased risk of falls, adverse drug events/drug-drug interactions, avoidable hospitalizations, and mortality (Rieckert et al., 2018).

Adverse drug events and/or drug-drug interactions (DDI) occur when one medication modifies the pharmacological effect of another medication when taken concurrently in one of three ways: synergistic, antagonistic or additive. Synergistic DDI result in increased efficacy of one or all of the drugs involved. Antagonistic DDI's result in decreased efficacy of one or all of the drugs involved. An additive DDI occur when the combined total effect of the medications is equal to the sum of the individual effects of each individual drug. The rate of adverse events or drug-drug interactions increased comparably with the increased number of medications (Rieckert et al., 2018). Clinicians must be mindful of age in association with the number and type of medications a person is prescribed, especially in frail persons or for those who take eight or more medications. Comprehensive medication reconciliation should be conducted regularly to evaluate the appropriateness, necessity, and potential adverse events associated with the medication regimen.

Effects of Nonadherence on Total Cost of Healthcare

In 2017, the estimated population of persons over the age of 60 years was 962 million. This group comprises 13% of the global population, and is expected to double by the year 2050 and triple by the year 2100 (United Nations, 2019). The United States Census Bureau (2020) notes that the U.S. older population, above the age of 65 grew from 3.1 million in 1900 to 35 million in 2000. This rapid growth can be linked to the advancements in medicine and

technology leading to increased lifespans as well as the aging Baby Boomers, who began turning 65 in 2011. Currently, the total population of persons aged 65 and older has surpassed the total population of 65 and younger (Roberts et al., 2018).

According to Iuga and McGuire (2014), financial impacts from medication non-adherence are passed from insurance payers to patients via higher medication copayments or via insurance payers to employers for medical coverage. This increase in cost to the consumer again negatively impacts medication adherence rates. Those who are already on a fixed income such as Medicare beneficiaries and those who are employed at minimum wage levels then have an even more difficult time affording medications when co-payments are increased. Benefits of improved medication adherence affect not only the individual but the community and society as a whole. Iuga and McGuire (2014) note that avoidable healthcare costs attributed to nonadherence account for $100 to $300 billion annually in the U.S, which represents 3% to 10% of total US healthcare costs annually. Reduction in total costs of care will only be obtained when collaboration between policymakers, insurers, providers, and patients occurs.

Multidisciplinary Approaches for Support and Strategies for Improvement

The literature clearly indicates that medication adherence can be improved at many different levels and points of contact in the healthcare system utilizing multidisciplinary and technology-based approaches. Patients, as well as clinicians, benefit when lines of communication are left open and attention is paid to adherence rates.

Research has shown that taking a multidisciplinary approach to patient-centered care leads to better outcomes overall (Iuga and McGuire 2014; Winters et al., 2016; Zaugg et al., 2018). This concept is the same for improving medication adherence rates and providing education and support. Physicians, nurses, pharmacists, other members of the clinical care team can utilize health-based technology to provide patient education and support patient self-management.

Several studies have been conducted assessing the effects of providing feedback to physicians regarding their patients' medication adherence and interventions for improved outcomes. Clinicians have a tendency to overestimate individual and population-wide medication adherence rates, leading to missed opportunities for improvement (Davis and Kendrick, 2014; Winters et al., 2016). One meta-analysis of eight various studies involving 22,942 patients found that although feedback regarding medication adherence may improve clinician processes of care,

there was little evidence to support that this feedback ultimately improves medication adherence rates overall (Zaugg et al., 2018).

Several interventions have been identified by various literature resources to improve adherence rates. Starting at the most basic level, Hugtenburg et al. (2013) identified that simplification of dosing regimens resulted in improved adherence rates. A meta-analysis of 76 studies showed that a once-daily dosing regimen had a 72% adherence rate. Sixty-nine percent of patients were adherent if they took medications twice daily. Three times daily dosing had a 65% adherence rate. Those who took medications four times daily were adherent 51% of the time. Other studies indicated that packaging systems such as weekly pill reminder boxes, blister packs, and calendar packaging resulted in increased adherence rates (Hugtenburg et al., 2013).

Use of Technology

Research on the use of electronic reminder systems such as smartphone apps has been shown to improve self-management support of individuals and thus improve medication adherence rates (Burhenn & Smuddle, 2015; Hammonds et al., 2015; Huang et al., 2019; Morrissey, et al., 2018; Osahon et al., 2020).

In a study completed by Hammonds et al. (2015), 57 college students who had a current prescription for an antidepressant were studied comparing adherence rates with and without the use of a smartphone app. Students in the treatment group were three times more likely to be adherent to their medication regimen as compared with the control group. The study concluded that the use of a medication reminder app was beneficial for adherence to antidepressant medication regimens.

Osahon et al. (2020), published a study on 200 glaucoma patients in Nigeria who participated in a randomized control trial to assess the impact of a medication reminder mobile app. In the study group, 56 % were very adherent, 18 % were moderately adherent, and 26 % were non-adherent as compared against the control group who were 45% very adherent, 13 % moderately adherent, and 42 % non-adherent. Additionally, 78% of those in the study group agreed that there was an improvement in their medication adherence since they started using the medication reminder application.

A qualitative study by Morrissey et al. (2018), set out to investigate patient's perspectives regarding engaging with smartphone applications to support and improve medication adherence in hypertensive patients. Data showed that participants could identify the benefits of a

medication reminder app and recognize that self-monitoring their blood pressure could be empowering in terms of their understanding of their condition, and improve interactions with their PCP's.

Consumer perspectives and feedback regarding the use of technological tools are largely positive and individuals are able to recognize the benefits and empowerment of such (Morrissey et al., 2018; Osahon et al., 2020). Medication adherence apps can be downloaded at little to no cost and can benefit both those who take a single medication as well as those who take multiple medications (Dayer et al., 2014).

Currently available medication reminder apps. Currently, there are thousands of different medication adherence apps available for download, however, many lack key functionality features. Differentiating which apps are best suited to meet the needs of the individual as well as fulfill the desires of healthcare providers is an area that needs more research (Huang et al., 2019). This investigator conducted an independent comparison of available medication reminder apps for both Android and iOS devices of desirable features and functionality (fulfilling aim 1, objectives 1-3). Features and functionally categories included: app star rating, free for use, iOS compatible, Android compatible, personalized dosing schedule, multiple dosing schedule, personalized pill identification, reminder generated with no data connectivity, tracking of taken and missed doses for the day, tracking of history, number of reminders of the same scheduled dose, medication education database, ability to sync with other users, could data storage and refill reminders. The top eight apps are identified in Table 2 along with the desired features and functionality. Each category was assigned 1 point, with the exception of app star rating and number of reminders for same scheduled doses which were scored based on the data in each cell. The total score was tallied and ranked from most to least points to identify the best app to use for this project.

Table 2

Comparison of smartphone app features and functionality

	App star rating	Free for use	iOS	Android	Personalized dosing schedule	Multiple dosing schedule	Personalized pill identification	Generates reminders with no data connectivity	Tracks taken and missed doses	Tracks history	Number of reminders for same scheduled dose	Medication education database	Syncs with other users	Cloud data storage	Refill reminder	**Total points**
Medisafe	4.7	x	x	x	x	x	x	x	x	x	3	x	x	x	x	**21.7**
MyTherapy	4.8	x	x	x	x	x		x		x	2		x	x	x	**16.8**
Mango Health	4.4	x	x	x	x	x	x	x	x	x	1		x	x		**16.4**
Pill Reminder	4.7	x	x		x	x		x	x		2	x		x	x	**15.7**
Dosecast	4.2	x	x	x	x	x		x	x		2			x	x	**15.2**
MyMeds	3.6	x	x	x	x	x		x	x		1		x	x	x	**14.6**
Round Health	4.5	x	x		x	x		x	x		2			x	x	**14.5**

Medisafe®. The Medisafe® Medication Management, developed by Medisafe, Inc. was deemed to be a first choice for this research project as it is the most cost-effective, usable on both iOS and Android devices, user-friendly, and had one of the highest user satisfaction ratings compared to other apps. Medisafe® is a well-designed app intended for patients who are on multiple medications for chronic diseases who have a hard time complying with their medication regimen. The app has a number of features including a personalized dosing schedule, medication reminders, multiple reminders for each dose, tracking of doses taken and missed, pill identification, medication interaction alerts, refill reminders, and a medication education database. The Medisafe® app is free for download and use and does not require a subscription for services. Some in-app purchases are available but do not restrict the use of the app if no purchases are made, however, data may be shared with third parties such as analytic services and used for market and customer analysis. The Medisafe® app has a “Medifriend” feature that allows the patient to add a family member, caregiver, or friend to his/her profile who can help monitor and encourage adherence (Majmudar & Aungst, 2020; MyMedisafe, 2019). Data is also stored on a cloud-based system and can be accessed from multiple devices.

CHAPTER 3

Project Goal

There is researched evidence of the relationship between the use of smartphone apps and the improvement of self-management support of individuals and in turn improvement medication adherence rates in the United States, however, the use of such has not been studied in the State of Hawai'i. The goal of this project was to assess the hypothesized improvement in medication adherence rates when a smartphone app is used as a reminder system. This chapter describes the methods used to implement the aims and objectives of this project, the steps and actions taken to meet the aims and objectives, the evaluation of results after implementation, and the project timeline.

Project Setting and Population

The setting for this project was conducted in a private family practice clinic in Hilo. The target population were patients of the family practice clinic. These participants were self-referred from a flier posted in the family practice clinic (see Appendix A). Participant inclusion criteria were the following: aged 18 years old and above; take at least one daily prescribed chronic medication; must be able to speak, read and write in English; have a personal smartphone; be willing to download and use the intended smartphone medication reminder app. Exclusion from participation included: aged 17 years old and below; do not take any daily prescribed chronic medications; unable to speak, read or write in English; do not have a personal smartphone; unwilling to download and use the intended smartphone medication reminder app. There was no discrimination based on gender, ethnicity, religious/cultural background, or sexual preference.

Participants were informed that participation was entirely anonymous and voluntary and that self-withdrawal was acceptable at any time. Written instructions were given to each participant directing the download of the app as well as the use and functionality of the app (see Appendix B). Participants only had interaction with the investigator when they required assistance in setting up the app on their phone. Participants were also informed of a required pre- and post-participation survey that was made available to them online via a link.

Ethical Assurance

Prior to engagement in the intervention, including completion of the surveys, informed consent was obtained from each participant (see Appendix C). To ensure confidentiality, and anonymity of data, each participant was assigned a unique identification number to link the

participant to the data collection and program outcomes. All study data was filed and stored by this investigator on a password-protected computer. The ethical standards of this project were reviewed and approved by the University of Hawai'i Institutional Review Board (IRB) on January 19, 2021 (see Appendix D). The investigator strictly followed the Health Insurance Portability and Accountability Act (HIPAA) regulations. Participant engagement in the project was not restricted based on participant demographics.

A Memorandum of Understanding (MOU) was signed by the participating family practice clinic. The principal investigator is an established employee, functioning as the clinic's registered nurse. The outcome of this project had no bearing on previous or continued employment at this clinic. A Letter of Agency Support was signed by The Family Medicine Center to conduct this research project with their patients and within this clinic (see Appendix E).

Methodology and Procedure

According to the theoretical framework of the Revised Health Promotion Model (RHPM), as previously discussed, healthcare professionals are encouraged to provide resources and tools to patients in order to achieve behavior-specific changes in pursuit of ideal health and well-being. The family practice clinic where this project took place conducts thorough medication reconciliation during each visit with the patient to ensure accuracy in dosing and directions of medications prescribed. However, true medication adherence is dependent solely on the individual.

The Medisafe® app was the tool that was used by participants. The intended behavioral outcome of the intervention was for participants to commit to the plan of action in order to achieve the intended health-promoting behavior of increasing and/or maintaining medication adherence and in turn assist in the achievement of their ideal health.

The intervention portion of this project lasted five weeks for each participant and focused on Aims 2 and 3. Aim 1 was completed prior to engagement with participants.

Aim one. The first aim of this project was to identify top-rated, evidence-based medication reminder apps for both Android and iOS devices.

Objective one. Objective one identified the top-rated medication reminder apps for Android devices based upon app star ratings.

Objective two. Objective two identified the top-rated medication reminder apps for iOS devices, again based on app star ratings.

Objective three. Objective three compared and contrasted medication adherence rates per app per device and chose a single app that can be used on either type of device.

Aim two. The second aim of this project engaged participants in the use of an appropriate medication reminder app. Participants were recruited via an informational recruitment flyer.

Objective one. Objective one was to survey participants in order to determine current medication adherence rates. A Likert-scale survey (Appendix F) was used as the primary means of data collection, accessed by participants via Survey Monkey, an online survey tool.

Objective two. Objective two focused on determining individual educational needs of patients using the smartphone medication reminder app. This was accomplished using open-ended questions immediately following the Likert-scale survey questions (Appendix F). Participants were also provided with this investigator's email within the Consent to Participate (Appendix C) in the event that participants had additional questions or educational needs.

Objective three. Objective three involved the implementation of the project wherein participants utilized the smartphone app. Participants were first provided with written instructions on how to download and utilize the smartphone app. Participants then used the smartphone app as the primary means of reminding participants to take their medications on time. This intervention portion of the project lasted three weeks for each participant.

Aim three. The third aim of this project was to evaluate the usage of the medication reminder app by participants as well as medication adherence rates after app use. Objectives one and two were completed during the week immediately following the three weeks of the intervention portion of this project.

Objective one. Objective one compared medication adherence rates of participants before and after using the app. Utilizing a post-intervention Likert-scale survey (Appendix G), data on adherence rates after app use were collected and analyzed in comparison with adherence rates prior to app use.

Objective two. Objective two evaluated the participant's experience of using the medication reminder app. Again, utilizing a post-intervention Likert-scale survey (Appendix G), data of patient experience of the app use overall were analyzed.

Objective three. Objective three was to provide practice-based change recommendations for improving medication adherence rates based on evaluation results and is summarized in the final recommendations of this project.

Data Collection Instrument

A 5-point Likert ordinal-scale survey was used for pre- and post-surveys of participants (Appendix F and Appendix G). The survey obtained basic demographic data such as age range, sex, and ethnicity. Quantitative data questions pertained to medication adherence rates and smartphone medication reminder app use. Qualitative data were also collected from the same survey. All questions were written at a sixth-grade reading level to ensure participant understanding of each question. This survey was constructed by this investigator, with the assistance of the University of Hawai'i at Hilo faculty.

The survey was available to participants via the internet survey platform SurveyMonkey which allowed participants to effectively answer the survey from home and also allowed for efficient aggregation of participant data. The Survey Monkey platform was accessible via the participant's smartphone or home computer via internet connection. Participants were given access to the SurveyMonkey link once consent to participation in the project was signed and returned to this investigator. Participants were required to use their participant identification number during both pre- and post-surveys in order to keep participant answers confidential and coordinated.

Timeline

The initial recruitment phase of the project began on February 2, 2021. Open recruitment lasted through February 28, 2021. Participants completed the pre-intervention survey and thereafter independently utilized the Medisafe® smartphone app for three consecutive weeks. Participant's recruitment date and pre-survey completion dates were tracked in order to maintain a 3-week intervention for each participant. When the participant completed the 3-week intervention, an email reminder to complete the post-survey was sent. Post-intervention surveys were collected beginning March 2, 2021, and continued through April 7, 2021, depending on when each participant signed the participation consent.

Data Analysis Methods

Pre- and post-intervention surveys were conducted to obtain statistical and descriptive data including demographics and participant characteristics. The pre- and post-survey was developed based on the 5-point Likert ordinal scale to evaluate the effectiveness of this project. Likert-type scales have been previously shown to have an 88%-90% reliability and 57%-89% validity (Louangrath, 2018), thus making it an acceptable tool to use to evaluate the effectiveness

of this project. Mixed methodology was used for data analysis of this project. Quantitative and qualitative data obtained from the Likert-scale and open-ended questions were aggregated on a spreadsheet. Descriptive statistics of quantitative data were used to calculate medication adherence rates prior to app use and to then understand the correlation between the use of the app and medication adherence rates. Qualitative data obtained from the open-ended questions were summarized into like-themes in addition to the use of representative quotes.

CHAPTER 4

Data Collection Process

Recruitment flyers for the study were posted throughout the family practice clinic and in each examination room starting on February 2, 2021. PCPs of the clinic as well as medical support staff assisted this investigator in promoting the study and recruiting participants. Initially, this investigator projected that 30-40 participants would be recruited because the family practice clinic sees on average 120 patients per week. During the initial recruitment week, only five participants were recruited. Clinical staff of the family practice clinic cited reasons for patients not wanting to participate included: "not having a smartphone," "not feeling that the app would be useful," or "not being interested in participating." Other reasons included prospective participants not returning the consent nor completing the pre-survey. Because of the initial low participant count in the first recruitment week of the project, this investigator extended the recruitment phase for three additional weeks – ending February 28, 2021 – to ensure a large enough participant pool to be statistically significant. In total, 13 signed consents were returned and 13 pre-surveys were completed.

Results

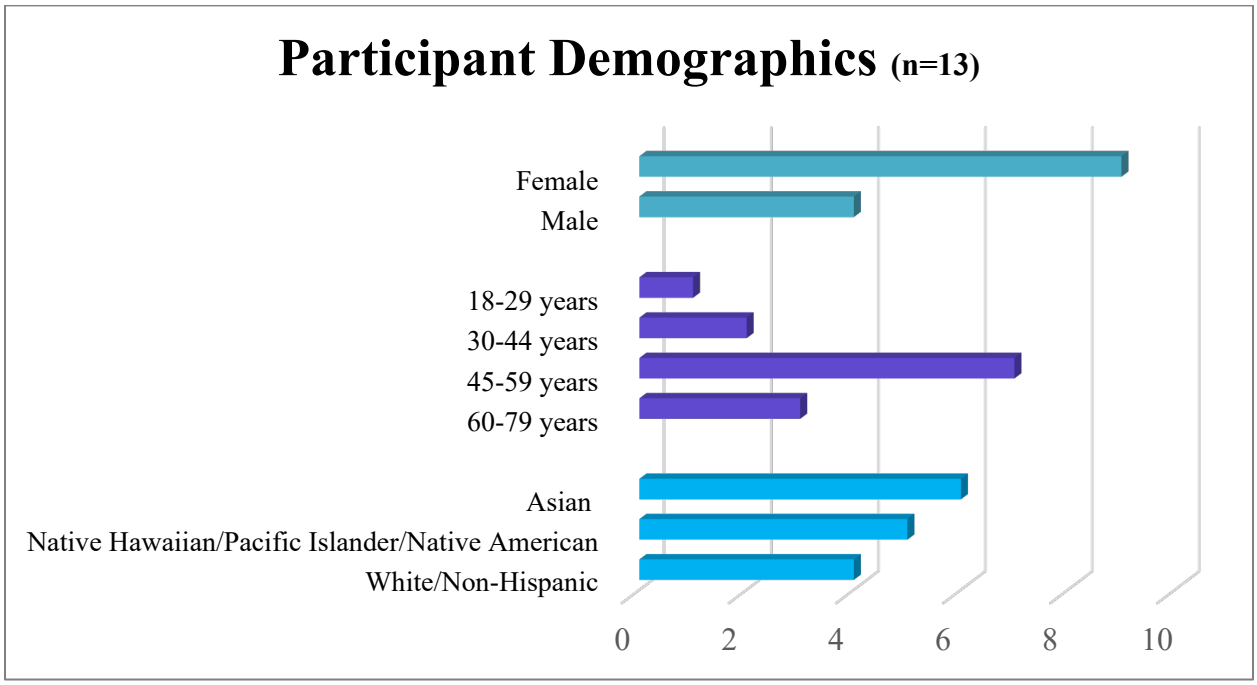
Pre-intervention Survey Results

Aim 2, objective 1 of this project was to determine current medication adherence rates of the surveyed population. Pre-intervention data collected via online survey focused on participant demographic data as well as data regarding medications and adherence rates before app use.

Participant demographic data. The participant pool of 13 individuals included 9 women (69%) and 4 men (31%). Reported ethnicities included Asian (40%), Native Hawaiian/Pacific Islander/Native American (33%), and White/Non-Hispanic (27%). Age of participants included: one participant (8%) who was between 18-29 years; Two participants (15%) who were between 30-44 years; seven participants (54%) who were between 45-59 years; and three participants (23%) who were between 60-79 years old. Graph 1 depicts participant demographics.

Graph 1

Pre-survey Participant Demographics

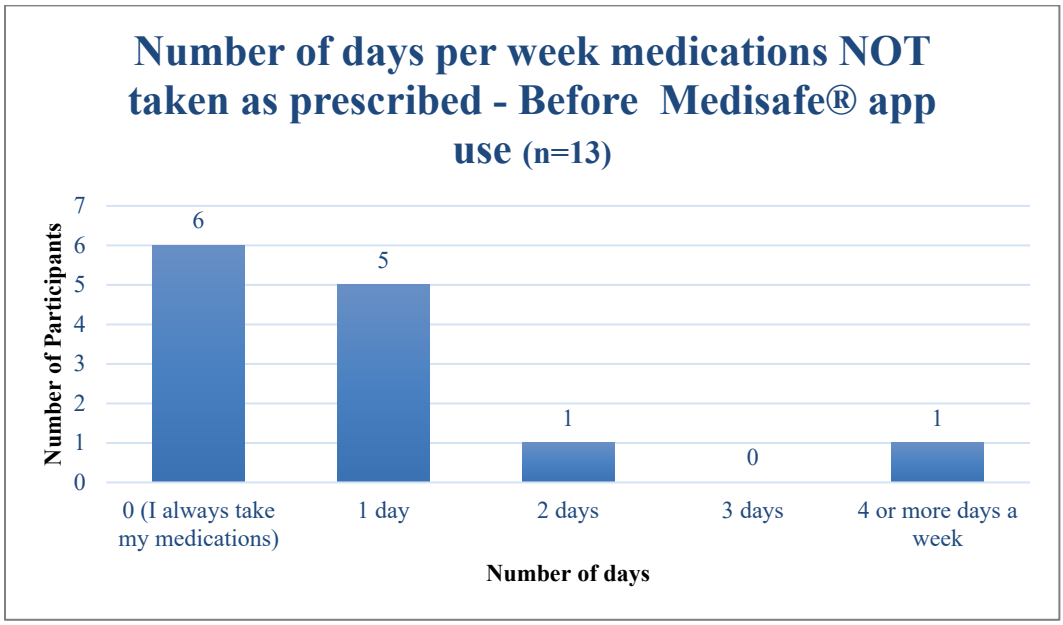


Data regarding number of daily medications and medication adherence before app use. Of the 13 recruited participants, four participants (31%) reported taking 1 daily medication; two participants (15%) reported taking 2-3 medications; four participants (31%) reported taking 4-5 medications; two participants (15%) reported taking 6-7 medications; one participant (8%) reported taking 8 or more daily medications.

Graph 2 depicts the number of days per week medications were not taken as prescribed before Medisafe® app use. Prior to using the medication reminder app, six participants reported that they always take their medications. Five participants reported that prior to app use, they did not take their medications one day per week on average. One participant reported that they did not take their medications on average two days per week. Finally, another single individual reported that they did not take their medications four or more days per week prior to app use. Overall, total medication adherence rates for the participant recruitment group were 46%.

Graph 2

Number of Days Per Week Medications Not taken As Prescribed Before Medisafe® App Use



Primary reported reason for participants not taking medications as prescribed was "I forget/can't remember" (69%) while 13% of participants cited "other" individual reasons such as "I'm not at home at the time I'm supposed to take my medication," and "other physical illness impeding desire or ability to take medications." Twenty-seven percent of participants indicated that they take their medications daily. This statistic is in contrast to the previous pre-intervention survey question how many days of the week do you not take your medications as prescribed? wherein 46% of participants answered that they do not forget to take their medications/that they always take their medications. No participants cited reasons of "I don't think the medications work," "the medication causes side effects I don't like," or "I don't want to take it" as reasons for not taking their medications as prescribed.

Data regarding app use. Overall, 45% (n=6) of participants felt "very confident" that they would be capable and willing to using the smartphone app every day; 31% (n=4) felt "confident"; while 23% (n=3) were "neutral." No participants reporting being unconfident or unwilling to use the app.

Seventy-seven percent (n=10) of participants were "very committed" to using the smartphone app every day as the primary means of their medication reminder system. Eight percent (n=1) of participants were "somewhat committed," eight percent (n=1) of participants

were “neutral,” and seven percent (n=1) of participants were “somewhat not committed” to the app use.

Educational needs. The pre-intervention survey asked participants if they had any concerns or anticipated difficulties while using the app that may impact the app use and subsequent medication adherence (Aim 2, objective 2). This part of the survey was intended to determine if there were any educational needs of the participants in order to help facilitate the app use. Eleven of the thirteen participants (85%) indicated no concerns or educational needs. One participant cited that they “had to change times to military time, then it worked.” This response indicated that the participant started using the app before the pre-survey was completed. A second participant indicated “app problems due to older phone.” Neither of these participants reached out to the investigator for assistance or further concerns.

Post-intervention Survey Results

Aim 3 of this project intended to evaluate the usage of the medication reminder app by participants as well as medication adherence rates after app use.

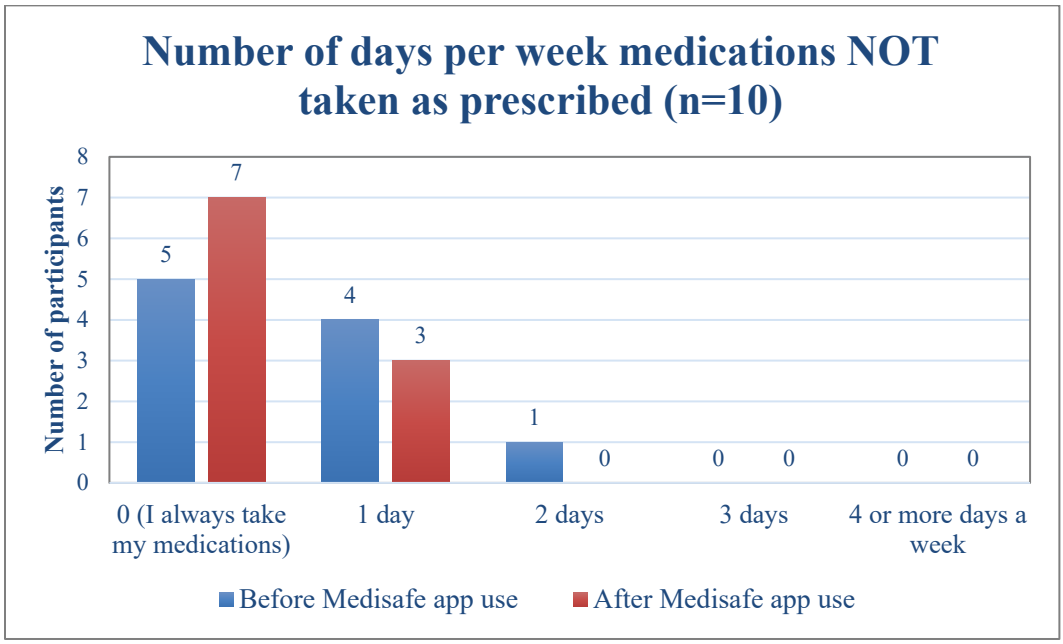
Data regarding medication adherence after app use. Aim 3, objective 1 of this project compared medication adherence rates of participants before and after using the app. After participants used the Medisafe® smartphone medication reminder app as the primary means of their medication reminder system, post-surveys were completed and collected from 10 of the 13 participants. Moving forward, all data will be discussed based on the 10 participants who completed the pilot project.

Utilizing a post-intervention Likert-scale survey, data on adherence rates after app use were collected and analyzed in comparison with adherence rates prior to app use. Medication adherence rates pre-intervention of the 10 participants were recalculated to be 40% (n=4). Post-survey results indicated that medication adherence rates of the 10 participants increased to 70% (n=7).

Participants were surveyed on how many days per week medications were not taken as prescribed while using the app. Graph 3 depicts the number of days medications were not taken as prescribed before and after app use. Seven participants (70%) now reported that they took their medications every day while three participants (30%) reported that after app use, they did not take their medications only one day per week on average.

Graph 3

Number of Days Per Week Medications Not Taken as Prescribed



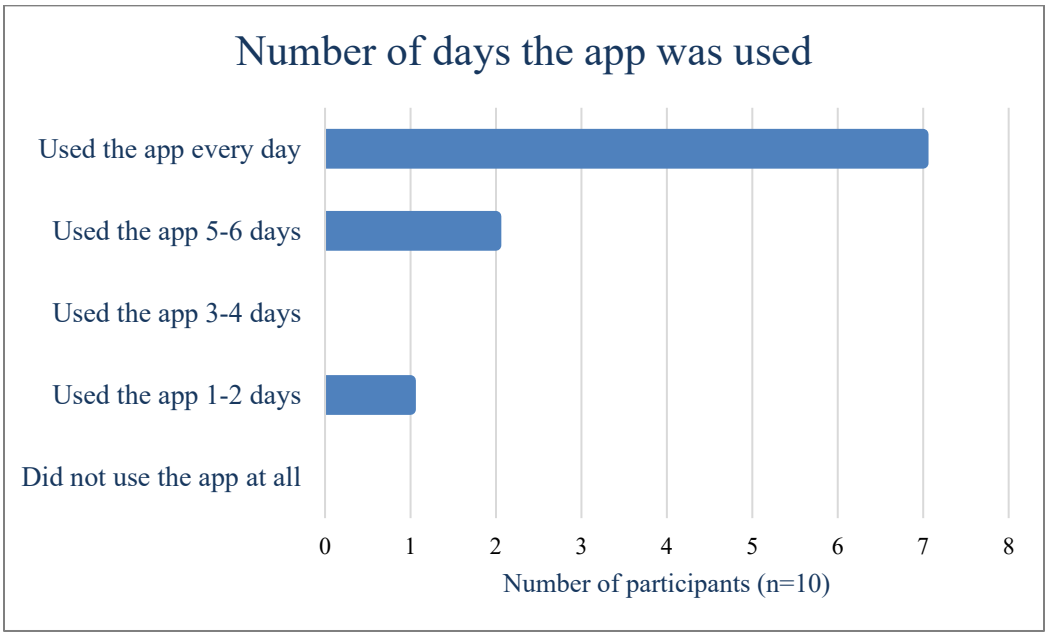
Reasons that participants cited for not taking their medications as prescribed after app use are as follows: Three participants (30%) cited "I forgot/did not take my medications despite the app reminding me to do so." The remaining seven participants (70%) indicated that they took their medications every day. No participants cited any of the following other options on the post-survey for not taking their medications as prescribed: "I did not use the app" "the app did not work as intended" or "I did not find the app useful for reminding me to take my medications."

Data regarding app use. Aim 3, objective 2 evaluated the participant's experience of using the medication reminder app. Again, utilizing the post-intervention Likert-scale survey (Appendix G), data of patient experience of the app use overall were analyzed.

Post-intervention, participants were surveyed on the number of days per week the Medisafe® smartphone medication reminder app was used (see Graph 4). Seventy percent (n=7) of participants used the app every day; 20% (n=2) used the app 5-6 days per week and 10% (n=1) used the app 1-2 days per week.

Graph 4

Number of Days the App was Used



Participants were asked if they found the smartphone medication reminder app easy to use. Overall, 100 percent (n=10) of participants found the app "very easy to use." Participants were also asked how useful the smartphone app was in helping to take medications as prescribed. Forty percent (n=4) reported that the app was "extremely useful," 50% (n=5) reported that the app was "very useful," and 10% (n=1) reported that the app was "somewhat useful." Overall, 100% of participants indicated that they are "very likely" to continue to use the smartphone medication reminder app to help take medications as prescribed. Finally, participants were asked how likely are you to recommend a smartphone medication reminder app to others. Ninety percent (n=9) of participants indicated that they are "very likely" to and 10% reported being "somewhat likely to recommend the app to others.

Several participants provided qualitative data on what would help to be able to use a smartphone medication reminder app daily in the future. There were no consistent themes identified from these responses. One participant responded "maybe a QR code from the prescription could be scanned by the app." Another participant stated "I would need to check my phone more often." A third participant stated "as an ALS patient, it would be good for my caretaker to use." Finally, a participant noted "more knowledge that one is available." Overall, participants did not indicate any difficulties with the app use.

CHAPTER 5

Discussion

Data Synthesis

The overarching goal of this PIP was to evaluate medication adherence rates with the use of a smartphone app. Prior to app use, participants had an overall medication adherence rate of 40% (n=4) and took their medications every day. After the intervention of the use of the smartphone app as the primary means of a reminder system, there was marked improvement in medication adherence. Seventy percent of participants (n=7) now took their medications every day. This shows a 30% improvement in medication adherence rates when a smartphone app is used as the primary reminder system.

In evaluating the participants' experience of using the app, there was overall positive reported feedback. One-hundred percent of participants were overall "very likely" to continue to use the medication reminder app as the primary means of their reminder system.

Project Limitations and Strengths

Participant recruitment was the primary limitation to this study. Initially, this investigator intended to recruit 30-40 participants. During the 4-week long recruitment period, only 13 participants were recruited despite numerous recruitment fliers posted throughout the family practice clinic and active involvement from clinic providers and staff. The attrition of the post-survey was three participants, resulting in a small sample size of 10 participants. Because of this small sample size, data were skewed and did not meet the assumption of normality. Additionally, due to the small sample size, neither a paired t-test nor Wilcoxon signed rank test was able to be used for statistical analysis. Unsolicited feedback from the family medicine clinic providers and staff identified other limitations to the study which indicated that patients wanted to participate but didn't have a smartphone or didn't think they could use the app successfully (generally among the older population).

Several strengths of the project are noted from the results. First, there was a wide range of participants (from young to old). In fact, 23% of the initial participant group were above the age of 60, thus, we can infer that advanced age does not limit app use. Second, the app worked as

intended as evidenced by participant report that the app was “very easy to use”, and the app was “very useful.” Third, providers and staff of the family medicine clinic made genuine effort to encourage participation in the study. Finally, feedback from providers and staff within the clinic indicated that individuals seemed more likely to participate when the provider directly recommended or “prescribed” the app use.

Theoretical Framework

The outcome of this pilot project aligns with the theories and concepts of the Revised Health Promotion Model. The providers and staff of the family medicine clinic encouraged the use of a self-management tool in order to help their patients achieve behavior-specific changes. The intended and subsequent observed behavioral outcome was for participants to commit to a plan of action via consistent use of the medication reminder app in order to achieve the intended health-promoting behavior of increasing and/or maintaining medication adherence towards achievement of ideal health. Results of the study reflect that individuals are primarily responsible for their own behavior as evidenced by voluntary participation and report of planned continuation after the study concluded. Ten of the thirteen individuals *committed* to completing the study, and positive outcomes were realized in the results as previously discussed.

Implications for Practice

The results of this PIP clearly support the hypothesis that the use of a medication reminder app improves medication adherence rates as well as improves behavioral outcomes. Practice-based change recommendations (aim 3, objective 3) are as follows:

1) Patients should be routinely educated on the potential negative health outcomes of medication nonadherence specific to their individual health needs in order to ensure understanding of the need for compliance to their medication regimen.

2) Clinician recommendation and encouragement of the use of a smartphone medication reminder app to support adherence.

3) Individuals themselves who have utilized the app are encouraged to provide firsthand testimony of the positive effects of its use to others.

Future research is needed to validate whether or not a clinician’s “prescription” of the use of a smartphone medication reminder app would increase the use of the app, but feedback from the family practice clinic providers and staff indicates so. Other future research is also needed on

ways to initially engage patients in the use of a medication reminder app, and how to retain utilization.

Conclusion

Data from this study are reflective of other previously conducted studies indicate that the use of smartphone medication reminder apps improves medication adherence rates. Individuals who utilize self-management tools to engage in health-promoting behaviors retain autonomy in realizing the outcome of their own goals towards their "ideal health." The Medisafe® medication reminder app is a useful, easy-to-use tool to support this self-management. Clinicians are encouraged to recommend the use of smartphone medication reminder apps to patients to support the long-term goal of improving medication adherence rates population-wide and decreasing the incidence of adverse events related to nonadherence, including avoidable hospital admissions to ultimately lower total healthcare costs.

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APPENDIX A: RECRUITMENT FLYER

STUDY PARTICIPANTS NEEDED!

SMARTPHONE APP MEDICATION REMINDER RESEARCH PROJECT

What

Study being conducted to determine the usefulness of utilizing smartphone medication reminder applications "apps" to improve medication adherence rates.

Why

Improve your health in the short term as well as the long term.

How

Download an APP at little or no cost (recommendations to be provided) and utilize the reminder system to help you take your medications daily and on time as directed by your primary care provider.

Who

Persons 18 years and older who take at least one daily medication.

When

Five weeks in the Spring of 2021.

Do you take at least one daily medication?

Do you sometimes forget to take your medications?

Do you want to be better about taking your medications as prescribed?

Do you have a smartphone?

Are you willing to participate in a 5-week study?

FOR MORE INFORMATION, CONTACT:

JESSICA ANAHU, BSN-RN
University of Hawaii at Hilo
Doctor of Nursing Practice Student
jna@hawaii.edu

APPENDIX B: MEDISAFE® APP USE INSTRUCTIONS

Thank you for your interest in participating in the *Smartphone Application Use Prompts an Evidence-Based Intervention to Improve Medication Adherence in the Family Practice Outpatient Setting* research project.

Your Participant ID#:

Steps for Participation:

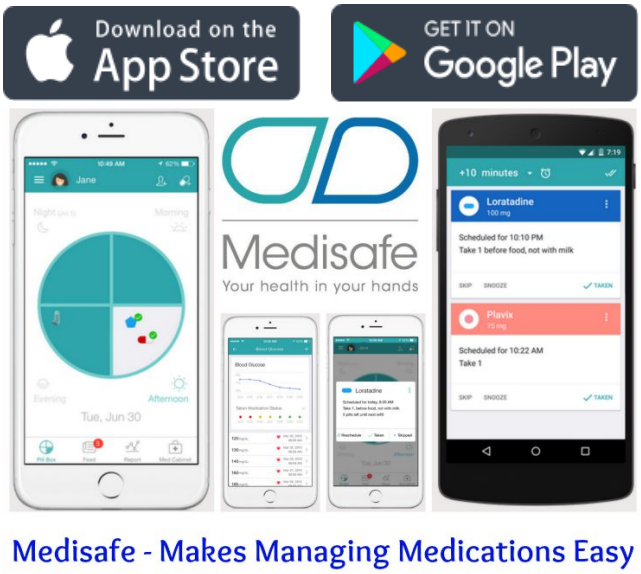
1) Before using the Medisafe app, please complete the pre-survey. The pre-survey consists of 10 questions and will take about 5 minutes to complete. The questions will focus on demographic data collection, how often you take or do not take your medications as prescribed and how willing you are to use the Medisafesmartphone app.
   - SurveyMonkey **Pre-survey** link: https://www.surveymonkey.com/r/G6P85VG

2) Download Medisafethe smartphone app to your iPhone or Android device. Directions on the attached pages.

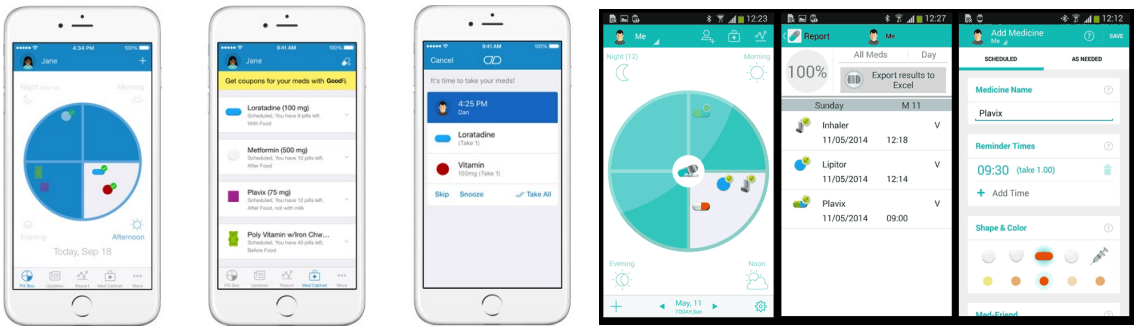
3) Enter your medication details including dosage, quantity and time of administration into the Medisafeapp.

4) Use theMedisafe app as the primary means of your medication reminder system for a total of **3 consecutive weeks.**

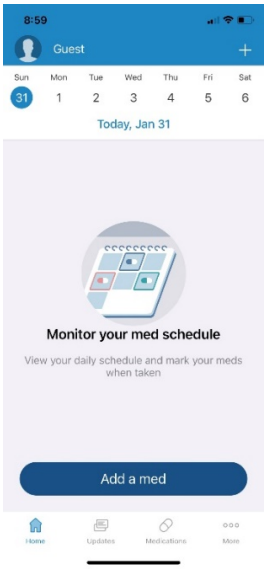
5) Take a post-survey via SurveyMonkey. The post-survey consists of 10 questions and will take about 5 minutes to complete. The questions will focus on how often you took or did not take your medications as prescribed while using the Medisafesmartphone app, and how beneficial you found theMedisafe smartphone app to be for you.
   - SurveyMonkey **Post-survey** link: https://www.surveymonkey.com/r/BKZKV5V



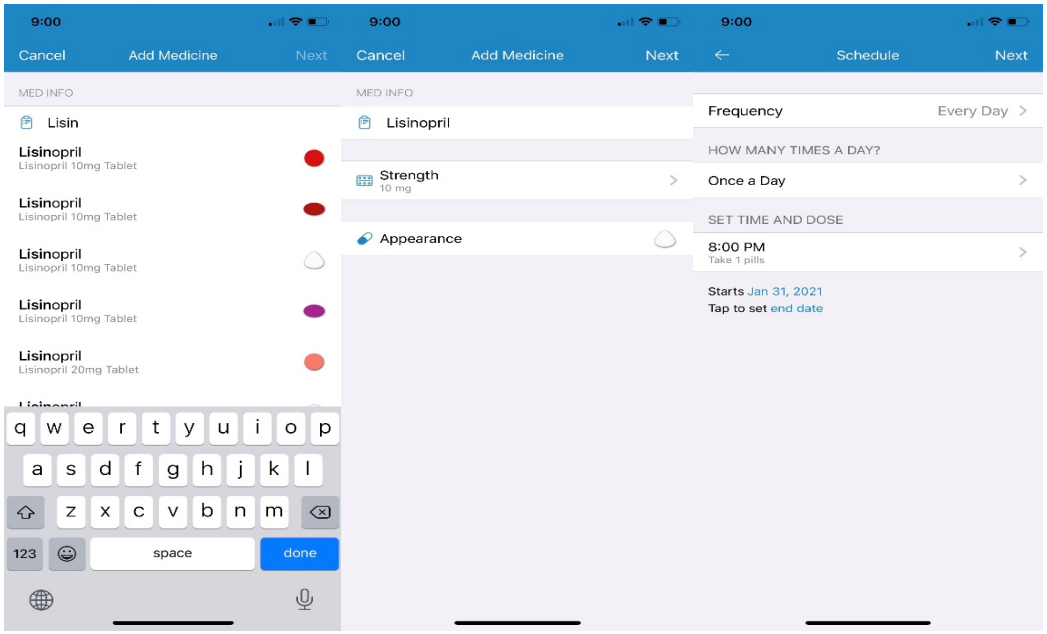
Or, scan this QR code with your phone's camera



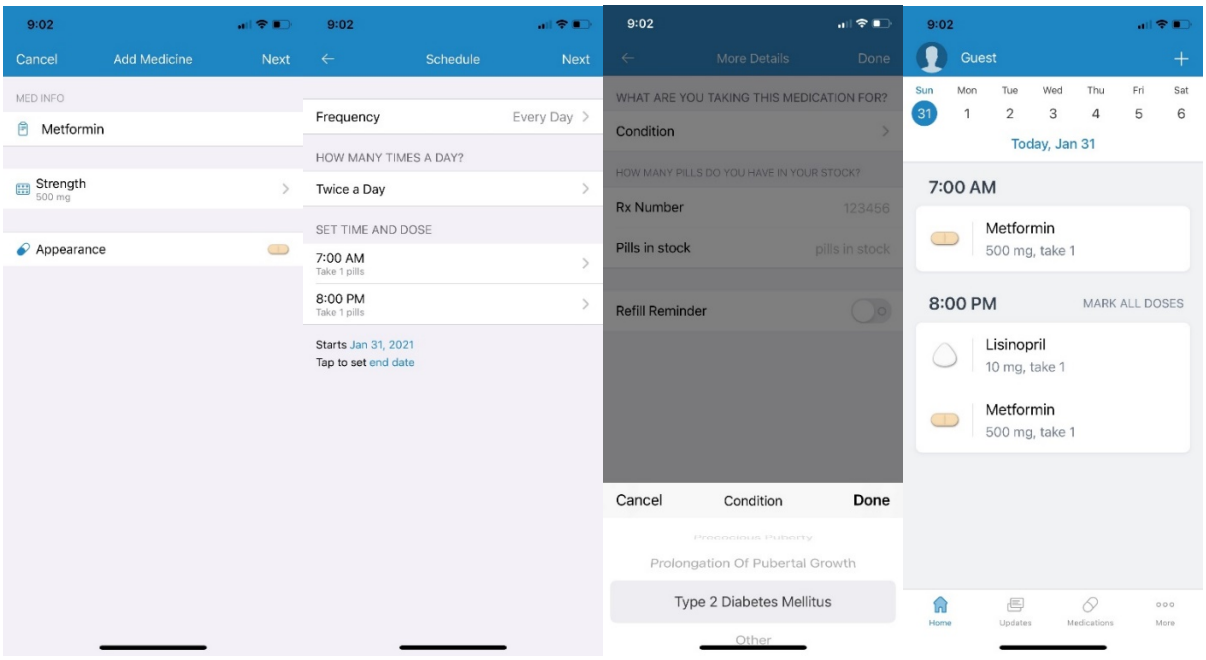
Follow the app to setup your user profile



- Add your medication
  - Name
  - Pill color and shape
  - When to take it
  - How many to take
  - The condition to take it for

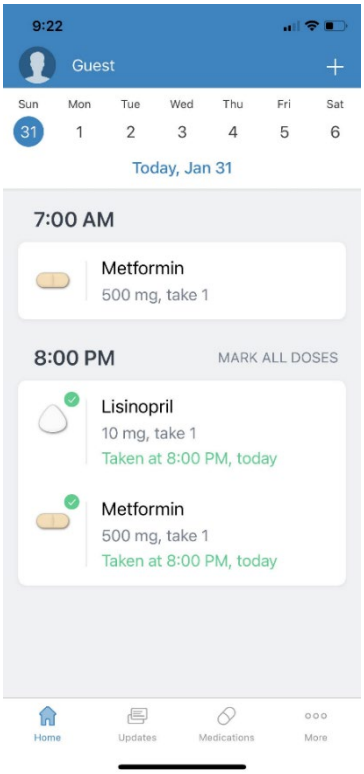


Repeat with every medication you take regularly



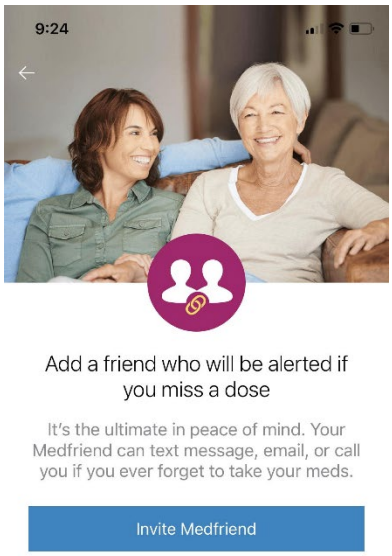
Wait for the reminder to alert you to take your medication.

Mark that you have taken your medication.

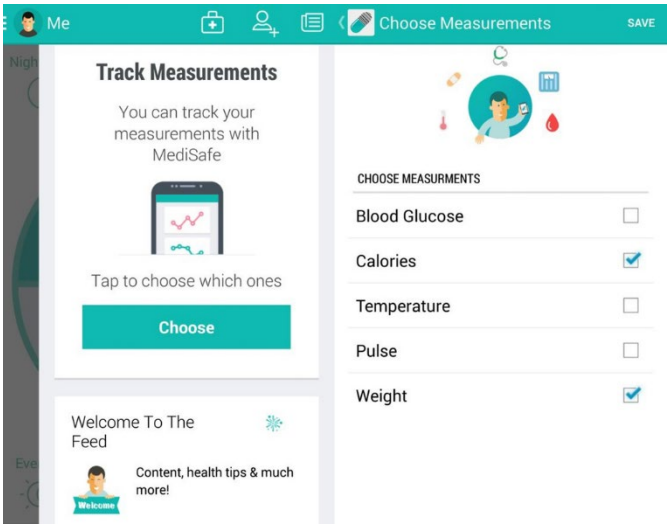


The app has may other useful features:

Invite a Medifriend



Track Measurements



APPENDIX C: PARTICIPANT CONSENT FORM

University of Hawai'i
Consent to Participate in a Research Project
Jessica Anahu, Principal Investigator
Smartphone Application Use Prompts an Evidence-Based Intervention to Improve Medication Adherence in the Family Practice Outpatient Setting

Aloha! You are being asked to participate in a Practice Inquiry Project research study conducted by Joyce Norris-Taylor and Jessica Anahu from the Doctor of Nursing Practice program at the University of Hawaii. This Practice Inquiry Project is a graduation requirement for Jessica Anahu.

What am I being asked to do?
If you participate in this project, you will be asked to utilize the Medisafesmartphone app as the primary means of your medication reminder system. You will also be asked to complete a survey before and after utilizing Medisafethe smartphone app.

Taking part in this study is your choice.
You can choose to take part or you can choose not to take part in this study. You also can change your mind at any time. If you stop being in the study, there will be no penalty or loss to you. Additionally, your choice to participate or not participate will not affect your rights to receive healthcare services at The Family Medicine Center.

Why is this study being done?
The purpose of my project is to determine the usefulness of utilizing a smartphone medication reminder application "smartphone app" to improve adherence to your prescribed medication(s), and to improve your health overall. The project focuses on utilizing the Medisafe smartphone app to help remind you to take your medication(s) on time, and as prescribed by your healthcare provider.

I am asking you to participate because you have indicated that you:

1) are at least 18 years old,
2) take at least 1 (one) daily chronic medication
3) are able to read and write in English
4) are willing to download and use a smartphone application.

What will happen if I decide to take part in this study?
If you decide to participate in this study, you will be asked to do the following:

1) Take a pre-survey via SurveyMonkey, an internet-based survey platform. The pre-survey consists of 10 questions and will take about 5 minutes to complete. The questions will focus on demographic data collection, how often you take or do not take your medications as prescribed and how willing you are to use the Medisafesmartphone app.
    - You will be given a participant ID# along with the pre-survey link. If you would like the survey link emailed to you, please provide your email at the end of this consent.

2) Download Medisafe smartphone app to your iPhone or Android device
   The Medisafeapp was chosen after a comparative review of many other smartphone medication reminder apps that are used on both iPhone and Android devices, and deemed by this investigator to be the easiest and most user-friendly. There is no cost to downloading the app.
3) Enter your medication details including dosage, quantity and time of administration into the Medisafe app.
4) Use the Medisafeapp as the primary means of your medication reminder system for a total of 3 consecutive weeks.
5) Take a post-survey via SurveyMonkey. The post-survey consists of 10 questions and will take about 5 minutes to complete. The questions will focus on how often you took or did not take your medications as prescribed while using the Medisafesmartphone app, and how beneficial you found the Medisafe smartphone app to be for you.
   - You will use your participant ID# and will be given a post-survey link.

What are the risks and benefits of taking part in this study?
The direct benefit to you is an individualized medication reminder system so that you stay on track with taking your medications as prescribed. There are no identifiable risks by participating.

Results of Research:
Results of this research will be used to determine if utilizing a smartphone medication reminder app statistically improves medication adherence rates over other medication reminder methods. Results will also be used to provide practice-based change recommendations for improving medication adherence rates.

Privacy and Confidentiality:
I will not use any personal identifying information that can identify you. I will keep all study data secure in a locked filing cabinet in a locked office/encrypted on a password-protected computer. Only my University of Hawai'i advisor and I will have access to the information. The University of Hawai'i Human Studies Program has the right to review research records for this study.

Future Research Studies:
Even after removing identifiers, the data from this study will not be used or distributed for future research studies.

Compensation:
Upon completion of the study, and after completion of the post-survey, a "thank you" gift card will be mailed to you (please provide mailing address below).

Questions:
If you have any questions about this study, please call me at The Family Medicine center at 808.933.987 or email me at jna@hawaii.edu. You may also contact my advisor, Joyce Norris-Taylor at joycenor@hawaii.edu

You may contact the UH Human Studies Program at 808.956.5007 or uhirb@hawaii.edu to discuss problems, concerns and questions; obtain information; or offer input with an informed individual who is unaffiliated with the specific research protocol. Please visit http://go.hawaii.edu/jRd for more information on your rights as a research participant.

If you agree to participate in this project, please sign and date the following signature page and return it to: *Jessica Anahu or any of The Family Medicine Center Staff*

Keep a copy of the informed consent for your records and reference.

Signature(s) for Consent:
I give permission to join the research project entitled *Smartphone Application Use Prompts an Evidence-Based Intervention to Improve Medication Adherence in the Family Practice Outpatient Setting*

Name of Participant (Print): _____

Participant's Signature: _____ **Date**_____

Email (for survey links): _____

Mailing Address (for gift card): _____

_____

Signature of the Person Obtaining Consent: _____

Date: _____

Mahalo!

Jessica Anahu, RN
Doctorate of Nursing Practice Student
University of Hawaii at Hilo

For Office Use Only

Date consent received: _____ Assigned Participant ID #: _____
Date pre-survey completed: _____ Date post-survey completed: _____

APPENDIX D: UNIVERSITY OF HAWAII INSTITUTIONAL REVIEW BOARD LETTER OF APPROVAL

UNIVERSITY of HAWAI'I® MĀNOA

Office of Research Compliance
Human Studies Program

DATE:	January 19, 2021
TO:	Norris-Taylor, Joyce, DNP, RN, University of Hawaii at Hilo, School of Nursing Anahu, Jessica, BSN, University of Hawaii at Hilo, School of Nursing
FROM:	Rivera, Victoria, Dir, Ofc of Rsch Compliance, Social&Behav Exempt
PROTOCOL TITLE:	Smartphone Application Use Prompts an Evidence-Based Intervention to Improve Medication Adherence in the Family Practice Outpatient Setting
FUNDING SOURCE:	None
PROTOCOL NUMBER:	2020-01041
APPROVAL DATE:	January 19, 2021

NOTICE OF APPROVAL FOR HUMAN RESEARCH

This letter is your record of the Human Studies Program approval of this study as exempt.

On January 19, 2021, the University of Hawaii (UH) Human Studies Program approved this study as exempt from federal regulations pertaining to the protection of human research participants. The authority for the exemption applicable to your study is documented in the Code of Federal Regulations at 45 CFR 46.104(d) 3.

Exempt studies are subject to the ethical principles articulated in The Belmont Report, found at the OHRP Website www.hhs.gov/ohrp/humansubjects/guidance/belmont.html.

Exempt studies do not require regular continuing review by the Human Studies Program. However, if you propose to modify your study, you must receive approval from the Human Studies Program prior to implementing any changes. You can submit your proposed changes via the UH eProtocol application. The Human Studies Program may review the exempt status at that time and request an application for approval as non-exempt research.

In order to protect the confidentiality of research participants, we encourage you to destroy private information which can be linked to the identities of individuals as soo as it is reasonable to do so. Signed consent forms, as applicable to your study, should be maintained for at least the duration of your project.

This approval does not expire. However, please notify the Human Studies Program when your study is complete. Upon notification, we will close our files pertaining to your study.

If you have any questions relating to the protection of human research participants, please contact the Human Studies Program by phone at 956-5007 or email uhirb@hawaii.edu. We wish you success in carrying out your research project.

APPENDIX E: LETTER OF AGENCY SUPPORT

The Family Medicine Center

409 Kilauea Avenue, Hilo, HI 96720 Ph: (808) 933-9187/ Fax: (808) 961-5905

Lynda Dolan, MD Erin Kalua, MD

Anna Casillas, APRN Katrina Chong-Tercero, PA-C Haley Rosehill-Reiger, APRN

July 9, 2020

To Whom it May Concern,

Jessica Anahu, RN, DNP student has described her proposed research project titled "Smartphone App Medication Reminder Research Project." As owner and president of The Family Medicine Center, I approve this research to occur within our facility and with our patients, pending individual patient consent to participate.

Sincerely,

Lynda Dolan, MD
Owner/President
The Family Medicine Center

APPENDIX F: PRE-SURVEY

Medication Adherence Pre-Intervention Survey

Please select the best answer for each question. Responses are kept confidential, and only aggregated data will be used in study results.

1	Participant ID #:				
2	What gender do you most identify with?				
	Male	Female	Transgender	Other	Prefer not to answer
3	What ethnicity describes you best? (select all that apply)				
	African American	Asian	Hispanic	Native Hawaiian/Pacific Islander/Native American	White/Non-Hispanic
4	What is your age?				
	18-29	30-44	45-59	60-79	80 or older
5	How many daily medications do you take that are prescribed by a medical professional?				
	1	2-3	4-5	6-7	8 or more
6	How many days a week do you **not** to take your medications as prescribed?				
	0 (I always take my medications as prescribed	1	2	3	4 or more
7	What is the reason for not taking your medications as prescribed? (select all that apply)				
	I forget/can't remember	I don't think the medication works	The medication causes side effects that I don't like	I don't want to take it	Other – please describe:
8	How confident and willing are you that you are capable of using a smartphone medication reminder app **every day** to remind you to take your medications as prescribed?				
	Not confident or willing at all	Somewhat unconfident or unwilling	Neutral	Confident and willing	Very confident and very willing
9	How committed are you to using a smartphone medication reminder app every day to remind you to take your medications?				
	Not committed	Somewhat committed	Neutral	Committed	Very committed
10	Please describe any concerns or difficulties you might have while using a smartphone medication reminder app:				

APPENDIX G: POST-SURVEY

Medication Adherence Post-Intervention Survey

Please select the best answer for each question. Responses are kept confidential, and only aggregated data will be used in study results.

1	Participant ID #:				
2	How many days a week did you use the smartphone medication reminder app to remind you to take your medications?				
	Did not use the app at all	1-2 days	3-4 days	5-6 days	Every day
3	Did you find the smartphone medication reminder app easy to use?				
	Not easy to use at all	Somewhat not easy to use	Neutral	Somewhat easy to use	Very easy to use
4	How useful did you find the smartphone medication reminder app in helping you take your medications as prescribed?				
	Not useful at all	Somewhat not useful	Neutral	Somewhat useful	Very useful
5	How many days a week did you **not** take your medications as prescribed while using the smartphone medication reminder app?				
	0	1	2	3	4 or more
6	What is the reason for **not** taking your medications as prescribed while using the smartphone medication reminder app? (select all that apply)				
	I did not use the app daily	The app did not work as intended	I did not find the app useful for reminding me to take my medications	I forgot/did not take my medications despite the app reminding me to do so	Not applicable. I took my medications every day
7	How likely are you to continue to use the smartphone medication reminder app in helping you take your medications as prescribed?				
	Not likely at all	Not very likely	Neutral	Somewhat likely	Very likely
8	How likely are you to recommend a smartphone medication reminder app to others?				
	Not likely at all	Not very likely	Neutral	Somewhat likely	Very likely
9	What difficulties did you have while using the smartphone medication reminder app? Describe:				
10	What would help you to be able to use a smartphone medication reminder app daily in the future? Describe:				