EVALUATION OF MOBILE APPS
TARGETING PEDIATRIC OVERWEIGHT AND OBESITY

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DEVELOPMENT OF A MOBILE APP TARGETING PEDIATRIC OVERWEIGHT AND OBESITY

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ABSTRACT OF THESIS

OBJECTIVE: To evaluate and rank the existing mobile apps for pediatric weight management and, in combination with interviews with pediatricians, Nurse Practitioners (NPs), Registered Nurses (RNs), and Registered Dietitians (RDs), to set out what features would be needed to develop an effective evidence-based mobile app for the treatment of pediatric overweight and obesity.

DESIGN: The study design included a review and ranking of existing iPhone mobile apps pertaining to pediatric weight management, physical activity, and healthy eating as well as the collection and analysis of qualitative information from pediatric practitioners, including MDs, NPs, RNs, and RDs.

METHODS: The mobile apps evaluated in this study were found through the iTunes App Store. Of the 45 apps selected for evaluation, 10 were unable to be successfully downloaded and launched, yielding an evaluation sample of 35 (n=35). These 35 apps were downloaded, evaluated, and ranked based on targeted behaviors and strategies according to guidelines from the American Academy of Pediatrics (AAP). In addition, 12 structured interviews were performed with practitioners. Interviews were recorded and analyzed using constant comparative analysis in order to gather a number of themes with regard to pediatric overweight and obesity management from their practices.

RESULTS: Of the 35 apps evaluated, 17 (48.6%) used no behavior or strategies, and 8 (22.9%) used only one behavior or strategy. Two (5.7%) of the apps used two behaviors or strategies, while 9 (25.5%) used three or more behaviors or strategies. Out of a total of a possible 40 points, the highest ranked app, Kurbo Health Coaching and Tracking for Kids, which had a total of 12 points and used 7 strategies and 3 behaviors. The next highest ranking app was Habit Changer Feeding Your Kids, which had 7 points, followed by lifeMite with 5 points. Overall, of the 35 apps that were evaluated, the mean number of behaviors used was 0.9 (SD=1.5), while the mean number of strategies used was 0.5 (SD=1.0), for a total combined mean of 1.4 (SD=2.1).

CONCLUSION: The current mobile apps for pediatric weight management and treatment do not adequately meet the need in the market for an affordable evidence-based product that uses the recommended or suggested behaviors and strategies of the AAP. There is the need for the development of such an app that could be offered at an affordable price to serve this community. Once developed, this app’s feasibility, effectiveness and cost effectiveness would need to be tested. The ultimate goal would be that practitioners and their families could use such an app not only for the management and treatment of pediatric overweight and obesity but also as a tool to prevent additional overweight and obesity in those youngsters who are growing up in today’s complicated food environment.

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CHAPTER 1: INTRODUCTION

Between 1980 and 2012, childhood obesity more than doubled in children between the ages of 6-11, growing from 7% to almost 18% and more than quadrupled among adolescents, growing from 5% to almost 21% (CDC, 2015). In 2012, 16.9% of 2-19 year olds were obese, while 14.9% of 2-19 year olds were overweight, resulting in 31.8% of 2-19 year olds being overweight or obese (Ogden et al., 2014).

Over the past few decades, there have been a number of studies exploring the impact of interventions on pediatric overweight and obesity. Traditionally, these studies have explored the effectiveness of counseling, behavioral change, dietary interventions and physical activity (Hoelscher et al., 2013). Despite these intervention efforts, overweight and obesity rates have continued to rise, prompting the question of what new interventions could be introduced to mitigate this issue.

The growth in health related mobile applications, also called mobile apps or apps, has been explosive and continues to evolve at a rapid rate. Mobile apps, downloaded to a smartphone device, may offer a cost-efficient opportunity to increase the efficacy of pediatric overweight and obesity interventions. As of November 2014, 64% of Americans owned a smartphone, with ownership being particularly high among younger individuals (Pew, 2015). Despite the number of mobile apps available, there is a gap in the research with regard to a comprehensive pediatric overweight and obesity app that uses evidence-based approaches and involves not only children but also their families and medical providers (Breton, Fuemmeler, and Abroms, 2011). For example, in one study that reviewed 204 weight-loss apps, researchers found that the majority included only 1 or 2 evidence-based practices out of a total of 13 (Breton, Fuemmeler, & Abroms, 2011), while in another study that reviewed 57 mobile apps for pediatric obesity, researchers found that 35 (61.4%) did not incorporate any of the recommended strategies or behavioral change targets as outlined in Table 1 below (Schoffman et al., 2013). Both studies referenced the 2007 Expert Recommendations from the American Academy of Pediatrics (AAP); however, each study picked slightly different criteria for app evaluation (Breton, Fuemmeler, & Abroms, 2011 and Schoffman et al., 2013).

Table 1: Strategies and Behavioral Targets for Pediatric Obesity Treatment
(Schoffman et al., 2013)

Strategies:

Calculate/plot BMI over time

Assess motivation to make changes

Use motivational interviewing to help create and sustain behavior changes

Tailor strategies and timing of interventions to the specific case (depending on child's weight status)

Set goals/limits (e.g., screen time limits)

Need to focus beyond individual behaviors to look at environmental influences

Involve the whole family

Combine multiple behavior changes for larger impact (e.g., physical activity and diet)

Behavioral Targets:

Reduce sugar-sweetened beverages with goal of completely eliminating

Consume ≥9 servings of fruits and vegetables every day

Decrease TV time to <2 h/day

Eat breakfast every day

Prepare more meals at home instead of purchasing restaurant food

Eat meals at the table together as a family

Be physically active for >1 h/day

Rationale and Potential Significance of this Study/Project

An evidence-based mobile app that could allow the medical team to monitor progress on a real-time basis as well as to provide feedback, encouragement and guidance could potentially have a statistically significant impact on BMI, physical activity levels, nutritional knowledge and dietary intake. If this turns out to be the case, such an app could be more broadly implemented in other pediatric overweight and obesity settings and programs. Over time, such an app could be made available to Registered Dietitians (RDs), Nurse Practitioners (NPs), Pediatric Registered Nurses (Pediatric RNs) and pediatricians in order to provide a cost-effective tool in the treatment and prevention of pediatric overweight and obesity.

Research Question

Do mobile apps for pediatric overweight and obesity use evidence-based behaviors and strategies?

Hypothesis

Mobile apps for pediatric overweight and obesity management incorporate evidence-based practices.

Sub-Problems/Short-Term Objectives

The short-term objectives of this study are to:

1. Review and rank currently available pediatric overweight and obesity related mobile apps in the market for the iPhone according to the 2007 guidelines from the American Academy of Pediatrics (Davis et al., 2007 and Barlow, 2007).
2. Interview pediatricians, NPS, RNs, and RDs to determine the greatest areas of need that a mobile app must address for weight management.

Sub-Problems/Long-Term Objectives

The long-term objectives of this study are to:

1. Interview families of overweight and obese children to learn what features they need in a mobile app.
2. Test the feasibility of using a developed mobile app.
3. Test the effectiveness of a developed mobile app with regard to changes in BMI, physical activity minutes, nutritional knowledge, and dietary intake for both the pediatric users and their families using a randomized-controlled trial or quasi-experimental trial.
4. Test the cost effectiveness of the developed mobile app.

Limitations

Limitations for this project include the following:

1. The interview sample of practitioners is small and may not fully represent the views of MDs, NPs, RNs and RDs.

2. Feedback from families with overweight or obese children is not part of this current study—but would be an important perspective to consider in the development of a mobile app.
3. The app search results in a number of unrelated and duplicate apps and also has the potential to miss some potentially relevant apps.
4. Due to time and resource constraints, a select number of apps was chosen by the researcher to evaluate. This may result in some relevant apps being overlooked.

Delimitations

Delimitations for this project include:

1. The proposed structure of the mobile app described above is limited to the feedback from interviewed pediatricians, RNs, RDs and families and peer-reviewed literature pertaining to the subject.
2. The proposed structure of the mobile app is further limited by looking at available iPhone apps and does not include an analysis of currently available Android apps.
3. Given time constraints, the development of the app is limited at this time to its proposed structure. Actual development of the app will take place following project completion.

Assumptions

Assumptions for this project include:

1. Pediatricians, NPs, RNs, and RDs answer questions honestly.
2. Survey questions are sufficient and appropriate to gather needed information for the proposed app features.
3. Target participants understand how apps and smartphones work and would be willing to learn how a new mobile app would work.

Definitions

Accelerometer: A movement monitor, which can capture the intensity of physical activity.

Acceptance and commitment therapy (ACT): An intervention that uses acceptance and mindfulness in combination with commitment and behavioral change therapies, in order to increase psychological flexibility.

Anterior cruciate ligament repair (ACL) *surgery:* A surgical procedure to reconstruct the anterior cruciate ligament, which is in the middle of a person's knee, with either tissue from the person's own body or tissue from a donor.

Body Mass index (BMI): A value calculated by dividing the weight (in kilograms) of a person divided by the square of a person's height (in meters). BMI is generally expressed as kg/m^2 and is used to determine whether a person is underweight, normal weight, overweight or obese.

Cognitive behavioral therapy (CBT): A type of therapy that seeks to make a person aware of negative thinking and to change that negative thinking and behavior.

Employee assistance programs (EAP): These are programs that are offered by employers in order to help employees deal with personal issues that could impact their performance, health and well-being.

Fatty liver disease: Fatty liver disease is the build-up of excess fat in the liver. Non-alcoholic fatty liver disease is the accumulation of excess fat in the liver that is not due to the consumption of alcohol. Alcoholic fatty liver disease is the accumulation of fat in the liver due to excessive consumption of alcohol.

Health Eating Index (HEI): The Healthy Eating Index measures dietary quality relative to the Dietary Guidelines for Americans.

Hemoglobin A1c (HbA1c): Hemoglobin A1c is a blood test, which indicates an individual's average blood glucose level of the prior 3 months.

Likert responses: Likert responses are often used in survey research and are typically broken down into five-levels such as strongly disagree, disagree, neither agree or disagree, agree, and strongly agree.

Metabolic Equivalent (MET): A metabolic equivalent is a way of expressing the energy cost of an activity as a multiple of the resting metabolic rate.

Mobile application (mobile app): A mobile application is a software that is specifically designed to run on a mobile device, such as a smartphone or tablet.

Motivational interviewing (MI): Motivational interviewing is a counseling technique that engages intrinsic motivation in the client in order to facilitate change. Motivational interviewing is often goal-oriented and client-centered.

Personal Digital Assistant (PDA): A personal digital assistant is a small hand-held mobile device, which can be used for personal computing.

Pediatric overweight: Pediatric overweight is defined as having a BMI-for-age in children that is greater than or equal to the 85^{th} percentile and less than the 95^{th} percentile.

Pediatric obesity: Pediatric obesity is defined as having a BMI-for-age in children that is greater than or equal to the 95^{th} percentile.

Pedometer: An instrument that records that number of steps taken in order to provide an estimate of the approximate distance travelled.

Smartphone: A smartphone is a mobile phone with an operating system, which combines features of a cellular phone with those of a personal computer.

Thirty-day point prevalence cessation: The 30-day point prevalence cessation outcome is a measure that indicates whether a person has stopped using a substance (such as cigarettes) in the thirty days prior to the follow-up survey.

Visual analogue scale (VAS): A visual analog scale is a scale that measures a characteristic or attitude across a range of values. It is often defined as a point along a line between two-endpoints.

CHAPTER 2: LITERATURE REVIEW

Introduction:

Over the past few decades, there have been a number of studies exploring the impact of interventions on pediatric overweight and obesity. Traditionally, these studies have explored the effectiveness of counseling, behavioral change, dietary interventions and physical activity. (Hoelscher et al., 2013). Given the growing prevalence of pediatric overweight and obesity in recent years, this is an area of tremendous focus. According to data from the 2011-2012 National Health and Nutrition Examination Survey (NHANES), 34.2% of 6-11 year-olds and 34.5% of 12-19 year-olds were overweight or obese, with 17.7% of 6-11 year-olds and 20.5% of 12-19 year-olds being obese, respectively (Ogden, 2014). In addition, studies have shown that there is a 50% probability that obese children will become obese adults, while obese adolescents are 70-80% at risk for becoming obese adults (Samour & King, 2012). Obese children are now experiencing many of the comorbidities experienced by obese adults, including hypertension, dyslipidemia, insulin resistance, Type 2 Diabetes Mellitus (T2DM), fatty liver disease, and psychosocial issues (Gungor, 2014). According to the CDC, the associated costs of obesity in the US were $147 billion in 2008 (CDC, 2015). With the growth in pediatric obesity over the past several decades, this number is only going to continue to increase until successful interventions can be implemented.

Over the past several years, the growth in health related mobile applications—also called apps—has been explosive and continues to evolve at a rapid rate. Mobile applications, downloaded to a smartphone device, offer a cost-efficient opportunity to increase the efficacy of pediatric overweight and obesity interventions. The growing use of smartphones and smartphone applications provides an opportunity to integrate some of the traditionally successful pediatric weight loss strategies into applications that could be more widely used by the pediatric overweight and obese population, their families, and their health professionals. As of November 2014, 64% of Americans owned a smartphone, with ownership being particularly high among younger individuals (Pew, 2015). Of these smartphone users, 62% have used the Internet to look up information about a health condition (Pew, 2015). That percentage climbs to 75% when looking at smartphone users between the ages of 18-29 years (Pew, 2015). As a result, the purpose of this literature review is to critically analyze studies that have assessed the feasibility and effectiveness of mobile applications and health outcomes over the past several years. Given the limited number of studies on this topic to date, it is important to consider both pediatric and adult studies that address this issue with regard to weight management as well as studies that have used mobile apps in the treatment of other disease conditions. Specifically, it's helpful to consider studies that have explored the use of mobile apps for smoking cessation, diabetes, post-operative surgical recovery and depression.

Background

Childhood obesity has more than doubled in children between the ages of 6-11 years, growing from 7% in 1980 to almost 18% in 2012, and more than quadrupled among adolescents, growing from 5% in 1980 to almost 21% in 2012 (CDC, 2015). There are a number of factors that have contributed to this growth, including poor diet, inadequate physical activity levels, sociocultural influences, genetics, and environment. According to data from the 2011-2012 NHANES, 34.3% of children and adolescents between the ages of 2-19 years ate fast food on any given day, with 12.1% of children and adolescents getting more than 40% of their calories from fast food (CDC, 2015).

In addition to increasing fast food consumption, children and adolescents are spending more and more time in front of a screen—be it television, computer or a smartphone—and less time participating in physical activity. According to the CDC, in 2013, less than 48% of high school students attended a physical activity class in an average week (CDC, 2015). Moreover, in the United States, according to the United States Department of Agriculture (USDA), there are over 6,500 food deserts, or areas with limited access to healthy and affordable food, based on a combination of 2000 census data and 2006 supermarket data (Dutko, Ver Ploeg, & Farrigan, 2012). These food deserts tend to be in poorer neighborhoods, where there are few full-service supermarkets but where there are many convenience stores, which typically stock high calorie, low nutrient dense items (Caprio et al., 2008). Clearly, there have been a number of factors, which have contributed to the rapid growth in the prevalence of childhood overweight and obesity over the past several decades in the United States.

To date, pediatric overweight and obesity treatment has typically focused on three different areas: primary prevention, secondary prevention and tertiary prevention (Hoelscher et al., 2013). Primary prevention efforts have focused on dietary intake and physical activity messages, in order to prevent the development of overweight and obesity (Hoelscher et al., 2013). Examples of these messages include eating five or more fruits and vegetables per day, limiting screen time to less than or equal to 2 hours per day, and participating in greater than or equal to 1 hour of physical activity (Katzmarzyk et al., 2014). Secondary prevention efforts, for those who are already overweight or obese but without comorbidities, have focused on structured eating and physical activity programs and have often incorporated the use of motivational interviewing (Hoelscher et al., 2013). These interventions tend to include a reduced calorie eating plan, less than or equal to 1 hour of screen time, and more than 1 hour of physical activity (Katzmarzyk et al., 2014). In addition, these secondary interventions may involve the use of a comprehensive multidisciplinary team, with more frequent contact, monitoring and feedback (Katzmarzyk et al., 2014). Tertiary prevention efforts, for those who are overweight and obese and who have comorbidities, have, to date, focused on intensive efforts under medical supervision and may also include pharmacology and/or bariatric surgery (Hoelscher et al., 2013).

Despite these intervention efforts, overweight and obesity rates have continued to rise. This provokes the question of what new interventions could be introduced that could help to mitigate this issue. Moreover, given the rapid changes occurring in technology, could mobile applications prove to be one such intervention tool? The growth in health related mobile apps has been explosive and continues to evolve at an incredible pace. Do these apps adhere to evidence-based practices, and are they effective? One study, for example, reviewed 204 first generation smartphone apps that pertained to weight loss and found that the majority of the 204 apps incorporated only one or two evidence-based practices out of a total of 13 possible (Breton, Fuemmeler, and Abroms, 2011). The authors concluded that there were three main types of apps among these 204. The most common were apps for assessing BMI and tracking weight, while the second most common were apps that served as dietary journals. The third most common, albeit in the minority, were apps that allowed for the tracking of weight, diet and physical activity (Breton, Fuemmeler, and Abroms, 2011). Another study, which looked at 57 mobile apps designed for pediatric obesity prevention and treatment, found that 35 of them, or 61.4% did not incorporate any recommended strategies or behavioral change targets (Schoffman et al., 2013). According to this study, the mean price per app was $1.05 ± 1.66, with 29 of the 57 being free (Schoffman et al., 2013). Therefore, although the current slate of apps may not incorporate as many evidence-based recommendations as one would ideally like to see, they do appear to be affordable for those who have access to smartphones.

In addition, mobile apps may be a way to engage a child in the process of weight management. They may also be a cost-effective way to provide more frequent updates to pediatric medical practitioners on how a particular child is progressing with regard to changes and goals. Given that a pediatrician can often have a multi-year relationship with a child and that child's family over a number of years, that pediatrician is in a unique position to play a role in childhood obesity prevention through being a behavior change agent (Daniels & Hassink, 2015).

Mobile Phone Trials

It's important to note that the rate of technology change and innovation can often outpace the availability of evidence-based peer reviewed research—and this appears to be the case with mobile apps and weight management. That said more and more studies are now being done in this area. As a result, it's helpful to review what has been done in order to explore what has been effective to date and what has not. This will help to clarify not only where there are gaps in the research but also where there are gaps in the capability of the mobile apps themselves. Since there is a paucity of research that specifically examines mobile apps and pediatric obesity, some of the studies reviewed here pertain to adults, while others examined pertain to the use of mobile apps for different disease states. With regard to apps that are focused on weight management issues, areas of interest include mobile apps that address sugar-sweetened beverage consumption, self-monitoring, physical activity adherence, and obesity.

Text messaging and sugar-sweetened beverages, physical activity and screen time

The primary objective of this study was to test the acceptability, attrition, adherence, and preliminary efficacy of using text messaging for the monitoring of steps taken, sugar-sweetened beverage (SSB) consumption and screen time in children (Shapiro et al., 2008). In the study, undertaken at the University of North Carolina at Chapel Hill Hospitals, there were 58 families, with children ranging in age from 5-13 years. These families were randomized into three groups: text messaging (SMS), paper diary (PD), and control (C). The study lasted 8 weeks. All three groups were asked to attend 3 weekly educational sessions that lasted 90 minutes each. The first session provided information with regard to pedometer usage, estimating beverage sizes, and estimating screen time minutes. In addition, those in the SMS and PD groups received training on how to record information. Each day, the SMS and PD groups were to answer three questions (What was the number on your pedometer today? How many sugar sweetened beverages did you drink today? How many minutes of screen time did you have today?). Participants in the SMS group were expected to send two SMS messages each day—one from the parent and one from the child--answering these three questions.

With regard to this study, the findings fell into a few different areas, including acceptability, attrition, adherence, and preliminary efficacy (Shapiro et al., 2008).

Acceptability: For acceptability, researchers asked parents at the conclusion of the study about whether the program met expectations, whether participants would recommend the program to others, and whether participants would do the program again. Similar types of questions were also posed to the children participating in the study. There were no significant differences in acceptability between the three groups (SMS, PD, and C). The only statistically significant result ($p=0.05$) was that the Control group was most likely to participate in the program again, if necessary.

Attrition: Researchers defined completion of the study as referring to those who attended 2 of the 3 sessions and who completed the post-assessment. Although the results were not statistically significant (perhaps due to the small sample size), attrition was lower in the SMS group at 27.8% compared to the PD group at 61.1% and the control group at 50%.

Adherence: Adherence to self-monitoring was 43% in the SMS group, which was statistically significant ($p<0.02$) when compared to the PD group at 19%.

Preliminary efficacy: With regard to self-monitoring, no statistically significant changes in behavior (steps, SSB servings, or screen time) were reported among the three groups. With regard to self-reported recall, however, the SMS group showed a statistically significant reduction in screen minutes relative to those in the PD or control group ($p<0.00$).

A strength of this study is that it assesses the efficacy of SMS text messaging with regard to sugar-sweetened beverage consumption, physical activity and screen time. With regard to limitations, it would be beneficial to see the results of a larger and longer-term study with a more diverse population. The use of SMS, or potentially a mobile app, may be a way to improve adherence to changes in dietary intake, physical activity, and screen time—which could help with pediatric weight management down the road. Since the study showed an improvement in adherence among the SMS group users, the question of whether that adherence would translate into weight loss and an improvement in diet quality over time.

Dietary self-monitoring and dietary quality using a smartphone app

In 2010, after a review of the evidence, the Dietary Guidelines Advisory Committee (DGAC) concluded that self-monitoring of dietary intake is a contributing factor to positive weight loss outcomes (USDA, 2012). To this end, the purpose of this next study was to compare the feasibility of dietary monitoring using an app called "Lose It!" when compared to using traditional paper and pencil methods as well as when compared to using the memo function on a smartphone (Wharton et al., 2014). Researchers from Arizona State University recruited 57 weight-stable adults who were

18-65 years old and had a BMI between 25 and 40 kg/m^2. The participants were semi-randomized into three groups—namely the app group (AP), the memo group (ME), and the paper diary group (PA). Prior to the start of the study, participants performed a 3-day food recall, filled out a short health history, and were measured for anthropometrics. The AP group were instructed to enter foods consumed via the smartphone app and would receive immediate feedback about their calorie intake for the day relative to their daily calorie allotment, which had been calculated with a goal of losing one pound per week. The AP group, however, did not receive any dietary advice. The ME and PA groups, on the other hand, attended a one-on-one counseling session prior to the study and received personalized diet plans. Moreover, the ME and PA groups received weekly emails about healthy eating while participating the study. All of the study participants (AP, ME, and PA) were encouraged to expend 150 calories per day through exercise, and exercise recommendations were provided for them. Information from the AP group was automatically transmitted once a day. The ME group emailed their data each day, while the PA group handed in their notebooks during weeks 4 and 8. The study lasted 8 weeks overall.

At the end of the study, there were 47 participants, resulting in 10 participants with loss to follow-up, for an overall attrition rate of 17.5% (Wharton et al., 2014). Interestingly, there was no attrition from the AP group, and this was statistically significant when compared to the ME and PA groups ($p=0.05$). In addition, the AP group recorded more complete days, defined as days when ≥ 800 kcal of food was recorded at 43.0 ± 2.5 days, relative to the PA group at 30.7.0 ± 4.6 ($p=.024$; effect size=0.153). Also, the ME and PA groups had twice the number of missing days relative to the AP group at 21 0 ± 4.9, 21.3 ± 3.4, and 10.3 ± 2.1 days, respectively ($p=0.04$; effect size=0.136). Body weight decreased significantly across all three groups at the end of the study. Mean weight loss did not differ between the three groups, nor did diet quality as measured by Healthy Eating Index (HEI) scores, a measure of diet quality (Guenther et al., 2013). Although self-monitoring was better in the AP group, diet quality did not improve—which may indicate that an app alone may not be enough to improve dietary quality and that an incremental counseling piece may be also needed in order to facilitate improvements in this area.

Over time, there has been quite a bit of evidence that supports the importance of self-monitoring as a contributing factor with regard to weight management (Wharton et al., 2014). Given that the AP group had significantly lower attrition over the 8-week period, using such an app may be a good way to maintain dietary self-monitoring. Limitations of this study, however, include the fact that the study group was small as well as the fact that the ME and PA groups received a personalized diet plan (while the AP group did not). In addition, although being able to connect with others online for social support was a possibility, participants were not instructed to do this. Perhaps if the AP group had received a personalized diet plan and had been encouraged to use the social support feature, they would have lost more weight than they demonstrated during this study. It might be interesting to test these items in the future in another study. With regard to implications for practice, this study shows that using an app may help with adherence to self-monitoring—which could be an important piece of the weight loss treatment puzzle.

Weight outcomes and dietary monitoring on a PDA

In this next study, researchers explored whether using a personal digital assistant (PDA) or a PDA with tailored feedback (PDA+FB) for self-monitoring was better than using a paper diary (PD) with regard to weight loss and weight loss maintenance over a 24-month period (Burke et al., 2012). The study further looked at the impact of treatment group assignment with regard to self-monitoring adherence. Participants were required to be aged ≤ 59 years and have a BMI between 27 and 43 kg/m^2. Overall, 210 participants were recruited from the community in Pittsburgh in 3 cohorts between 2006-2008. The average age of participants was 46.8 years, with an average education level of 15.7 years. Of the 210, 21% were minorities and 78.1% were white.

Participants were randomly assigned using a computer-implemented algorithm to either a Paper Diary group (PD), a PDA group (PDA), or a PDA + feedback group (PDA + FB). Separate evening intervention sessions were held for each of the three treatment groups (PD, PDA and PDA + FB). Meetings were held weekly during months 1-4, biweekly during months 5-12, and monthly for months 13-18. There was only one meeting session during the final 6 months of the 24-month trial. After participants were trained in their self-monitoring technique (PD, PDA, or PDA + FB), other materials used during the sessions were the same for all three groups. The sole difference between the groups was the type of self-monitoring of dietary intake, which included paper diaries for the PD group, PDA with Dietmate software for the PDA group, and PDA with

Dietmate software + feedback for the PDA + FB group. For this last group, participants would receive a daily feedback message regarding their intake. In addition, participants had a number of goals including a daily calorie target of 1200-1800 calories based on weight and gender, a goal of ≤ 25% of calories being from fat, and a weekly exercise goal of 180 minutes by the end of 6 months (a number which was increased by 30 minutes semi-annually).

Researchers took measurements at baseline, 6 months, 12 months, 18 months and 24 months (Burke et al., 2012). Of the 210 participants, 180 (85.6%) completed the study. The mean percentage weight loss within the groups at 24 months was not statistically significant for the PD group (-1.94% [95% CI= -3.88, 0.01]) or the PDA group (-1.38% [95% CI= -3.38, 0.62]). However, the PDA + FB group had a statistically significant weight loss (-2.32% [95% CI= -4.29, -0.35], $p=0.02$).

In addition, adherence to self-monitoring differed significantly between the PDA and PDA +FB groups and the PD group ($p=0.03$). A greater percentage of the PDA group and the PDA + FB were adherent ≥60% of the time, with PDA versus PD ($p=0.03$) and PDA + FB versus PD ($p=0.01$). With regard to self-monitoring adherence and weight loss, there was a greater weight loss achieved with greater adherence when looking at those who were adherent <30%, 30%-59%, and ≥60% of the time ($p<0.001$). Further, at 18 months, 19-20% of the PDA and PDA + FB groups were adherent ≥30% of the time, but the PD group had adherence of that point of only 8%. The authors concluded that adherence to self-monitoring was more important than the way that self-monitoring was performed. In addition, the authors acknowledged that technology improved self-monitoring adherence. They also concluded that a feedback message helped with adherence and with weight loss.

This study had a number of strengths. First, it was the first large trial to test mobile technology versus paper diary self-monitoring and adherence retention (Burke et al., 2012). Second, it was a randomized controlled trial; and, third, it had a retention rate of 85.6%. With regard to limitations, only 15.2% of the participants were male, with the balance of 84.8% being female. This could have been more evenly distributed. Moreover, mobile technology is moving very quickly. When this study was performed during 2006-2008, mobile applications were in their infancy, which may have impacted the level of adherence and also potentially the amount of weight loss achieved.

Dietary self-monitoring appears to be an important factor in this study, as is the level of adherence. Another piece that appears to be important is feedback. Are there other areas where a mobile app could help contribute to weight loss or weight management?

Using mobile phone and Internet technology to deliver a physical activity program

The purpose of this next study was to evaluate the impact of a physical activity program delivered over the Internet and on a mobile phone between September and December of 2005 (Hurling et al., 2007). For the study, researchers recruited 77 healthy adults in Bedfordshire, UK. The participants had a mean age of 40.4 years (SD=7.6) and mean BMI of 26.3 kg/m^2 (SD=3.4). The participants were randomized into a test group, which had access to a physical activity program over the Internet and over a mobile phone, and into a control group that received no intervention. The test group received solutions for perceived barriers, a schedule for planning exercise over a 7-day period, a message board for sharing with others, and feedback on their activity level. Outcome measures included data from an accelerometer, which unlike a pedometer can measure movement as well as the intensity of activity, and self-reported physical activity levels. Each of the 77 participants received a wrist-worn accelerometer and a Bluetooth-compatible phone. Physical activity was monitored for 3 weeks and then participants were randomly allocated to the control group (n=30) or the test group (n=47). Participants were instructed to wear the accelerometer for the 9 weeks of the study (in addition to the 3-week baseline period before the 9-week study period started).

Results showed a significant difference in the amount of time spent in the 3 to 6 metabolic equivalent (MET) range for the test group versus the control group (p=0.02) (Hurling, 2007). A 3 to 6 MET range would include exercises requiring a light to moderate effort, such as leisurely biking, swimming or brisk walking. In addition, after the trial, the test group had a sense of internal control that was statistically higher than the control group (p=0.03). The test group also had a statistically significant higher level of interest in using an Internet based behavior change system than did the control group (p<0.001). Body fat also showed positive results among the test group. The change in body fat for the test group (-2.18, SD=0.59) was statistically significant when compared to the control group (-0.17, SD=0.81; p=0.04). Lower BMI was observed for the test group at the conclusion of the 9-weeks, but did not achieve statistical significance (p=0.06). More than 70% of those who were in the test group logged onto the system at least two times per week for the entire 9-week duration of the study; moreover, the test group showed an increase of 2 hours 18 minutes per week in physical activity over the control group.

Limitations of this study include the small sample size (n=77) and the short duration. Furthermore, it is unknown whether individuals in this study performed exercise that met the US recommendation of 150 minutes per week. However, the results, especially with regard to the increase in physical activity relative to the control group as well as the greater sense of perceived internal control, were encouraging. It would be interesting to conduct a larger—and longer study--with a more diverse population in order to see if the positive changes would persist over time. It's well known that physical activity is an important part of weight management. Therefore, in looking at a mobile app that addresses pediatric weight management, a physical activity component and a self-monitoring component—with both including a feedback feature—might be important to consider.

Starting the conversation—a childhood obesity knowledge project

It is clear that mobile applications may have a role to play with regard to self-monitoring and physical activity, but could such a mobile application also be used as an educational tool at the same time? The purpose of this next study was to see whether or not the use of a free smartphone app had an impact on the level of knowledge of nutritional indicators, physical activity, and screen time (Appel et al., 2014). The study was conducted during 2011 and 2012 in Snohomish County, Washington. Overall, 421 students expressed interest in the study and completed a pre-survey, but in the end only 118 participants between the ages of 14 and 19 years participated. The participants were recruited from 7 high schools, and 65.3% of the participants were minorities. In addition, 64% of the participants were female and 34% were male. Of the participants, 79 handwrote their responses while 39 used the app. All participants filled out a pre-survey, which asked questions about physical activity, screen time, nutritional knowledge, and types of food eaten. The pilot study lasted for 20 days. The test group used the free mobile app from Lose It! (www.loseit.com). All participants were asked to record physical activity and dietary intake during the 20 days of the pilot. After the 20 days, researchers collected the logs and conducted a post-survey.

The pilot resulted in descriptive and quantitative results. Seventy-four percent of the participants agreed that the study helped them to “watch what I ate,” and 45% indicated that they had “motivation to exercise more” (Appel et al., 2014). It’s important to note that the app group had a lower average BMI going into the study than the handwritten group—and that this difference was statistically significant ($p=0.010$). There were some interesting results from the study. For example, paired t-test results, comparing post to pre differences, did not show a statistically significant change with regard to BMI, physical activity, or knowledge of veggies for the app group or the handwritten group. There was, however, a statistically significant change in knowledge about the correct amount of daily water intake for both the app group ($p<0.001$) and the handwritten group ($p<0.001$). In addition, although the change in screen time approached significance in the handwritten group ($p=0.09$), it decreased significantly in the app group ($p=0.031$). The American Academy of Pediatrics (AAP) recommends less than 2 hours of screen time per day (Davis, et al., 2007). In this study, 30.8% ($n=12$) of the app group (n=39) was in the less than 2 hours category before the intervention, while 43.6% (n=17) was in this category after the intervention, for an increase of 12.8% (n=5). The 5 people who moved into the less than 2 hours of screen time category represented nearly 13% of the app group (Appel et al., 2014).

There were a number of limitations to this study (Appel et al., 2014). First, 421 people filled out the pre-survey, but only 118 completed the study, for a very high drop-out rate of 72%. Second, there were more females in the sample than males. And, third, there were more people in the handwritten group than in the app group, which resulted in lower statistical power. Lastly, the app group and the handwritten group were not matched with regard to physical activity, nutrition and screen time. The study did, however, demonstrate the acceptability and feasibility of using self-monitoring. Now that even more adolescents have smartphones than they did even a few years ago, it would be interesting to replicate this study on a larger scale, while integrating a physical activity component as well.

Although the published research with regard to mobile apps and pediatric weight management is lacking, other studies have been conducted to understand the effectiveness of mobile apps for other disease states, including smoking cessation, diabetes, depression and surgical recovery. These studies may provide valuable insight for the development of a feasible and effective application for pediatric weight management.

Pilot trial of a smartphone app for smoking cessation

The purpose of this study was to test the design feasibility of a mobile app, called SmarQuit, with regard to assessing a number of factors including: patient receptivity and satisfaction, preliminary cessation outcomes, and the impact of the app with regard to the acceptance of cravings (Bricker et al., 2014). According to the Surgeon General, smoking causes 484,000 deaths annually, is the number one preventable cause of premature death, and costs the nation approximately $289 billion annually. Given that 42 million Americans still smoke, there is clearly a need for a cost effective intervention. To this end, the researchers in this study wanted to compare the mobile app SmartQuit and the National Cancer Institute's mobile app QuitGuide. Both apps use US Clinical Practice Guidelines for smoking cessation (Fiore et al., 2008). However, the SmartQuit app also uses the concept of Acceptance and Commitment Therapy (ACT). ACT focuses on increasing the willingness of individuals undergoing treatment to experience physical cravings and emotions while making value-guided behavior changes. To date, there have been a number of studies that have shown that the use of ACT can be effective with regard to drug addiction and depression.

This study was conducted in 2013 (Bricker et al., 2014). Participants were recruited nationally between March and May 2013. Criteria included being 18 years or older, smoking at least 5 cigarettes per day, wanting to quit in the next 30 days, and wanting to learn skills to quit. In all, 196 individuals were randomized into the two arms. The demographics of the two arms were balanced with the exception of race. With regard to race, 84% of the participants were Caucasian in the SmartQuit arm versus 94% in the QuitGuide arm ($p=0.06$). The study lasted 8-weeks. Each arm received an identical weekly email reminder. At the end of the 8 weeks, there was a follow up survey, and participants received $25 upon completion of the follow-up survey. The study looked at utilization, treatment satisfaction, ACT theory-based acceptance, and the 30-day point prevalence cessation outcome. The 30-day point prevalence cessation outcome indicates that there has been no smoking by the participant in the thirty days prior to the follow-up survey.

There were a number of interesting results from this study. First, there was an 84% retention rate (for both arms), which compares favorably with an average of 54% for other web delivered cessation trials (Bricker et al., 2014). Second, SmartQuit participants opened their app an average of 37.2 times during the study versus 15.2 times for the QuitGuide participants, or 2.5 times more often ($p<0.001$). This result may suggest that the content of SmartQuit was more engaging than that of QuitGuide. Third, there was a statistically significant difference in satisfaction with regard to how the SmartQuit application was organized relative to the QuitGuide application (85% versus 67%, respectively; $p=0.006$). Fourth, although not statistically significant ($p=0.12$), there was a 30-day cessation rate of 13% for SmartQuit versus 8% for QuitGuide. And, lastly, there was a statistically significant increase in acceptance of cravings for SmartQuit participants ($p<0.04$) but not for QuitGuide participants ($p=0.15$).

As with other studies, there were some limitations with regard to this trial. One limitation was the small sample size of 196 (Bricker et al., 2014). Another was the substantial relapse that can occur with smoking, which was not measured given the short timeframe of the trial. Another was that utilization for QuitGuide had to be self-reported because it was not an automatic feature of the program—which could have impacted reported utilization numbers. And, lastly, researchers relied on self-reported abstinence in terms of the 30-day point prevalence results. The study did however demonstrate the acceptability and feasibility of using a mobile app for smoking cessation. As a result, it would be interesting to see a larger study that compared SmartQuit and QuitGuide that had a longer follow-up and automatic recording of participant utilization of the QuitGuide app. Furthermore, the use of ACT is perhaps an interesting facet to consider when looking at the development of a mobile app for the treatment of pediatric overweight and obesity. It is important to note, however, that there is a difference between smoking cessation and weight management. With smoking cessation, total abstinence is the goal. In this way, weight management is quite different because a person needs to eat in order to live; therefore, managing the condition can be somewhat more problematic since a person can't avoid food in the same way that a person can avoid cigarettes. However, the use of ACT—or a similar type of behavioral therapy--might be something to consider.

Another area where there has been some research with regard to mobile apps and treatment is with regard to diabetes management. The following trial is interesting because it addresses not only the effect on glycemic control among diabetes patients but also looks at the cost effectiveness of such a program.

Mobile phone diabetes project and its effect on AIC and healthcare costs

The purpose of this study was to explore the impact of a mobile phone intervention, using SMS, on patients with diabetes (Nundy et al., 2014). The trial took place between May 2012 and February 2013 at University of Chicago Medicine and utilized the CareSmarts diabetes program. In this particular trial, which was quasi-experimental, members of the University of Chicago employee health plan who were over 18 and had type 1 or type 2 diabetes were contacted. In all, there were 348 eligible members, with 74 being enrolled in the treatment group using CareSmarts and 274 being part of the control group.

Participants in the treatment group received text messages that included both information and questions that were relevant to diabetes self-care, such as “Time to check your blood sugar” and “Do you need refills of any of your medications?” (Nundy et al., 2014). Participants responded to these questions via text messages. In addition, those enrolled in the treatment group participated in an educational curriculum, consisting of two-week modules. These modules focused on diabetes related topics such as medications, glucose monitoring, exercise, and living with chronic illness. After ten weeks of modules, participants could choose to receive additional modules. Overall, the trial lasted six months. One of the interesting parts of this trial was that the text responses that the participants sent could trigger alerts. Low-level alerts included such items as medication refills, which nurses could help to coordinate. High-level alerts included such items as low adherence to a participant’s medication regimen or low responsiveness to questions. These alerts could lead to a telephone call from a nurse to the patient. Following the phone call, an email communication was sent to the rest of the care team for that patient.

Of those in the treatment group, 67 (80%) completed the six-month trial (Nundy et al., 2014). Of those who completed the trial, 73% were satisfied with the CareSmarts program and 77% indicated that they would be willing to participate in such a program again. Participants found the calls from the nurses helpful, not only for educational purposes, but also for engagement purposes. In addition, there were a number of interesting behavioral and clinical results. In order to assess the different measures (such as healthy eating, glucose monitoring, and foot-care, among others), researchers used The Summary of Diabetes Self-Care Activities Measure (Toobert , Hampson & Glasgow, 2000). With regard to behavioral results, the number of days of healthy eating (in a week period) increased from 4.5 to 5.2 ($p=0.03$), the number of days of glucose monitoring increased from 4.3 to 4.9 ($p=0.03$), and the number of days of foot-care increased from 3.6 to 4.3 ($p=0.01$). In addition, diabetes medication adherence increased from 83% to 91% ($p=0.003$). There was also a statistically significant change in HbA1c for the treatment group. For example, the average HbA1c declined from 7.9% to 7.2% ($p=0.01$) for the treatment group. The change for those with poorly controlled diabetes was even more dramatic, with HbA1c declining from 10.3% to 8.5% ($p=0.01$). In addition, there was a statistically significant increase in patients' perceived quality of care in the treatment group ($p=0.04$).

The cost-effectiveness of the CareSmarts program showed a net decline in medical cost of $812 per patient, comprised of a $1,322 decline in visit costs offset by a

$520 increase in drug costs (p<0.0001) (Nundy et al., 2014). The program costs over the six months were $375, for a net savings of $437 per participant (or 8.8%) for those in the treatment group.

Features of this trial could potentially be used for the management of pediatric overweight and obesity. For example, text message alerts could be helpful with this population with regard to physical activity or food and beverage choices. In addition, text messages could be sent requesting a weight update from the participant. And, similar to the diabetes trial, responses to these texts could trigger low level or high level alerts that could then include the involvement of a nurse or a registered dietitian (RD).

Using a mobile app for monitoring post-operative recovery

The purpose of this study was to examine the feasibility of using a mobile app at home in order to monitor post-operative surgery recovery (Semple et al., 2015). In health care, the first 30 days following surgery are of particular importance, especially with regard to post-operative complications. Monitoring of these patients after surgery could potentially result in lower costs due to earlier detection of issues and lower readmission rates. This feasibility study took place in October of 2011 in Toronto and included 33 breast reconstruction patients and 32 orthopedic surgery patients, who had undergone anterior cruciate ligament repair (ACL) surgery. Inclusion criteria required that a participant be between the ages of 18 and 75 years of age, be a nonsmoker, and be able to communicate in English. Prior to surgery, each study participant met with a research coordinator for 30-45 minutes in order to learn how to use the mobile app and how to take a photograph of the surgical wound area. Post-surgery and prior to discharge, each participant received a smartphone or tablet with the software and a booklet detailing the use of the mobile app. Each of the three surgeons who participated in the study used either a mobile interface or a desktop interface in order to access and review the patient data submitted via the mobile app.

The software used for the study was QoR-9, provided by QoC Health Inc. in Toronto (Semple et al., 2015). The trial lasted for 30 days following discharge, and patients were asked to fill out the survey on the mobile app once per day, although patients were not reminded about filling out the mobile app. The mobile app solicited the answer to a number of questions including a visual analogue scale (VAS) for pain and Likert responses relating to questions about the quality of recovery. Answers that were outside of defined target ranges were flagged, with the surgeon being alerted, and the flagged records then appearing in red and at the top of the surgeon's roster of participating patients. The app updated every 5 minutes, and once a flag appeared, the surgeon and/or nurse could phone the patient to follow-up. In addition, surgeons reviewed the photographs of the wounds that were submitted by participants. The study looked at a number of different items, including data entered by the patients, post-recovery follow-up surveys, post-recovery interviews, and post-pilot surveys filled out by the surgeons.

All 65 patients completed the trial (Semple et al., 2015). Mean logins for the 33 breast reconstruction patients were 23.9 over the 30-day period. Mean logins for the 32 orthopedic patients were 19.3 over the 30-day period. For both groups of patients, mean logins were higher during the first 14 days following surgery when compared to days 15-30. Looking at the first 14 days compared to days 15-30, mean logins for the breast reconstruction patients were 13.4 versus 10.5 ($p<0.001$), respectively, while mean logins for the orthopedic patients were 13.4 versus 6.0 ($p<0.001$). With regard to photos, 82% of the breast cancer patients uploaded at least one photo per day compared to 58% of the orthopedic patients ($p<0.002$). Two complications were detected as a result of reviewing the photographs.

With regard to post-recovery follow-up surveys, 82% of the participants completed the survey, including 31 breast cancer patients and 22 orthopedic patients (Semple et al., 2015). Based on a scale of 1 (poor) to 4 (excellent), the mean score with regard to satisfaction with the mobile app was 3.9 for breast patients and 3.7 for orthopedic patients. All indicated that they would be willing to use the mobile app again during another post-operative recovery period.

With regard to surgeon follow-up, all three of the surgeons completed the follow-up survey (Semple et al., 2016). Surgeons found that the platform was user-friendly and easy to navigate. However, two concerns were raised. One concern related to how much additional time would be required by providers for monitoring such patients on an ongoing basis, while another concern related to the fact that that there is currently no reimbursement code in Canada’s health care system that applies to such an activity. The surgeons further indicated that they would feel comfortable canceling a follow-up visit if patients appeared to be recovering well. Interestingly, the surgeons indicated that they would prefer to replace the canceled appointment with electronic communication including feedback instead of a phone call, which they viewed as an inefficient option.

Although a very small study, this pilot demonstrated that with regard to breast reconstruction and ACL surgery, the use of a mobile app for monitoring post-surgery recovery was feasible (Semple et al, 2015). The decline in adherence after the first 14 days is an interesting development and may be related to the fact that the questions posed were no longer as relevant as the patient's recovery progressed. The authors noted that different questions might therefore be needed as patients progress through their recovery. The pilot also demonstrated that it is feasible for surgeons to monitor patients via the mobile app post-operatively and that the use of photographs could potentially be effective for early detection of complications.

There were a number of limitations with regard to this study (Semple et al., 2015). The sample size of both patients and surgeons was small. There were limited demographic variables collected. The patients were young and therefore might be more comfortable with mobile technology than an older patient population in a similar post-operative environment. Lastly, cost-effectiveness was not evaluated. As a result, more and larger studies are clearly needed with regard to this area. This study highlights that remote monitoring by a qualified professional can have an impact, which may also be relevant with regard to the treatment of pediatric overweight and obesity.

Using a mobile app for mild-to-moderate depression

Another area where mobile apps have come into play is with regard to depression management (Birney et al., 2016). According to the authors, depression related costs are an estimated $210.5 billion annually, with depression estimated to be the second leading cause of disability by 2020. As a result, a cost effective treatment option is needed. This study compared an intervention using MoodHacker, a mobile web app, with an alternative care arm that linked users to websites for depression. It's important to note that the MoodHacker program is a product of ORCAS, a health innovation and technology company, which employs the primary author of the article, Amy Birney. The primary objective of this study was to examine the efficacy of MoodHacker compared to the alternative care arm. A secondary objective was to see how access to an employee assistance program (EAP) impacted the outcomes.

For this study, researchers recruited participants who had mild-to-moderate depression between August 2012 and April 2013 with help from a number of organizations including Chestnut Global Partners EAP, Hope to Cope, Esperanza, LIVESTRONG among others (Birney et al., 2016). The study was a randomized controlled trial, with 150 participants being assigned to the MoodHacker intevention group and 150 being assigned to the alternative care group. MoodHacker is a clinically validated cognitive behavioral theory-based mobile application. Participants were further divided by those who had access to EAP programs and those that did not. There were three assessments as part of the trial. There was an assessment at baseline, a second assessment at 6 weeks, and a third assessment at 10 weeks. The intervention itself lasted six weeks. For each assessment completed, participants received $50. Those assigned to the treatment group had access to MoodHacker for six weeks, while those assigned to the alternative care group received links to six websites that contained information about depression (such as the Mayo Clinic, Mental Health America, and the National Institute of Mental Health among others). The two arms were not statistically different with regard to demographics or pretest variables. Outcome measures were assessed using analysis of covariance.

Attrition was limited with only 10 of the 150 in the MoodHacker group not completing the 6 week assessment for a 6.7% attrition rate, compared to 4 out of 150 in the alternative group for a 2.7% attrition rate (Birney et al., 2016). By 10 weeks, these numbers did not change appreciably, with 10 out of 150 in the MoodHacker group not completing the 10 week assessment for a 6.7% attrition rate, versus 5 out of 150 in the alternative group for a 3.3% attrition rate. Participants using MoodHacker logged into the app 16 times over the course of the six weeks for an average duration of 1.3 hours. For the primary outcome, depression symptoms, there was a statistically significant effect after six weeks ($p=0.01$, partial $eta^2=0.021$). Interestingly, at six weeks, subpopulation analysis indicated that those with access to an EAP program had statistically significant program outcomes ($p=0.004$, partial $eta^2=0.093$), while those who did not have EAP access did not have statistically significant program outcomes ($p=0.66$, partial $eta^2=0.001$). At 10 weeks, however, there was no program effect with regard to depression symptoms ($p=0.17$, partial $eta^2=0.006$), which demonstrated the existence of an attenuation effect. Those in the intervention arm also had significant improvements in work absence, work productivity, and workplace distress for those who had access to an EAP. However, this outcome did not hold for those who did not have access to an EAP. As with depression symptoms, these effects attenuated at 10 weeks, except for work absence, which still had a statistically significant outcome for those with EAP access ($p=0.007$, partial $eta^2=0.080$). As is clear from the above results, the effect of the program appears to have been enhanced by EAP access.

As with other studies, there were a number of limitations with regard to the study (Birney et al., 2016). One limitation was the fact that participants were recruited through a variety of measures and therefore had volunteered to participate. This may have resulted in a self-selection bias. Another limitation was that participants self-reported results, which may have also have had an impact. Yet another limitation was that reliability of some of the measures was only moderate, which could have had an impact on study outcomes. Lastly, the participants received $50 for each assessment, which could have impacted completion—and therefore retention and attrition percentages. Another important consideration was that there did appear to be an attenuation effect at 10 weeks, which could indicate that a longer period of engagement is needed.

Overall, however, this study is interesting for a number of reasons—especially when considered with the other studies reviewed. First, as with other studies, there appears to be an attenuation effect after a few weeks of using a mobile app. In order to avoid this attenuation effect, features of a mobile app might have to evolve as time progresses and as the needs of the patient group changes. This could be costly. Second, there appears to be a positive effect from having human interaction—either in the form of phone calls, electronic communication, or employee assistance program support. This is interesting as it implies that a mobile app on its own does not appear to be enough. This raises a few issues, however. For example, the time for interactions from healthcare professionals may be extensive, and it is not clear how healthcare professionals would be compensated, given current limitations with regard to reimbursement, especially for RD related services.

Summary and Conclusion

Although it is still early with regard to the development of mobile applications for overweight and obesity treatment among children and adolescents, it is clear that there is a need for more research into the effectiveness of these mobile apps. There is little question that mobile applications may provide a cost-effective treatment solution. Furthermore, mobile apps may provide a way to integrate behavior change, physical activity, dietary monitoring, and personalized feedback.

Giving existing regulations in healthcare, there is limited reimbursement for overweight and obesity management—unless the child or adolescent already has an existing comorbidity. And, with regard to treatment options, it is often difficult for parents to get out of work and to take their children out of school in order to attend weight management appointments with their children. Lastly, there is little, if any, follow-up between appointments, which can be several months apart. Because many of these families already have smartphones, a well-thought out mobile application could deliver evidence-based nutritional advice for parents and their children. Such an app could also provide physical activity programs and tracking, screen time tracking, weight tracking, and dietary intake tracking for families. From the research, it appears that having a mechanism for monitoring and input from medical professions might be a necessary component in order to increase efficacy. Overall, a high-quality mobile app that uses evidence-based guidelines could potentially be a useful and cost effective tool in treating childhood obesity. As mobile apps evolve and improve, there is clearly a need for more evidence-based research.

CHAPTER 3: METHODS

The purpose of the first part of this research project was to evaluate the existing mobile apps that were available through the iPhone App Store that address pediatric weight management. The purpose of the second part of this research project was to conduct interviews with pediatricians, NPs, RNs, RDs in order to clarify what features would be needed as part of an evidence-based mobile app for the treatment of pediatric overweight and obesity.

Target Demographic

Healthcare practitioners (including MDs, NPs, RNs, and RDs) were the initial target of this investigation, as they would ultimately be involved with those using the mobile app. Pediatric overweight and obese children will be the ultimate target demographic for the longer-term objectives of this project.

Data Collection:

There were four main avenues for collecting data. These included: 1) reviewing the current literature on the subject of healthcare mobile apps, 2) reviewing and ranking existing mobile apps pertaining to pediatric weight management, 3) interviewing relevant healthcare practitioners, and 4) summarizing recommendations for the development of a future mobile app.

This study was approved by the Mount Mary University IRB. Office names, clinic names, and participants' names were not disclosed in the summary and/or final report.

Data Collection: Mobile Apps

The principal investigator (PI) compiled a list of the existing relevant iPhone mobile apps that were available from the iTunes App Store between June 6, 2016 and June 7, 2016. Apple Care was consulted by the PI with regard to the best way to search for relevant apps. In order to simulate a real world experience, several different words were entered into the iTunes App Store search box. The terms used for these searches are presented in Table 2.

Table 2: Search Terms for iPhone Apps

Weight Loss	**Physical Activity**
Kids weight loss	Kids physical activity
Children weight loss	Children physical activity
Teen weight loss	Teen physical activity
Family weight loss	Family physical activity
Weight Management	**Healthy Eating**
Kids weight management	Kids healthy eating
Children weight management	Children healthy eating
Teen weight management	Teen healthy eating
Family weight management	Family healthy eating
Diet	**Overweight**
Kids diet	Kids overweight
Children diet	Children overweight
Teen diet	Teen overweight
Family diet	Family overweight

A total of 655 apps were identified using the search terms listed. A number of the apps that resulted from the search were duplicates, while others were not related to children. In a number of cases, the apps were not relevant to the search conducted. As a result, 242 duplicate apps were excluded and 208 unrelated apps were excluded, yielding a total of 205 apps for content analysis. Of these 205, further screening by the PI was conducted to extract those apps that pertained to BMI, education, exercise, healthy eating, recipes, and weight management for children and adolescents. A total of 45 apps were reviewed for their content according to AAP guidelines.

Data Collection: Qualitative Interviews with Practitioners

The second part of data collection in this study pertained to the gathering of qualitative feedback through structured interviews with pediatricians, NPs, RNs, and RDs. For these meetings, the PI asked a number of set questions in order to solicit feedback with regard to what these professionals wanted and needed from a mobile app targeting pediatric overweight and obesity. The PI interviewed 7 MDs and 5 NPs/RNs/RDs. Questions for practitioners are presented in Table 3.

Table 3: Questions for Structured Interviews with Practitioners

1. How do you currently run your practice as it relates to pediatric obesity?

   On average, what percentage of your patients is overweight/obese?

   Do you provide a copy of the child's growth charts to the families and explain what it means?

   If a pediatric patient presents with a BMI for age at or above the 85^{th} percentile but below the 95^{th} percentile, what do you tell that patient and/or their family?

   If a pediatric patient presents with a BMI for age at or above the 95^{th} percentile, what do you tell that patient and/or their family?

   Do you counsel patients (or their parents) to track and overweight or obese child's weight between visits?

2. How do you communicate with parents/families?

3. What resources do you provide for patients and families with overweight or obese children?

4. What additional resources are needed?

   Do you recommend any computer based programs or mobile apps for these patients and/or families? If so, which ones?

   Do you refer these patients to a Registered Dietitian?

   If you had a mobile app that patients and/or families could use, what features would you like it to have?

5. What, in your opinion, is the biggest barrier to pediatric weight management?

Data Analysis: Existing Relevant Mobile Apps

The 45 apps selected for review were downloaded from iTunes between July 5, 2016 and July 10, 2016. Of these, 10 were unable to be downloaded and launched successfully, resulting in 35 apps being downloaded for evaluation. Apps were then categorized into different categories according to content, including: Books (2), BMI (5), Education (7), Exercise (4), Games (5), Healthy Eating (4), Recipes (1), Trackers (4), Water (2) and Weight Loss (1) as presented in Table 4 below.

Table 4: Descriptive Characteristics of Apps (n=655)

Characteristics	**Number**	**%**
Apps found in searches	655	100%
Duplicates	242	37%
Unrelated	208	32%
Apps identified for content analysis	205	85%
Apps selected for download	45	7%
Unable to download/launch/use	10	2%
Included for content analysis	35	5%
Focus of App		
Books	2	6%
BMI	5	14%
Education	7	20%
Exercise	4	11%
Games	5	14%
Healthy Eating	4	11%
Recipes	1	3%
Trackers	4	11%
Water	2	6%
Weight Loss	1	3%
Total	35	100%

Similar to an earlier study by Wearing et al. (2014), these apps were then evaluated relative to guidelines from the American Academy of Pediatrics (AAP), published as part of the Expert Committee Recommendations (Barlow, 2007) and the Recommendations for Prevention of Childhood Obesity (Davis et al., 2007). Apps were rated out of a total of 12 recommended or suggested behaviors and 4 recommended strategies. Table 5 lists the breakdown or recommended or suggested behaviors and strategies (Davis et al., 2007 and Barlow, 2007).

Table 5: Expert Recommended Behaviors and Strategies for the Prevention of Pediatric Obesity (Davis et al., 2007 and Barlow, 2007)

Recommended and Suggested Behaviors:	
1	Limit consumption of sugar sweetened beverages
2	Eat five fruits and vegetables per day
3	Limit screen time to less than 2 hours per day
4	Eat breakfast daily
5	Limit fast food, take-out, and eating out
6	Regularly eat family meals together
7	Limit portion sizes
8	Eat a diet rich in calcium
9	Eat a diet high in fiber
10	Eat a diet with balanced macronutrients
11	Promote physical activity for at least 60 minutes per day
12	Limit consumption of energy dense foods
Recommended Strategies:	
1	Goal setting
2	Positive reinforcement
3	Monitoring
4	Cognitive Restructuring

Target behaviors and strategies were grouped similar to the method used by Wearing et al. (2014). As a result, breastfeeding was excluded from the list and the recommendations for eating a “diet rich in calcium” and switching “to low-fat dairy products” were combined into one recommended behavior, “eating a diet rich in calcium”. Similar to the Wearing study, the behaviors were rated on a scale of 0 to 3 (Wearing et al., 2014). A 0 indicated that that there was not a recommendation for that behavior. A ‘1’ indicated a weak recommendation. An example of a weak recommendation would be that portion size is important but no specific recommendation or sizes are given. A ‘2’ indicated a moderate recommendation. An example of a moderate recommendation would be that there is specific information on portion sizes but that it isn’t repeated regularly. And a ‘3’ indicated a strong recommendation. An example of a strong recommendation would be that there is specific information about portion sizes and that portion size information was repeated for reinforcement. As a result, scores could range from 0 to 36, where 0 represented no targeted behaviors being recommended, and 36 presented all targeted behaviors being strongly recommended.

Behavioral strategies were also rated (Wearing et al., 2014). If a recommended strategy was not present, the app received a score of 0 for that behavioral strategy. If a recommended strategy was present, the app received a score of 1 for that strategy. As a result, scores for the behavioral strategy category could range from 0 to 4. Total points for behavioral targets and strategies were then summed for each of the apps.

The apps were then sorted and ranked overall. The maximum number of points that an app could receive was 40, while the minimum number was 0. Reviewed apps, assigned category for this study, their author, price, in-app purchases, short description, evaluation date, last date of update, age group, and iTunes ratings were summarized and are presented in the Appendix.

Data Analysis: Qualitative Interviews with Practitioners

All interviews were recorded using a digital recorder and transcribed. Using constant comparative analysis--a method for analyzing qualitative data--the interviews were coded into themes (Hewitt-Taylor, 2001). Themes were coded independently by the PI and a research assistant. These coded comments were then grouped into categories in order to help define conclusions about what features might be needed as part of a comprehensive mobile app that would best serve practitioners and ultimately families of overweight and obese children.

CHAPTER 4: RESULTS

The 35 apps evaluated varied in price. As outlined in Table 6, 26 (74%) of the apps could be downloaded for free, but 9 of them contained in-app purchases in order to unlock all the available features. As a result, 18 (51.4%) of the apps had an associated fee. Some of the “free” apps had some of the highest in-app price points. Of the 9 (25.7%) apps that had an upfront fee, prices ranged from $0.99 to $9.99.

Table 6: Price of Apps Downloaded for Evaluation (n=35)

Price	**Number**	**%**	**In-App Purchases (%)**
Free	26	74%	9 (25.7)
$0.99	2	6%	
$1.99	2	6%	
$2.99	3	9%	
$5.99	1	3%	
$9.99	1	3%	
Total	35		

Table 7 presents the apps ranked by total behavior and strategy points. Out of a total of a possible 40 points, the highest ranked app was Kurbo Health Coaching and Tracking for Kids, which had a total of 12 points and used 7 strategies and 3 behaviors. The next highest ranked app, Habit Changer Feeding Your Kids had a total of 7 points, followed by lifeMite with 5 points.

Table 7: Apps Ranked by Behaviors and Strategies

Name of App	Total Behaviors Used	Total Behavior Points	Total Strategies Used	Total Strategy Points	Total Points
Kurbo Health Coaching and Tracking for Kids and Teens*	10	12	3	3	15
Habit Changer Feeding Your Kids	4	6	1	1	7
lifeMite	3	3	2	2	5
Figure Facts Teen Nutrition	2	2	2	2	4
Fitbit	1	1	3	3	4
Munch Code!	3	3	0	0	3
Healthy Heroes 1 - Nutrition for Kids	3	3	0	0	3
My Balance Buddy	1	1	2	2	3
Lifesum - Healthier living, better eating, more movement	0	0	3	3	3
fooya! Let's move nutrition education for kids, to having fun & eating healthy	2	2	0	0	2
Calorie Counter & Diet Tracker by MyFitnessPal	0	0	0	2	2
Kids Food Adventure	0	0	1	1	1
Healthy Eater - Educational Game for Children	1	1	0	0	1
Iron Kids	1	1	0	0	1
7 minute workouts with lazy monster PRO: daily fitness for kids and children	1	1	0	0	1
Workouts for Children - Exercises for Kids	1	1	0	0	1
SNaX League - Students for Nutrition and eXercise	1	1	0	0	1
Peppy Buddy		1	0	0	1
Daily Water Free - Water Reminder and Counter	0	0	1	1	1

* Note that this was the free version of Kurbo, and it’s possible that if one paid for the one-on-one coaching service, more behaviors and strategies might be included.

Table 7 (cont): Apps Ranked by Behaviors and Strategies

Name of App	Total Behaviors Used	Total Behavior Points	Total Strategies Used	Total Strategy Points	Grand Total
Veggie Bottoms Lite for iPhone	0	0	0	0	0
Your Ideal Weight: calculator for your losing diet	0	0	0	0	0
BMI 4 Teens (Find out how your WEIGHT, HEIGHT & BMI compares with others of the same age)	0	0	0	0	0
Teen BMI (Find out how your WEIGHT, HEIGHT, and BMI compares with others of the same age)	0	0	0	0	0
Child BMI (Growth Percentiles - Height, Weight, and Body Mass Index	0	0	0	0	0
BMI: Kids and Teens	0	0	0	0	0
Eat & Move-O-Matic	0	0	0	0	0
This is my food - Nutrition for kids	0	0	0	0	0
Science Heroes: Digestive System for Kids	0	0	0	0	0
iTooch 6th Grade / Health	0	0	0	0	0
Max's Plate	0	0	0	0	0
Eat This, Not That! The Game	0	0	0	0	0
Carefree Capers: Shaping Up!	0	0	0	0	0
Healthy eating with Diana - educational game to teach children about healthy eating	0	0	0	0	0
Kids recipes by ifood.tv	0	0	0	0	0
CalorieKing Food Search	0	0	0	0	0
Coloring Book 19 Lite: Eating Healthy	0	0	0	0	0

Seventeen (48.6%) of the apps used no behavior or strategies. Eight (22.9%) of the apps used only one behavior or strategy. Two (5.7%) of the apps used only two behaviors or strategy. Nine (25.5% of the apps used three or more behaviors or strategies. All of the apps were available on an iPhone, while 27 (77.1%) were also available on an iPad. Overall, of the 35 apps that were evaluated, the mean number of behaviors used was 1.0 (SD=1.9), while the mean number of strategies used was 0.5 (SD=1.0), for a total combined mean of 1.5 (SD=2.5).

Table 8 presents the number of apps that used a particular behavior or strategy. Looking at behaviors, 8 (22.9%) promoted physical activity, while 5 (14.3%) promoted the consumption of fruits and vegetables.

Table 8: Behaviors and Strategies Used by Apps (n=35)

Behaviors for Pediatric Obesity Treatment	**Total (%)**	**Promoted "Weakly" (%)**	**Promoted "Moderately" (%)**	**Promoted Strongly (%)**
Limit consumption of sugar sweetened beverages	4 (11.4)	3 (8.6)	1 (2.9)	
Eat five fruits and vegetables per day	5 (14.3)	5 (14.3)		
Limit screen time to less than 2 hours per day	2 (5.7)	2 (5.7)		
Eat breakfast daily	2 (5.7)	2 (5.7)		
Limit fast food, take-out, and eating out	1 (2.9)	1 (2.9)		
Regularly eat family meals together	2 (5.7)	2 (5.7)		
Limit portion sizes	3 (8.6)	2 (5.7)	1 (2.9)	
Eat a diet rich in calcium	1 (2.9)	1 (2.9)		
Eat a diet high in fiber	1 (2.9)	1 (2.9)		
Eat a diet with balanced macronutrients	2 (5.7)	2 (5.7)		
Promote physical activity for at least 60 min/day	8 (22.9)	8 (22.9)		
Limit consumption of energy dense foods	4 (11.4)	4 (11.4)		
	Used Strategy (%)			
Goal setting	6 (17.1)			
Positive reinforcement	6 (17.1)			
Monitoring	8 (22.6)			
Cognitive restructuring	0 (0.0)			

Only 1 app (2.9%) limited fast food, take-out, and eating out, encouraged a diet rich in calcium, or a diet high in fiber. With regard to strategies, 6 (17.1%) used goal setting and 6 (17.1%) used positive reinforcement, while 8 (17.1%) used some form of monitoring and 0 (0.0%) used cognitive restructuring.

Interviews

The second part of the study involved interviews with practitioners. There were twelve interviews performed—seven with MDs and five with NPs, RNs or RDs. All interviews were conducted between June 4, 2016 and June 24, 2016. Summary themes from the interviews are summarized in Table 9.

Table 9: Summary Themes from Interviews with Practitioners

MD Interviews (n=7)

<u>Current Practices:</u>

- Get height, weight, and BMI for age at each well-visit. Generally have 15-20 minutes to go over all topics that need to be covered--including weight.
- Go over the growth charts on the screen with patients and families.
- Provide meal and snack tips--but with no consistent practice.
- If child is overweight talk about: growing into or maintaining weight, what extra weight can mean long-term, and increasing physical activity.
- If child is obese: try to get them to come back in the next few months, talk about a few achievable goals, and tell kids to be more active.
- Don't generally ask patients or their families to check weight between visits.
- Sometimes provide handouts, sometimes refer to a few websites, and sometimes give oral recommendations.

<u>Barriers and Perceptions:</u>

- Barriers include: families, lack of family meals and fast food, lack of time and socioeconomic status.
- Patients often don't come back, and MDs don't see progress.
- Desire: kid friendly handouts, access to a pediatric dietitian whose services are covered, parental understanding of what long-term risks are.
- Desire an app that: allows tracking of foods, provides reminders, provides data back to office, highlights calories per day, fruits and vegetables, portions, exercise and screen time.
- Other: need to tell families that they can't take a holiday from this; have to be vigilant all the time.

NP, RN and RD Interviews (n=5)

<u>Current Practices:</u>

- Generally use concept of 3 meals per day, 2 hours or less of screen time, 1 hour of physical activity and 0 sweetened beverages.
- If child is overweight/obese: talk about good healthy habits regarding meals, activity, screen time, and sweetened beverages.
- Don't generally ask patients or their families to check weights between visits.
- Generally provide handouts; sometimes recommend websites or apps--but only a handful.

<u>Barriers and Perceptions:</u>

- Barriers include: technology, education, access, socioeconomic status, cost of eating healthy, lack of reimbursable resources, parents, lack of motivation.
- Desire: more face to face contact.
- Desire an app that: provides an easy way to keep a food record (including food groups), weight, fluid intake, exercise, sleep and sedentary time.
- Other: need changes and good choices everyday.

CHAPTER 5: DISCUSSION

Previous studies that have looked at mobile apps for pediatric obesity prevention have found that there is a need for more evidence-based strategies as well as greater adherence to the published expert recommendations (Breton, Fuemmeler, and Abroms, 2011, Schoffman et al., 2013, and Wearing et al., 2014). The ranking of the mobile apps in this study was consistent with the findings of these previous studies and highlights the fact that the apps currently available for pediatric weight management are not adequate. The current study demonstrates that there is the need for the development of a comprehensive mobile app for pediatric weight management at an affordable price that adheres strongly to evidence-based behaviors and strategies as recommended by the American Academy of Pediatrics (Davis et al., 2007 and Barlow, 2007).

Themes from Interviews with MDs

Looking at the interviews that were conducted with MDs as part of this study, a few themes emerge. First, the primary opportunity for the MD to intervene is during a 15-20 minute wellness visit, which occurs once a year (and, in some cases, once every other year). During these visits, the MD will use the growth chart to demonstrate where the child falls with regard to percentages for height, weight, and BMI for age. If the child is overweight or obese, the MD will assess the degree of overweight and obesity. In some cases, the MD will order additional lab tests. If not, it appears that each MD has his or her own approach to matters—sometimes asking about exercise or physical activity, sometimes asking about screen time, and sometimes asking about typical meal intake. However, there appears to be no consistent approach or resources available to MDs across the board.

Some MDs provide handouts, if available; others do not. Some MDs refer to websites; others do not. What did come through in the interviews is that if a child is overweight and/or obese, the doctor often will try to get that child to come back for an appointment in two or three months (versus waiting another year). Often, these patients do not come back for that follow-up visit. And, most times, MDs find what they are doing is not working, with the result being that more often than not, children continue to gain weight with each passing year.

Themes from Interviews with NPs, RNs, and RDs

Looking at the interviews with NPs, RNs and RDs, there are also a few themes that emerge. NPs, RNs and RDs tend to focus on the concept of 3 meals per day, 2 hours of screen time, more than 1 hour of physical activity and 0 sweetened beverages. They often provide handouts to their patients. They wish that they had more face-to-face contact with patients and that patients could be in touch more often between visits. In addition, they feel that they are not sure exactly what works.

It's this issue—namely that practitioners are not sure exactly what works—that needs to be addressed. Given the growth in pediatric overweight and obesity over the past several decades, there is a tremendous need to find a solution that works and can be cost effectively implemented. An effective, affordable and comprehensive mobile app would appear to be one such component of that solution, but it is clear from the analysis conducted in this study that the current apps are not adequate.

Apps Come with Some Limitations

Kurbo Health Coaching and Tracking for Kids and Teens seems to be the one app that comes closest to following evidence-based practices—but at a cost that might be prohibitive for many of the families affected by pediatric overweight and obesity. The coaching component, where clients have a once-a-week face-to-face online meeting with a Kurbo Coach, costs $85 for one month, $210 for 3 months, and $300 for 6 months. In effect, it's an app that supports one-on-one interaction between kids/teens with a personal coach, which may be effective and meet the need for increased face-to-face time outlined in the interviews but which may not be generally affordable for this population.

In addition, apps come and go. The second highest rated app, Habit Changer Feeding Your Kids was evaluated on July 7, 2016. By July 11, 2016, it was no longer available for download. Given that 10 of the 45 apps (22.2%) that were selected for evaluation were not able to be successfully downloaded and/or launched highlights yet another issue—that things in the mobile app world are constantly evolving and changing. The update date on an app appears to be a fairly good indicator of whether an app is being maintained. For example, 13 (37.1%) of the apps evaluated have been updated since the beginning of 2016, but as you can see in Table 10, many have not been updated since 2015 and earlier.

Table 10: Date of Update for Evaluated Apps

Year updated	Number of Apps	% of Total (n+35)
2016	13	37.1%
2015	9	25.7%
2014	3	8.6%
2013	3	8.6%
2012	4	11.4%
2011	2	5.7%
2010	1	2.9%
Total	35	100.0%

Furthermore, searches aren't perfect—and sometimes despite a search, a good app might not come up. For example, one practitioner mentioned a goal setting app called Strides. Although the search used for this project yielded 655 apps, Strides was not one of them. Strides allows a user to track a number of goals—such as exercise, weight, water consumption, getting up early, reading, budgeting, etc. The free app lets you track a number of things on a weekly basis—but has some limitations. For the expanded app, called Strides Plus, the cost is $4.99 per month or $39.99 per year. As with Kurbo, Strides is an app that appears to have value--but at a price.

Lastly, given that apps may have a specific goal—such as calculating BMI for age—it would make sense that they don't encompass all of the behaviors or strategies proposed for the management of pediatric overweight and obesity. However, it was interesting to find that there was actually only one app from the search, namely Kurbo, which specifically focused on pediatric overweight and obesity management.

Features Needed in an App

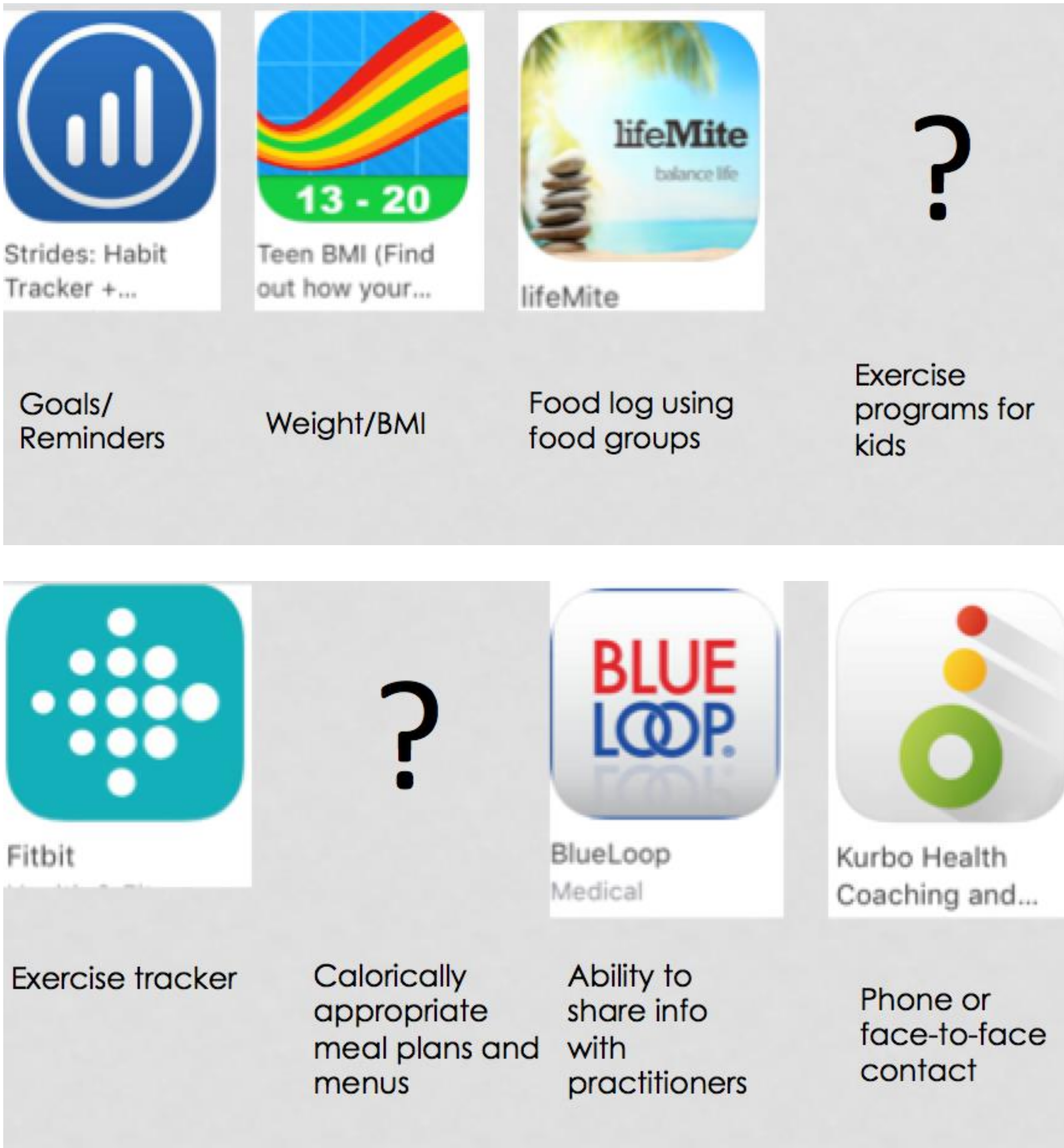
There are a number of features that would appear to be needed in order to make a pediatric weight management app effective. Table 11 lists these features:

Table 11: Features Needed in a Mobile App for Pediatric Weight Management

- Goal setting
- Weight and BMI tracking
- Comprehensive and easy to use food log that ties into food groups
- Reminders and encouragement
- Exercise programs appropriate for age and location
- Exercise tracker
- Calorically appropriate meal plans and menus
- Ability to share information with practitioners and family members
- Opportunity for phone or to have face-to-face (online) contact with practitioner

There are potentially two ways to go about this. One is to develop a new app from scratch that incorporates these features. Another is to work with an existing app provider or providers to develop a new product that incorporates not only some of the features these apps already have but also some of the ones that they don’t. Figure 1 lists the features that are needed—and apps that to some degree address those features.

Figure 1: Apps that Address Features Needed in a Mobile App



Although there are a number of apps that address pieces that are needed, there is a gap with regard to exercise programs for kids and with regard to calorically appropriate meal plans and menus. What is needed is an app that provides all of the above features—not just some.

How Such An App Could Be Developed

There are a few ways such an app could be developed. First, such an app could be developed from scratch. This app would need to be funded—either through grants or private funding such as venture capital. Second, such an app could be developed by one of the companies, who are already providing mobile apps. For example, a company such as FitBit could create a new product line that addresses the pediatric market. This might be too far afield from FitBit's current business model and might take the company in a direction that it does not want to pursue; however, FitBit already has a detailed food database, a method for tracking steps and exercise, weight tracking, and reminders. Potentially, such a company could add to its existing offering by incorporating calorically appropriate meal plans and menus as well as appropriate exercise routines that could be performed by the target demographic (in this case pediatric overweight and obese children and adolescents). It could also expand its information sharing capabilities so that a medical team could have access to the data as well.

How Would Such An App Function?

A comprehensive pediatric weight management app would have the features listed in Figure 1. It would provide families with calorically appropriate meal ideas that are easy to make with ingredients that are easily accessible. For example, the app could include 14 different breakfast ideas. Families and children could create a weekly schedule for those breakfast options. Families and children could then monitor and log their breakfast choices. In addition, the app could remind families and children to weigh themselves weekly. The scale could be electronically tied to the device (like the FitBit Aria scale), thereby automatically recording the weight, or the weight could be entered manually. If a weekly weight is desired, there could be a reminder each Saturday evening that the weight should be recorded on Sunday morning, upon waking, before any food or beverages are consumed. In addition, there could be a daily exercise module. Again, the exercise program would allow for some choices, such as indoors or outdoors. There would be goals and reminders around the exercise program built into the app. Furthermore, there would be a feature allowing all of this information to be shared with the medical practitioner. In this way, if a child's weight trended up each week, the practitioner could receive an alert and reach out to the parent or guardian in order to follow up and to make suggestions. These follow-ups could be by phone or by email—or by Skype or Facetime.

A telehealth feature, via Skype or Facetime, for example, would be an added benefit, but if an RD were involved in face-to-face online counseling with the family and child, there would have to be a reimbursement model that would make sense. Such a reimbursement model does not currently exist. The Kurbo mobile app with one-on-one coaching comes closest to this type of model. The question is whether pediatric weight management is going to be something that is provided by an outside provider, like Kurbo, or whether it is going to be provided as part of a child's overall pediatric care. Pediatricians have a lot of things to cover during wellness visits with children, but given that pediatricians often have continuity with children and families, it would make sense that they would be involved in this part of the care model (specifically weight management) as well.

A structure where there is an app and communication with a practitioner is somewhat similar to that provided by Blue Loop for diabetes management. With Blue Loop, families pay $7.95 per month ($95.40 per year). Families enter the information, and providers can receive notifications and can log in to see data. Providers then can communicate with families and make adjustments as needed. The monthly fee of $7.95 per month does not, however, pay for the providers' time but is instead a payment to Blue Loop for the provision of the service. The Blue Loop model, however, allows the current medical team to be involved in the care of the child. A weight management app that integrated the current medical team—and ultimately had a telehealth option available as well—would be ideal but would necessitate some sort of reimbursement model that does not currently exist.

Given the growth in pediatric overweight and obesity, an app that contains many of these features—if not all--as well as evidence-based solutions is clearly needed.

Strength and Limitations

A strength of this analysis is that it looked not only at the apps but also at feedback from practitioners with regard to how they currently manage pediatric overweight and obesity in their practices. There were, however, a few limitations. First, the interview sample of 12 practitioners used as part of this study was small. To gain a broader sense of what MDs, NPs, RNs and RDs are doing and of what they need, it would be helpful to have a larger interview sample. Second, feedback and input from families with overweight or obese children was not part of the current study—but would be an important aspect going forward in the development of a mobile app. Third, the app searches performed resulted in a number of unrelated and duplicate apps but also missed some potentially relevant apps. In the future, it might be helpful to use a different search method than the one employed as part of this study—perhaps seeking out specific apps if they have been mentioned by practitioners or by trying other search methods. Fourth, due to time and resource constraints a select number of apps—specifically 45 apps—were chosen by the researcher to evaluate. This may have resulted in some relevant apps being overlooked. Lastly, there may be a need to develop a method for determining what gives an app longevity. This could include looking at when an app was last updated or how many iTunes ratings it has. However, ratings appear to be fairly unreliable—with the exception of those apps that have thousands or tens of thousands of ratings. With regard to this study, only 7 (20%) of the apps had over 1,000 ratings, and only 4 (11.4%) of those had over 10,000 ratings. 15 (42.3%) had not received enough ratings to display an average and another 7 (20%) had fewer than 20 ratings, for a total of 22 (62.3%) having 20 or fewer ratings. It would be helpful to have a means to estimate what apps will be around so that a list could be provided to practitioners of helpful—and potentially available—apps without concern that they might be unavailable within a short period of time.

For next steps, it would be helpful to see a comprehensive review of all pediatric weight management mobile apps (including exercise, tracking, education, etc.), to make sure that no apps have not been missed through this analysis that would be useful to practitioners, children and families. It would also be helpful to develop a comprehensive mobile app as outlined and to test its feasibility, effectiveness and cost effectiveness.

Future Research

Once developed, such an app would have to be tested for feasibility, acceptability, and effectiveness. This could be done either through a randomized controlled trial or a quasi-experimental trial. Ideally, the best way to test such an app would be through a randomized controlled trial that compared use of such an app compared to a current pediatric weight management program using traditional counseling practices and a control. If such an app proved to have a statistically significant and cost effective impact on pediatric weight management, then such an app could have a broader application in the management and treatment of pediatric overweight and obesity. Implications for practice could include the use of such an app by practitioners and their families in order to treat pediatric overweight and obesity—as well as to prevent additional overweight and obesity in the youth who are growing up today.

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APPENDIX

Evaluated Apps

Assigned Category	Name of App	Author	Price	In-App Purchase	Evaluated	Updated	Age	Ratings for All Versions
Book	**Coloring Book 19 Lite: Eating Healthy**	Dataware LLC	Get	$4.99	5-Jul	12-Jan-16	4+	NA
	Coloring book app that allows you to color different foods. There are pictures of foods that you color in. The pictures show healthy foods and unhealthy foods trying to ambush the healthy foods;in the end, they find a healthy balance. You can pay $4.99 to unlock the full version which has 50 pages to color.							
Book	**Veggie Bottoms Lite for iPhone**	Red Card Studios	Get	$0.99	10-Jul	7-Apr-16	4+ (6-8)	NA

Book about fruits and vegetables. Each page is about a different fruit or vegetable. In the Lite version, there are 8 pages in the free version and a total of 17 pages in the paid version.

Assigned Category	Name of App	Author	Price	In-App Purchase	Evaluated	Updated	Age	Ratings for All Versions
BMI	**Your Ideal Weight: calculator for your losing diet** Opens with Begin Test. Seclect your gender, height, weight and age. It then tells you your ideal weight range and your ideal weight according to what people with your weight, age and height would like to have. The next screen provides your BMI. If you want to track your weight, you need to do the in-app purchase.	Movisol	Get	$2.99	5-Jul	11-Nov-14	12+	3/48364
BMI	**BMI 4 Teens (Find out how your WEIGHT, HEIGHT & BMI compares with others of the same age)**	Tactio Health Group Inc.	Get		5-Jul	20-Oct-11	4+	3/41

Doesn't let you enter your age (but is tailored towards 13 to 19 year olds). You provide your weight and height, and it gives you your BMI.

Assigned Category	Name of App	Author	Price	In-App Purchase	Evaluated	Updated	Age	Ratings for All Versions
BMI	**Teen BMI (Find out how your WEIGHT, HEIGHT, and BMI compares with others of the same age)**	Tactio Health Group Inc.	Get		5-Jul	21-Dec-12	4+ (13-20_	3/4415
	Enter age, height and weight, and it calculates BMI and BMI for age percentile. If you want to track the data, you need to open Tactio Health: My Connected Health Logbook. This app lets you add more data points, such as sleep, steps, physical activity. There is also a nutrition plan which tells you how many calories you should have to maintain or lose weight. You can also set a weight goal.							
BMI	**Child BMI (Growth Percentiles - Height, Weight, and Body Mass Index**	Tactio Health Group Inc.	Get		5-Jul	31-Dec-12	4+ (2-13)	3.5/396

Similar to Teen BMI, enter age, height and weight, and it calculates BMI and BMI for age percentiles. If you want to track the data, you need to open Tactio Health: My Connected Health Logbook as above.

Assigned Category	Name of App	Author	Price	In-App Purchase	Evaluated	Updated	Age	Ratings for All Versions
BMI	**BMI: Kids and Teens**	Vladamir Kutser	Get		5-Jul	25-Nov-15	4+	NA
	Enter age, height, and weight, and it calculates BMI for age. You can also see the BMI for age in graph form. No way to track over time.							
Education	**Eat & Move-O-Matic**	Learning Games Lab, NM State University	Get		7-Jul	17-Mar-15		3.5/47

Set up like a slot machine, you press the button, and a food comes up and what it will take to burn it off. For example, one medium orange has 62 calories, and you could burn it off by doing gymnastics which burns 4 calories/minute for 16 minutes. It goes on to say that oranges are a good source for vitamins and minerals, especially Vitamin C.

Assigned Category	**Name of App**	**Author**	**Price**	**In-App Purchase**	**Evaluated**	**Updated**	**Age**	**Ratings for All Versions**
Education	**Kids Food Adventure**	Haymachine Entertainment	Get		10-Jul	4-Jun-12	4+	NA

	Explore foods, track the foods you've tried, and rate them. For example, pick cheese. There are a variety to choose from. When you click on a type of cheese, it gives you information about the cheese, including what it contains (protein and calcium, for example). When you try a food and rate it, you can get a sticker.					
Education	**Munch Code!** Munch Code! Is a game that uses the stoplight method. In the first game, you move the foods into a green, yellow or red category. The second game has you pick the right snacks to eat. The third game has you choose the right number of green, yellow and red snacks. There are three games in total.	Hot Pink, Ink	Get	7-Jul	16-Oct-14	NA

Assigned Category	Name of App	Author	Price	In-App Purchase	Evaluated	Updated	Age	Ratings for All Versions
Education	**This is my food - Nutrition for kids**	Urbn; pockets	$2.99		8-Jul	10-Mar-16	4+ (6-8)	4/10
	Pick a friend. Your friend tells you about different foods. You click on the different main courses or sides and then learn about them. There are some sections where you have to read about a food.							
Education	**Science Heroes: Digestive System for Kids**	Yogome, Inc	Get	$5.99	8-Jul	29-Feb-16	4+ (9-11)	3.5/74
	Talks about digestion. Starts in the mouth. Mechanical and chemical. Tracks the food as it travels through your digestive system. Starts with an educational piece before the game. To access the games, you have to pay the $5.99.							
Education	**Healthy Eater - Educational Game for Children**	BABYUS	Get		7-Jul	27-May-16	4+	4.5/8

Game where you put food on a plate and then have the panda eat it. Items are from the different food groups.

Assigned Category	Name of App	Author	Price	In-App Purchase	Evaluated	Updated	Age	Ratings for All Versions
Education	**iTooch 6th Grade / Health** Has a lesson summary. Then a game that asks you to identify foods in a food group. You select which ones belong. Then, you complete a test before going on to the next chapter and lesson plan. Education focused. You can refer back to the lesson plan as needed. Chapters 1 and 2 were on Foods and Nutrients. Chapter 3 is on Food Safety. Chapter 4 is on Vitamins and Supplements.	eduPad Inc.	$5.99		10-Jul	20-May-16	4+	4.5/10

Education	**Max's Plate** Game where you drag the food image to the right food group on the plate. When you get it correct, you get a point. Level 1 has one food image for each group. Level 2 has two food images for each group. Level 3 has three food images for each group.	Merryweather Farms, LLC	Get	10-Jul	20-Nov-11	4+	NA

Assigned Category	Name of App	Author	Price	In-App Purchase	Evaluated	Updated	Age	Ratings for All Versions
Exercise	**Iron Kids** Strength training for adolescents. From the American Academy of Pediatrics. Targeted towards young athletes.	American Academy of Pediatrics	$2.99		8-Jul	23-Aug-12	4+	2/7
Exercise	**7 minute workouts with lazy monster PRO: daily fitness for kids and children** Follow the one-eyed animated character. Exercises include 30 seconds of running in place, windmill, vertical jumps, shadow boxing, step-ups, crunches, bending down, and wall-sit. It indicates that there are 7 workouts; however, only able to access the one workout in the $1.99 version.	Pavel Mylnikau	$1.99		8-Jul	10-Jun-16	4+	NA

Assigned Category	Name of App	Author	Price	In-App Purchase	Evaluated	Updated	Age	Ratings for All Versions
Exercise	**Workouts for Children - Exercises for Kids**	Do Tri	$1.99		10-Jul	20-Jun-15	4+	NA
	Starts with text about the benefits of exercise. Then shows six exercise moves for kids: pank, chest press on a stability ball, chair squats, bent-knee push-up, lying row, bicep curls. There is a 5-minute home video type exercise video . There's a tab for nutrition and wellness tips which takes you to the USDA's Nutrition and Wellness Tips for Young Children.							
Exercise	**SNaX League - Students for Nutrition and eXercise**	Boston Children's Hospital	Get		8-Jul	2-Nov-15	12+	NA

Refers you to You Tube Videos. Exercises inlude basketball shoots, bicycle crunches, crab crawls, jumping jacks, mountain climbers, plank, push ups, running in place, slalom, squat jumps and stair climbers. No actual workouts.

Assigned Category	Name of App	Author	Price	In-App Purchase	Evaluated	Updated	Age	Ratings for All Versions
Game	**Eat This, Not That! The Game**	Galvanized Brands LLC	Get	$0.99 ea	8-Jul	25-Nov-15	4+	2.5/37610
	Game that provides you with two choices and you pick which one would be better to eat. Most of the choices are restaurant foods, and so in many cases neither choice is a great one.							
Game	**fooya! Let's move nutrition education for kids, to having fun & eating healthy**	FriendsLearn Inc	$9.99		8-Jul	20-May-16	4+ (9-11)	5/62
	Game where you throw food at robots, who throw food back at you. If you are hit, you get fat. Once you are too fat, you lose. After the game, you see the foods and the nutrition labels for them. There is a need for a tutorial.							

Assigned Category	Name of App	Author	Price	In-App Purchase	Evaluated	Updated	Age	Ratings for All Versions
Game	**Healthy Heroes 1 - Nutrition for Kids** You feed the hungry monster food. In between each game is a healthy tip--about screen time, portions, sugar sweetened beverages, etc. There are a handful of messages, which repeat. Kids might play the game, but it would be good to have adults hear the messages. In another game, you spell the name of the picture on the screen and learn a healthy fact about that food.	Yogome, Inc	$2.99		8-Jul	26-Feb-15	4+ (6-8)	3/16
Game	**Carefree Capers: Shaping Up!** Pick up vegetables in the garden and then exhange them for foods. Point of the game not completely clear.	3DDUO	Get		8-Jul	30-Apr-15	4+ (6-8)	NA

Assigned Category	Name of App	Author	Price	In-App Purchase	Evaluated	Updated	Age	Ratings for All Versions
Game	**Healthy eating with Diana - educational game to teach children about healthy eating**	Mutua General de Catalunya	Get		10-Jul	16-May-13	4+	NA
	A number of games with Diana. Sometimes difficult to distinguish what the foods are from the picture. A game to help Diana choose which foods she can eat daily, weekly or occasionally, a memory game, a game where you choose whether a particular food is for energy, daily function or growth, a painting game to fill in pictures with various foods, a game to choose healthier options, a puzzle game where you place the pieces, a game where you help Diana make choices by giving her mother healthy foods and putting unhealthy foods in a cupboard.							

Assigned Category	Name of App	Author	Price	In-App Purchase	Evaluated	Updated	Age	Ratings for All Versions
Healthy Eating	**Habit Changer Feeding Your Kids**	Habit Changer	Get		7-Jul	15-Jun-10		1.5/11
	42 days of challenges, including such things as eating a family meal, reading labels, eating breakfast, eating fiber, eating at the table, needing to try new foods 10-20 times, etc. Format is writing on the screen.							
Healthy Eating	**lifeMite**	Anthony Gilardi	$0.99		7-Jul	31-Jan-13	4+	NA

You enter you name, gender and weight. Then, you can add goals, including cholesterol, blood pressure, fiber, vegetables, fruit, water, medication, vitamins-supplements, journal, family-friends time, and spirituality-meditation. You can add a choleseterol lowering diet or a juicing or natural juice diet for an extra fee. Diet goals are in servings (servings of fiber, vegetables, fruit, etc.). It's easy to add servings by clicking on an icon.

Assigned Category	Name of App	Author	Price	In-App Purchase	Evaluated	Updated	Age	Ratings for All Versions
Healthy Eating	**My Balance Buddy**	MyBalanceBuddy	Get		10-Jul	11-Nov-13	4+	NA

Pick a reward (going to the park, etc.) and write it in. Then, pick your age group, and up comes a figure with the number of fruits, vegetables, meats, dairy, and grains you should have (in 1 oz servings). As you eat, you click on one of the servings. When you eat all your vegetables, you get a pop up that says, "You Rock" or "Fantastic" etc. The idea is to get kids to eat the different food groups.

Assigned Category	Name of App	Author	Price	In-App Purchase	Evaluated	Updated	Age	Ratings for All Versions
Healthy Eating	**Figure Facts Teen Nutrition** Put in your gender, age, height, weight, activity level and goal weight. Add foods to your Figure Facts Diary, and it shows how many of each food group you have had. However, some glitches with adding foods: showed up in servings count but not in diary. Page with some Healthy Eating and Fast Food Tips, some Body Fueling Tips, and Top Ten Healthy Snack Ideas.	Figure Facts LLC	$0.99		10-Jul	1-Mar-13	4+	NA
Recipes	**Kids recipes by ifood.tv** Video recipes by folks who appear to have their own channels, to which the app wants you to subscribe.	FutureToday Inc	Get		8-Jul	12-Nov-14	4+	4.5/17

Assigned Category	Name of App	Author	Price	In-App Purchase	Evaluated	Updated	Age	Ratings for All Versions
Tracker	**Fitbit** Set a daily step goal, distance goal, calories burned, active minutes, floors climbed, and an hourly activity goal. You can log food, log sleep, log water, add friends, and log weight. You can have a water goal, weight goal, body fat % goal, and a food goal (calorie deficit).	Fitbit, Inc.	Get		10-Jul	30-Jun-16	4+	4/74084
Tracker	**Lifesum - Healthier living, better eating, more movement** Enter your gender, height, weight, and weight goal. Lifesum provides the calories and how long it will take. You can track your calories and exercise. It asks if you want to upgrade to Lifesum Gold, which has a number of packages ($8.33 per month for 3 months, $5.83	ShapeUp Club AB	Get	$3.74/mo for 12 mos	7-Jul	6-Jul-16		3.5/4514

per month 6 months, and $3.74 per month for 12 months).

Assigned Category	Name of App	Author	Price	In-App Purchase	Evaluated	Updated	Age	Ratings for All Versions
Tracker	**Calorie Counter & Diet Tracker by MyFitnessPal**	MyFitnessPal.com	Get	\$9.99/mo or \$49.99/yr	10-Jul	5-Jul-16	4+	4.5/489015
	You can put in a weight goal, nutrition goals, and fitness goals. You can log your food and exercise. However, if you add exercise, it will add those calories to your daily total.							

Tracker	**CalorieKing Food Search** Check nutrition information on foods in CalorieKing's Food Database.	CalorieKing	Get	$1.99 w/o ads	5-Jul	17-Feb-15	12+	3.5/319
Water	**Peppy Buddy** Peppy buddy is an animated character that tracks your steps and encourages you to drink water.	Smarcle, inc.	Get		7-Jul	2-Dec-15	4+	NA

Assigned Category	Name of App	Author	Price	In-App Purchase	Evaluated	Updated	Age	Ratings for All Versions
Water	**Daily Water Free - Water Reminder and Counter**	Maxwell Software	Get		10-Jul	20-Apr-16	4+	4.5/2119
	App to track water consumption. Can link to Apple Health Access. Shows nine glasses of water (7 oz each when you click on it). You can set reminders to remind you to drink at different hours of the day.							
Weight Loss	**Kurbo Health Coaching and Tracking for Kids and Teens**	Kurbo Health, Inc.	Get	For coaching	7-Jul	8-Jun-16	4+	4.5/167

Can sign in as the parent initially. Kids create a separate account. Uses a traffic light system. You can track foods. Uses the stoplight method. Some short videos called Portion Planner, Go for the Goal, Fitness Fiend, Label Whisperer, and Nutrition Nut. If you sign up for the coaching portion, the fees are $85 for one month, 3 months for $210, and 6 months for $300.