AN EVALUATION OF MOBILE APPS FOR THE COLLATION OF MATERIALS TO PROPOSE AN APP FOR TYPE 2 DIABETES SELF-MANAGEMENT

by
Sydney Watson

A thesis submitted to the faculty of The University of Mississippi in partial fulfillment of the requirements of the Sally McDonnell Barksdale Honors College.

Oxford
May 2018

Approved by

Advisor: Dr. Meagan Rosenthal

Reader: Dr. Erin Holmes

Reader: Dr. Donna West-Strum
ABSTRACT

This study is an evaluation of mobile application (apps) with the intention to collate materials appropriate for the proposal of a mobile app for type 2 diabetes self-management. In order to decipher the most vital aspects to be included in the app, an evaluation of mobile apps pertaining to nutrition and diabetes management were investigated. It was found that there is a lack of mobile apps that have all-encompassing features regarding the management of the disease. Future app developers looking to develop a mobile app that is efficient in type 2 diabetes self-management should include each feature as follows: blood sugar level tracking, medication tracking, meal tracking, insulin tracking, weight tracking, nutrition and exercise advice, goal setting, shareability to doctors, contain reminders for many activities within the app, and allow for customization per mobile app user.
Table of Contents
LIST OF FIGURES ......................................................................................................................... v
LIST OF TABLES ........................................................................................................................... vi
INTRODUCTION ............................................................................................................................... 1
OBJECTIVE ....................................................................................................................................... 12
RESULTS .......................................................................................................................................... 14
DISCUSSION .................................................................................................................................... 21
CONCLUSION .................................................................................................................................... 23
WORKS CITED .................................................................................................................................. 24
LIST OF FIGURES

Figure 1. Inclusion/Exclusion Criteria.................................................................14
LIST OF TABLES

Table 1: Application Information.................................................................18
Table 2. Mobile App Evaluation Results .......................................................20
INTRODUCTION

Diabetes has become one of the most important health issues nationally and globally, where the prevalence of diabetes is dramatically increasing, and is expected to continue to rise. The number of people with diabetes provides for a large healthcare burden for the entire population (Huang et al.). There is an incidence of about 1.7 million new patients diagnosed with type 2 diabetes each year with around 9.3% of the population already having the disease (McGlennon et al.). The current projection for those with diabetes around the globe is 0.5 billion to be diagnosed by the year 2030 (Asaad et al.). The rising percentage of the population with diabetes is a problem that the United States is facing, and that percentage of the population is expected to rise. An estimated 30.3 million Americans, 23.1 million diagnosed and 7.2 million undiagnosed, had diabetes in the year 2015 (Drive et al., “Statistics About Diabetes”). The rates of diabetes can be broken down into race and ethnic backgrounds such as 15.1% of American Indians/Alaskan Natives, 12.7% of non-Hispanic blacks, 12.1% of Hispanics, 8.0% of Asian Americans, and 7.4% of non-Hispanic whites (Drive et al., “Statistics About Diabetes”).

The Institute for Alternative Futures research team state’s that despite prevention efforts or medical advances diabetes is creating a major health crisis for the United States in terms of financial costs, morbidity, prevalence that is predicted to significantly rise before the year 2030, and significant efforts must be made in society, including effective management, prevention, and effective screening in order to reduce the diabetes epidemic (Rowley et al.). Type 2 diabetes is plaguing the nation with 29 states having over 10% of its population with diabetes (Drive et al., “Statistics About Diabetes”). In 2015, diabetes was the seventh leading cause of death even when it may have been underreported because only 35-40% of those with diabetes were listed on the death certificate (Drive et al., “Statistics About Diabetes”).
WHAT IS DIABETES

Diabetes mellitus is a chronic and progressive metabolic disorder that causes the development of hyperglycemia and high blood sugar levels, because of a deficiency in the insulin hormone (Shrivastava et al.). Insulin is one hormone involved in the regulation of blood glucose level. The glucose from food that circulates in the blood is the source of energy for each cell in the body. Type 2 diabetes mellitus, also known as adult onset diabetes, is the most common form of diabetes and can develop at any age, however, it is the most common in middle-aged and older adults (“Type 2 Diabetes”). Type 2 diabetes causes the body to develop an insensitivity to insulin (McGlennon et al. 2). Insulin insensitivity prevents sugar from entering the cells and causes of an excess of sugar in the blood (“Type 2 Diabetes”).

The pancreas maintains the body’s normal glucose levels by producing insulin and glucagon that counteract each other. Glucagon supports normal production of insulin by stimulating cells to release glucose, whereas insulin stimulates cells to absorb glucose causing a decrease in blood glucose levels. In type 2 diabetes, the body may be unable to produce insulin or may not have enough insulin to handle the amount of glucose in the blood, which may result in insulin insensitivity (An Overview of the Pancreas). In an effort to counter this insensitivity, the pancreas increases insulin production, but this still fails to allow the glucose to enter the cell and keep blood glucose at normal levels. The result of consistently high blood glucose levels is the development of type 2 diabetes (Drive et al., “Facts About Type 2”).

Type 2 diabetes is generally diagnosed in one of three ways. In the first, an A1C test, which measures the average blood glucose levels for the past 2 or 3 months, is performed. The diagnosis of type 2 diabetes occurs when A1C measurement is at or greater than 6.5%. The second way of diagnosis type 2 diabetes is with a fasting plasma glucose (FPG) test, which tests
glucose levels after not having anything to eat or drink for at least 8 hours. In this test the diagnosis of diabetes occurs with a blood glucose of great or equal to 126 mg/dL. The third type of test to diagnose diabetes is the oral glucose tolerance test (OGTT), which is a two-hour test that checks blood glucose while drinking a sweet drink to determine how the body processes glucose. Here diabetes is diagnosed when the 2 hour blood glucose is greater than or equal to 200 mg/dL (Drive et al., “Diagnosing Diabetes and Learning About Prediabetes”).

Common symptoms of diabetes include urinating often, feeling thirsty, hungry, extreme fatigue, blurry vision, cuts and bruises that heal slowly, and tingling pain or numbness in the hands and feet (Drive et al., “Diabetes Symptoms”). Symptoms in adults that are 65 or older may be different or more severe than in middle-aged adults, where one may experience flu-like fatigue, urinary tract infections, numbness in arms, legs, hands, and feet, and dental problems (“Type 2 Diabetes” 2).

**DEVELOPMENT RISK AND COMPLICATIONS OF TYPE 2 DIABETES**

If a patient is diagnosed with prediabetes, this does not mean that type 2 diabetes will automatically develop. In fact, early treatment may result in levels of blood glucose returning to a normal range. This can be done by losing 7% body weight with moderate exercise 5 days a week (Drive et al., “Diagnosing Diabetes and Learning About Prediabetes”). Those who have prediabetes or experience symptoms of type 2 diabetes should report them to his or her doctor immediately. The sooner treatment begins, the more benefits the patient can experience due to early management of the chronic condition (“Type 2 Diabetes”).

In addition to age there are other factors that give groups a higher risk of developing type 2 diabetes. These factors include having metabolic syndromes, which is a cluster of biochemical and physical abnormalities associated with cardiovascular disease and type 2 diabetes, obesity,
and being from certain racial/ethnic groups like African Americans, Latinos, Native Americans, and Asian Americans (Drive et al., “Facts About Type 2”). Obesity is one of the biggest health concerns in the country and is related to priority health issues like lack of good nutrition and lack of physical activity at 58 percent, heart disease and hypertension at 57 percent, and diabetes at 44 percent. Those that are overweight are at an increased risk of the development of type 2 diabetes, which causes financial issues, community safety issues, child development and academic issue (“The State of Obesity: Obesity data trends and policy analysis,” n.d.).

The inability to gain control of blood glucose levels may cause serious emergent complications such as hypoglycemia and hyperglycemia. Hypoglycemia occurs when a blood glucose level lower than 70 mg/dL and is caused by a relative overproduction of insulin. Hypoglycemia symptoms such as confusion, dizziness, feeling faint, heart palpitations, rapid heartbeat, mood changes, sweating, clamminess, and loss of consciousness must be recognized early as it can possibly cause seizure or coma (“Type 2 Diabetes”). Hypoglycemia can be self-treated when symptoms are mild by eating a snack or consuming something with about 15 grams of glucose, however the patient should go to the emergency room if the blood glucose levels remain low for longer than an hour (“Type 2 Diabetes”).

Hyperglycemia is a condition caused by the overproduction of the hormone glucagon and causes abnormally high blood glucose levels and is a defining characteristic of diabetes. Hyperglycemia may cause increased thirst, frequent urination, sugar in the urine, headache, blurry vision, and fatigue. Those with diabetes must control blood sugar levels to control hyperglycemia by taking medications like insulin, avoiding consumption of too many calories, and staying active. Though hyperglycemia is a complication of type 2 diabetes, it can be
controlled with medication, exercise, and meal planning, and maintaining those levels in the recommended range will prevent long-term complications of diabetes (“Hyperglycemia”).

In addition to emergent complications, there are long term complications of type 2 diabetes such as high blood pressure, nerve damage, heart and blood vessel diseases, foot damage, eye damage, kidney disease, hearing problems, and skin problems (“Type 2 Diabetes”). Type 2 diabetes can cause many other health problems to the patient such as heart disease, vision loss, and neuropathy (Stephens et al.).

Type 2 diabetes not only causes physical harm, but it can also have detrimental effects to the psychological health of the patient. Type 2 diabetes can result in psychological stress due to the burden of diabetes symptoms, and diabetes-related emotional distress that can negatively impact the patient’s chronic condition in the long-term (Huang et al). In addition, it is found that diabetes symptoms are significantly associated with stressful life events that cause the patient to have less control over blood sugar levels (Huang et al). It is noted by the Department of Health Sciences of the United Kingdom (UK) that the prevalence of depression in females with diabetes was 23.8% compared to males at 12.8%, and the overall ratio of males and females with diabetes and depression to those with just depression was 17.6% vs. 9.8% (Ali et al.). Psychological distress leads to a poor self-care regimen, poor adherence to medical treatment, and a diminished quality of life with higher rates of morbidity, mortality, and health care costs (Ali et al.).

MANAGING AND PREVENTING TYPE 2 DIABETES

Major goals for patients with type 2 diabetes include decreasing and maintaining a blood sugar level in the normal range, which for type 2 diabetes is between 70-130 mg/dL before meals, preprandial, and less than 180 mg/dL after meals, postprandial (“Blood Sugar Chart”). According to the American Dietetic Association, the management of type 2 diabetes can be
successful with the essential aspect of nutrition therapy, and there may be benefits to adopt a lower-GI diet which includes a dietary pattern of carbohydrates from fruit, vegetables, whole grains, legumes, and low fat dairy products (Ali et al.). The diabetes prevention program clinical trial showed a reduction in the risk of obese and overweight adults of getting type 2 diabetes by 58% through participation in an intensive lifestyle modification program (Rowley et al.).

In one study a prospective cohort study of 3075 older adults, “The Health, Aging and Body composition”, indicators of glucose metabolism and systemic inflammation were assessed and food intake was estimated using a block food frequency questionnaire (Anderson et al.). The dietary patterns of 1751 participants were derived using cluster analysis. A six ‘healthy foods’ cluster was identified as low fat dairy products, fruit, whole grains, poultry, fish, and vegetables, and was associated with a significantly lower fasting insulin levels and homeostasis than those that ate breakfast cereal and high fat dairy products. The healthy foods cluster also had lower fasting insulin, lower fasting glucose, and lower inflammatory markers than others such as high dairy fats, cereals, sweets and desserts. In addition, the health cluster contained higher energy from protein, higher intake of fiber, higher energy from carbohydrates, lower energy from total fat and lower glycemic index than any other cluster (Anderson et al.). It can be concluded that the dietary patterns containing the healthy food cluster are associated with greater insulin sensitivity and lower systemic inflammation in adults, which may cause a decrease in the prevalence of type 2 diabetes (Anderson et al.).

In addition to dietary changes, patients must adopt behaviors that increase physical activity because physical activity increases the skeletal muscles’ sensitivity to insulin that can reduce the risk of type 2 diabetes (Huang et al.) However, many people struggle to adopt such
patterns. Behaviors such as physical inactivity and poor dietary habits are difficult to change as the intention to change and actual behavior change do not match (Schwarzer).

**DIABETES SELF-MANAGEMENT**

The reasons for the increase in the rates of type 2 diabetes and for peoples’ difficulty in managing it are complicated. For example, dietary problems can be due to a lack of access to healthier foods, and the ease of access to cheaper foods which lack of nutritional substance, especially for those of lower socioeconomic means (McGlennon et al.). The standards of care in diabetes are regulated by The American Diabetes Association’s *Standards of Medical Care in Diabetes*, which is updated with the most recent evidence-based recommendations such as patient-centered communications to incorporate patient preferences. The most recent set of Standards found that only 50% of patients with type 2 diabetes receive diabetes self-management and education (DSME), and only 16.2% of those adhere to recommended self-management activities (Association, 2018). The American Diabetes Association has noted that there is a four-fold increase in diabetic complications for the patients that did not undergo any education or training regarding self-care practices (Shrivastava et al.).

Support groups and educational programs can increase the development of knowledge-based decisions on the part of the patient (McGlennon et al. 2). The current recommendations for diabetes self-management education and support are extensive and note that there are four critical times to evaluate the need for diabetes self-management education and support such as: at diagnosis, annually, when complications arise, and when transitions in care occur (Association, “Standards of Medical Care in Diabetes”).

The 2018 *Standards of Medical Care in Diabetes* include the following recommendations: improving care and promoting health in certain populations, changing the
classification and diagnosis of diabetes, comprehensive medical evaluation and assessment of comorbidities, lifestyle management, prevention, glycemic targets, obesity management, pharmacologic approaches, cardiovascular disease, microvascular changes and, older adult recommendations, and diabetes care in the hospital and during pregnancy. Lifestyle management was modified to include individual and group settings and technology-based platforms for the delivery of education and support (Association, “Summary of Revisions”). Self-monitoring of blood glucose levels provides information about the current status of the disease, which allows for a more accurate assessment of control of the patient, and can guide the patient to make adjustments in diet, exercise, and medication to continue to strive for optimal glycemic control (Shrivastava et al.).

In addition, the Standards were modified to state that there is no ideal macronutrient distribution for patients with type 2 diabetes because meal plans should be individualized (Association, “Summary of Revisions”). It is also recommended that adult patients with type 2 diabetes should engage in 150 minutes per week of moderate aerobic activity, and should decrease the amount of time spent sedentary (Association, “Standards of Medical Care in Diabetes”). Health care providers should also consider assessment of psychosocial symptoms of the diabetic patient including depressive symptoms, anxiety, and cognitive impairment, and they should be routinely monitored for diabetic distress when the treatment target has not been met (Association, “Standards of Medical Care in Diabetes”).

The supportive role from family members, most often spouses, is critical to the patient’s ability to adhere to diet, exercise, and treatment. However, it must be noted that the supportive role of the spouse be a positive control such for persuasion and motivation to change rather than a negative control strategy such as the attempt to pressure or control another person’s actions
(Stephens et al.). In addition, social support can be a significant health promoting factor to influence better control of blood sugar and adherence to self-management regimens and can have beneficial effects on future health outcomes and an improved overall quality of life (Huang et al.).

The DSME promotes consistent quality information for the self-management of diabetes, however, the educational process of the DSME may not be meeting the needs of the patients participating. Most current DSME programs are structured in a lecture format, so the patient does not have the opportunity to think about his or her own reality and apply it to their lives in a way that would be a better fit for them (New). So, rather than providing a step by step instruction on how to self-manage diabetes, it has been shown that development of a co-created plan where the clinician helps identify barriers and ways to overcome them with ideas and input from the patient will better meet the learning needs of the patient and enhance diabetes self-care and self-management (New).

Patients not only need to take control of their disease, but there is also a need for the perception of the patient’s own ability to influence the course of their disease (Gonzalez et al.). The perceived control of the patient is a vital mediator of medication adherence and the patient’s A1C outcomes because it is influenced by the emotional distress of the patient. The emotional distress caused by the self-management of diabetes is highly associated with poor treatment adherence and low glycemic control (Gonzalez et al.). In addition, empowerment, better knowledge related to diabetes, medication, and improved self-care behaviors of the patient to deal with his or her chronic condition leads to higher self-efficacy and improved outcomes in the management of diabetes. Patients that are successful in incorporating self-care activities significantly reduce the long-term complications that diabetes can cause, and may experience an
overall better quality of life or diabetic symptom reversal in some cases (Shrivastava et al.). Technology assisted tools like social networking and mobile applications may be useful to incorporate useful elements of lifestyle modifications to prevent and manage diabetes in a cost-effective manner (Association, “Standards of Medical Care in Diabetes”).

THE POTENTIAL OF MOBILE APPLICATIONS

The self-care required for type 2 diabetes is an evolutionary process that requires awareness, knowledge development, reliable and valid measures that can be used by patients and clinicians (Shrivastava et al.). Self-report is the most practical and cost-effective way for assessment of self-care, however, this type of regimen is often unsuccessful. The management of type 2 diabetes is demanding and requires direct involvement by the patient, such as monitoring blood glucose and focusing and modifying lifestyle behaviors, and the health care provider providing regular feedback. Though telemedicine exists, it is often challenging and costly on the patient’s end which suggests the need for something more tailored to a patient that will enable the patient to be more autonomous in patient self-management (Goyal and Cafazzo). Diabetes self-care requires modifications in diet and lifestyle that must be supplemented by a supportive role, such as a spouse or community of patients, in order for the patient to make decisions that lead to a successful behavior change, which may be possible with the development of an application that is tailored to the patient (Shrivastava et al.).

Mobile apps have the potential to address gaps in self-care and empower the patient to take control of and effectively manage their chronic condition (Goyal and Cafazzo). Clinicians are taking a particular interest in the ability to harness smart phone apps to deliver behavior interventions because of the ability and breadth of reach of health-related apps (Dennison et al.). The possibilities of smartphone apps in health behavior include the ability to record and track
behavior of individuals, acquire information, and provide feedback for the user of the smartphone (Dennison et al.). There are a wide range of benefits that may come from mobile health apps, and possibilities such as shaping behaviors and guiding patients to achieve optimal mental, emotional, and physical health and well-being while delivering real-time feedback, education and secure data sharing (Goyal and Cafazzo).

Patients describe their smartphone use in multiple ways such as looking up potential symptoms to determine whether a doctor visit is recommended, healthy recipes, and even search for exercise advice on a multimedia platform that has audio and video capabilities (Dennison et al.). Smartphones contain many advantages and easy access for “on the go” information with convenient tools that allow the patient to monitor, track, and review their attempts at changing or improving health behavior (Dennison et al.). It must be noted, however, that many perceive actions related to healthy lifestyles a private activity, so there is a need for patients to feel that their information being inputted is secure and private. In addition, apps are far more appealing and useful when they are well integrated with how consumers and patients use their phones naturally (Dennison et al.).

Features that may be valuable to health behavior apps include: low effort and pleasant to use, cost and effort to download and set up, developed by experts, provides positive feedback, and accurate and reliable information (Dennison et al.). These features of the smartphone provide a multitude of opportunities for the field of health care to take of advantage of these resources to provide a more tailored experience for patients.

A recent study was performed to determine the behavioral functionality of mobile apps in health intervention in which there were 18 apps used and evaluated for each app’s self-monitoring capabilities of multiple health behaviors. The results suggest that use of the apps did
not give significant results in changes, the mean retention rate for smartphone use throughout the intervention was 79.6%, meaning that of the studies that reported on user acceptability, most reported high user acceptability and feasibility for using smartphone apps for behavior changes. In turn, this shows that mobile health apps may have the potential to change behaviors and possibly health outcomes (Payne et al.).

Mobile health apps can be used to deliver health services, and can also be used as a self-management tool (Goyal and Cafazzo). There are currently many health apps available however, a lot of them tend to not be able to differentiate between type 1 and type 2 diabetes, and, in addition, are not evidence-based applications (Goyal and Cafazzo). There are apps available with features such as manual data recording, insulin and medication tracking, followed by data export and communication; however, those are not all encompassing and pinpoint the need for an application with those features in addition to a dietary plan for those with Type 2 diabetes.

**OBJECTIVE**

The objective of this project is to collect and collate the material needed to develop a comprehensive application to help people with Type 2 diabetes to make better food choices.

**METHODS**

**Design**

The study design is a review and synthesis of current diabetes and nutrition mobile applications (apps) for the development of a comprehensive diabetes self-management specific app.

**Subjects**

The subjects of the study are currently available mobile apps related to diabetes and nutrition management. The team reviewed all nutritional apps on the market based on the user
interface compatibility, user ratings of the app, the quality of the nutritional information embedded in the app, tracking options, cost, and innovative features that were specifically related to diabetes management.

Procedures

Upon reviewing a collection of mobile apps, the first step was to trim down the selection to only the apps that had an average user rating of a 4 and above on a scale of 1-5. The applications with a high user rating were chosen because the high rating was assumed to indicate that both the quality of the information and the user experience were higher. The ability of the app to be straightforward to use for patients is a top priority. Once the list of apps was narrowed down to include only those with user ratings over 4, the apps were then broken down based on the nutritional information quality. The nutritional quality was rated by the original collators of materials that evaluated each application and gave each application a rating of excellent, acceptable, or poor (Darby et al.). The nutritional rating of information was found by searching each app for nine of the most popular foods: three generic foods, three restaurant foods, and three branded products. The three generic foods contained bananas, apples, and sweet potatoes. The three restaurant foods were selected from a list of most popular chain restaurant meals such as: Friendly’s Honey BBQ supermelt, Red Lobster’s Ultimate Feast, and Applebee’s House Sirloin. The top three products were: Lunchables UPLOADED, Bud Light Lime Straw-Ber-Rita, and Chobani Simply 100. The number of results that were returned suggested the inclusiveness of the database where if less than 6 were found it was poor, 6 or more was adequate, and all of 9 were excellent. (Darby et al).
Those that had excellent or acceptable quality were retained for manual analysis, and the poor nutrition quality apps were removed from the sample. In addition, apps that used the Droid operating system were removed for the purposes of this study.

The applications were then manually reviewed to note which apps contained features that were related to type 2 diabetes and nutrition management of the disease. These features included: step count, water intake, nutrition tracker, reminders, blood sugar tracking, medications (types and dosages), meals, insulin, blood pressure, HbA1c levels, weight, nutritional and lifestyle advice, an accessible support community, goal setting, customizable to the patient, and shareability to doctors. Each of these features are important to the management of type 2 diabetes, which requires an approach that is larger in scope and more difficult than one may expect.

Other features that may be relevant to the patients include but are not limited: to diabetes friendly meal plans, restaurant guide and ratings, exercise tutorials, medical lookup that allows patients to see what medications may or may not affect his or her glucose levels, and nutritional suggestions with an alternate lookup. These features will allow patients to have an app that encompasses the patient as a whole rather than just the management of the condition, or aspects of the condition. This app should help the patient achieve outcomes that are more realistic and manageable, and develop goals that are attainable, giving him or her greater autonomy in the management of this condition.

RESULTS

There were initially 42 apps identified for possible inclusion within this project (Figure 1). However, after the application of the inclusion and exclusion criteria 11 apps were identified for further evaluation for the creation of a comprehensive type 2 diabetes self-management
application. Each included app uses the Apple operating system, has a user rating over 4 on a scale of 1-5, and acceptable or excellent nutritional information.

Figure 1. Inclusion/Exclusion Criteria

In the app evaluation, 1 out of 11 apps had blood sugar monitoring, 1 application had medication tracking, 0 of 11 had insulin level monitoring, 10 of 11 had weight tracking, 9 of 11 had nutrition advice, 1 of 11 was shareable, and 6 of 11 had a reminder feature. There were no other apps that contained features which monitored blood sugar, where the patient could input information from his or her glucose monitor, or medications, and there was no app that
monitored insulin use. Every app under evaluation contained features that were customizable to
the patient, weight tracking, meal tracking, and goal setting.

The degree of customizability of each application varied across the app features where
some applications such as Diabetes In Check allowed for patient input that generated meal
suggestions based on the patient goals. Few apps contained customizability features as detailed
where most generated just a calorie goal based on height and weight input by the patient. With
regards to reminders, the applications varied in this feature where there were no apps that
reminded patients about diabetes information except for Diabetes In Check for glucose
monitoring. Apps like MyFitnessPal and MyDietDiary reminded users to input information about
meal tracking, weight, and exercise.

Diabetes In Check was the most comprehensive app regarding the preferred features, and
it also contained novel features such as digital coaching by a certified diabetes educator,
reminders for medications, meal tracking, and blood glucose levels tracking, barcode scanners to
quickly track nutrition facts for packaged foods, personalized meal plans from diabetes-friendly
recipes with personalized daily plans to achieve set goals, exercise tracking, and message boards
with a community of over 200,000 people who are also living with type 2 diabetes. In addition,
all of this information is easily logged and can be quickly sent to the patient’s doctor to monitor
diabetes management progress during appointments. In addition, there were no apps other than
Diabetes In Check that contained data that was easily accessible or shareable to a care provider.

The CARROT app was the only one that did not contain insight or advice about
nutritional and exercise related information. Fooducate contained two novel features, one of
which was that it was customizable for gluten or other food allergies, and the second feature was
that gives a nutritional rating with suggested alternatives for better weight and nutrition management.
<table>
<thead>
<tr>
<th>Donation Level</th>
<th>4.5</th>
<th>4.5</th>
<th>4.5</th>
<th>4.5</th>
<th>4.5</th>
<th>4.5</th>
<th>4.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>MyFitness Pal</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
</tr>
<tr>
<td>Myplate</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
</tr>
<tr>
<td>Room Coach</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
</tr>
<tr>
<td>Flosee</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
</tr>
<tr>
<td>Everyday Health</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
</tr>
<tr>
<td>GamiLLC</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
</tr>
<tr>
<td>Carrot</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
</tr>
<tr>
<td>Crosscall</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
</tr>
<tr>
<td>Developer</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
</tr>
</tbody>
</table>

Table 1: Application Information
<table>
<thead>
<tr>
<th>Reminder</th>
<th>Manual entry of custom foods and beverages, exercise and water</th>
<th>Excellent</th>
<th>Phone call</th>
<th>Excellent</th>
<th>App name</th>
<th>Nutrition database</th>
<th>Log-in option</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reminder</td>
<td>Manual entry of custom foods and beverages, exercise and water</td>
<td>Excellent</td>
<td>Manual entry of custom foods and beverages, exercise and water</td>
<td>Excellent</td>
<td>Manual entry of custom foods and beverages, exercise and water</td>
<td>Excellent</td>
<td>Manual entry of custom foods and beverages, exercise and water</td>
</tr>
<tr>
<td>Reminder</td>
<td>Manual entry of custom foods and beverages, exercise and water</td>
<td>Excellent</td>
<td>Manual entry of custom foods and beverages, exercise and water</td>
<td>Excellent</td>
<td>Manual entry of custom foods and beverages, exercise and water</td>
<td>Excellent</td>
<td>Manual entry of custom foods and beverages, exercise and water</td>
</tr>
<tr>
<td>Reminder</td>
<td>Manual entry of custom foods and beverages, exercise and water</td>
<td>Excellent</td>
<td>Manual entry of custom foods and beverages, exercise and water</td>
<td>Excellent</td>
<td>Manual entry of custom foods and beverages, exercise and water</td>
<td>Excellent</td>
<td>Manual entry of custom foods and beverages, exercise and water</td>
</tr>
<tr>
<td>Reminder</td>
<td>Manual entry of custom foods and beverages, exercise and water</td>
<td>Excellent</td>
<td>Manual entry of custom foods and beverages, exercise and water</td>
<td>Excellent</td>
<td>Manual entry of custom foods and beverages, exercise and water</td>
<td>Excellent</td>
<td>Manual entry of custom foods and beverages, exercise and water</td>
</tr>
<tr>
<td>Reminder</td>
<td>Manual entry of custom foods and beverages, exercise and water</td>
<td>Excellent</td>
<td>Manual entry of custom foods and beverages, exercise and water</td>
<td>Excellent</td>
<td>Manual entry of custom foods and beverages, exercise and water</td>
<td>Excellent</td>
<td>Manual entry of custom foods and beverages, exercise and water</td>
</tr>
<tr>
<td>App Name</td>
<td>blood sugar</td>
<td>medication</td>
<td>meals</td>
<td>insulin</td>
<td>weight</td>
<td>customizable</td>
<td>nutrition</td>
</tr>
<tr>
<td>----------</td>
<td>-------------</td>
<td>-------------</td>
<td>-------</td>
<td>---------</td>
<td>--------</td>
<td>--------------</td>
<td>-----------</td>
</tr>
<tr>
<td>Control</td>
<td>y</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Smartpe</td>
<td>y</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Noon Coach</td>
<td>y</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>MyHealth</td>
<td>y</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Lose It!</td>
<td>y</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>CARROT</td>
<td>y</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>ProTracer</td>
<td>y</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>MyFitnessPal</td>
<td>y</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>MyDiabetic</td>
<td>y</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Foodmate</td>
<td>y</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Check</td>
<td>y</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Diabetes in</td>
<td>y</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

Table 2: Mobile App Evaluation Results
DISCUSSION

The objective of the study was to evaluate mobile apps regarding the self-management of type 2 diabetes in order to propose the materials for the production of a more comprehensive self-management diabetes app. Overall, the results suggest that there is a lack in mobile apps that contain all of the necessary features specific to diabetes self-management such as blood sugar, medication, and insulin tracking. This means that patients are having to rely upon multiple sources of information in order to manage his or her condition.

Clinicians and researchers are heavily interested in increasing mobile app use as a basis for the management of diseases like type 2 diabetes because this technology has the means of delivering both behavioral interventions and insight into the patients’ daily lives that was not previously available (Dennison et al.) In addition it must be noted that by evaluation of mobile app users, it suggests the need for app developers to consider the features being used for health behavior apps because of the major challenges in ensuring patient efficacy in self-management and behavior change applications (Dennison et al.)

In addition, most apps that are commercially available are not evidence based with regards to the differentiation between type 1 and type 2 diabetes, therefore suggesting that the features considered for type 2 diabetes self-management by mobile apps must be further investigated (Goyal and Cafazzo). In order to fully impact patient self-management for type 2 diabetes, the gap must close between evidence-based guidance to be in line with the functionality of the consumer apps dependent on the needs of the specific patient (Goyal and Cafazzo).

Type 2 diabetes is a chronic metabolic disorder that results from insulin insensitivity which can cause many complications and unwanted side effects like frequent urination, thirst, extreme fatigue, blurry vision, slow healing, and tingling pain in the hands and feet (Drive et al.) Though these complications and symptoms of this disease can be debilitating, there are methods
to manage type 2 diabetes. One major component is the use of self-management in the treatment of type 2 diabetes. In addition, it is important that after diagnosis, the patient is successful in incorporating the proper changes to ensure self-management success. In addition, self-reporting information is the most practical and cost effective way to assess the patient’s self-management efficacy, and mobile apps have potential to allow the patient to control his or her chronic condition and effectively manage it (Goyal and Cafazzo).

The creation of a new mobile application that has features encompassing all aspects that are relevant to the condition will lead to improvement in the management of the patient’s condition and improve the patient’s overall quality of life. With the incorporation of the aspects of management such as exercise, nutrition, medication management, glucose and insulin tracking, and the ability to share this breadth of information with physicians may give the physician insights into the patients’ lives that will allow the physician to treat the patient according to his or her lifestyle. This incorporation of patient-centered care into practice and the integration with self-management will lead to patient success for self-management and behavior change.

Limitations

There are a number of limitations to this study that must be considered. First, the applications used for evaluation were only compatible with the Apple operating system. Second, the subjects of the study were restricted to a list of 42 apps used from an individual resource, meaning that there was no additional search of new apps. Third, the original apps were not all created specifically for patients with diabetes and target other patient populations.

Future directions
This study proposes that mobile applications regarding type 2 diabetes self-management include each feature: blood sugar level tracking, medication tracking, meal tracking, insulin tracking, weight tracking, nutrition and exercise advice, goal setting, shareable to doctors, contain reminders and allow for customization per mobile app user. The production of a mobile app with each of these features should be the most up-to-date regarding self-management tactics, and the app should be the most efficient and cost-effective way to help patients to manage type 2 diabetes and give insight to physicians into patients’ everyday lives.

CONCLUSION

Overall, this study demonstrated that there are many aspects to type 2 diabetes management that lead to patients failing to manage his or her chronic disease. The self-management of type 2 diabetes can be an overwhelming task without the proper resources. The potential of mobile applications to help fix this issue is greatly recognized by both patients and physicians. This study showed that there are no apps which contain all of the features necessary for patient self-management for type 2 diabetes. There are a large number of mobile nutritional tracking applications with each application having different features for users but there is a need for a mobile application that contains each feature vital to the management of type 2 diabetes that will lead to better outcomes for patients.
WORKS CITED


“Blood Sugar Chart.” *Diabetes Self-Management*,


care.diabetesjournals.org, doi:10.2337/dc09-S087.


“Hyperglycemia: When Your Blood Glucose Level Goes Too High.” *EndocrineWeb,*

Larson, Nicole, and Mary Story. “A Review of Environmental Influences on Food Choices.”

*Annals of Behavioral Medicine,* vol. 38, no. 1, Dec. 2009, pp. 56–73. link.springer.com,


Accessed 8 Apr. 2018