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Examining the Use of mHealth Technology for Weight Management: A Hybrid Effectiveness-Implementation Trial in Family Medicine

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Abstract

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Overweight and obesity are prevalent and problematic conditions in the United States and worldwide, and effective weight management interventions are underutilized. Efforts to improve weight management practices have focused almost exclusively on changing physician behavior, without considering the larger healthcare context or the reciprocal patient-physician relationship. The current study explored the possibility of leveraging technology to improve the implementation of weight management clinical practice guidelines and increase patient-physician weight management discussions. 100 patients of five family medicine physicians were randomly assigned to either complete a weight management mobile application (app) prior to their primary care visit (app condition), or to undergo their primary care visit as usual (control condition). Findings suggested that patients largely viewed the app as an acceptable use of their time in the waiting room and they were able to complete the app with moderate fidelity prior to meeting with their physicians. Consistent with hypotheses, patients in the app condition were statistically more likely to initiate discussions about weight status than patients in the control group. However, contrary to hypotheses, these discussions did not occur at a statistically higher rate in the app condition than in the control condition. Overall weight status conversations were low relative to patient need, occurring in 42.7% of total visits, though 82.5% of the total sample was classified as overweight or obese. Also contrary to hypotheses, patients in the app condition did not demonstrate statistically improved BMI at follow-up than the control condition. Strengths, limitations, and directions for future research are discussed.

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Introduction

Rates of overweight and obesity have been increasing in the United States (U.S.) and worldwide over the past several decades (National Institute of Diabetes and Digestive and Kidney Diseases, n.d.). In fact, the prevalence of obesity reached epidemic proportions at the national level in the U.S. in 1998 (Hill & Peters, 1998) and was named a global epidemic by the World Health Organization in 2008 (James, 2008). Trends continue to increase, with the most recent estimates from 2018 indicating that nearly 40% of U.S. adults are obese (Centers for Disease Control and Prevention, 2019), up from approximately 30% in 2014 (Ogden, Carroll, Fryar, & Flegal, 2015). In addition to the high percentage of U.S. adults who are obese, another roughly one-third of the population is considered overweight (Centers for Disease Control and Prevention, 2019). The distinction between overweight and obesity is based on differences in excess body weight and is often defined by body mass index (BMI). BMI is the ratio of an individual's weight to height and is a time- and cost-effective method of estimating body fat. For adults, overweight is defined as a BMI of 25.0 – 29.9 while obesity is defined as a BMI of greater than 30.0 (Trust for America's Health, 2017).

Despite definitional differences, the health consequences are the same for the roughly 70% of U.S. adults who are overweight or obese. These health consequences include a greater risk of developing type 2 diabetes, high blood pressure, joint problems, certain types of cancer (National Institute of Diabetes and Digestive and Kidney Diseases, n.d.), sleep apnea, and cardiovascular disease (Visscher & Seidell, 2001) among others. In addition to diminishing the individual's overall wellbeing and life expectancy, these health complications also result in substantially greater healthcare costs (Finkelstein, Trogdon, Cohen, & Dietz, 2009; Wang et al., 2015). Worldwide estimates note that individuals who are obese have 30% greater healthcare costs than adults of normal weight (Withrow & Alter, 2011). In the U.S. specifically, meta-

analytic findings suggest that annual expenditures for obesity range from $1,239 – $2,582 per person, resulting in a cost of $149.4 billion nationally (Kim & Basu, 2016). Earlier data indicate that nearly 44% of national expenditures for severe obesity specifically (defined as a BMI of 35 or greater) was paid for through taxpayer-based funds such as Medicare and Medicaid (Wang et al., 2015). Thus, rising rates of overweight and obesity not only contribute to increased morbidity at the individual level, but also have larger societal consequences.

Fortunately, sustained weight loss and healthier lifestyles (e.g., increased physical activity and improved diet, even without concomitant weight loss) have been shown to reduce morbidity (Aucott et al., 2009; Baillot et al., 2015; Poobalan et al., 2004) and mortality (Harrington, Gibson, & Cottrell, 2009; Kritchevsky et al., 2015; Poobalan et al., 2007) in adults who are overweight or obese. As such, efforts have been taken to identify effective interventions for promoting healthier life styles and improved weight management (e.g., Dombrowski, Knittle, Avenell, Araújo-Soares, & Sniehotta, 2014; Gloy et al., 2013; Kirk, Penney, McHugh, & Sharma, 2012; Turk et al., 2009; Yanovski & Yanovski, 2014). Research has suggested that the most effective weight management interventions are multicomponent (Kirk et al., 2012), including a combination of diet counseling, nutritional education, promoting physical activity, and cognitive-behavioral therapy to support behavior change (Kirk et al., 2012). Not all of these components are necessary, and the overall intervention package should include components that are individualized to the unique risk factors of each patient. Other important factors include that the intervention package should specifically target weight management rather than comorbid conditions, and should be planned for at least 6 months with regularly-scheduled follow-up appointments (Kirk et al., 2012).

Despite the existence of effective interventions and even amid greater awareness of concerns associated with the increasing prevalence of overweight and obesity, research has found that these conditions are often underdiagnosed (Ma, Xiao, & Stafford, 2009; Smith et al., 2011) and undertreated (Kraschnewski et al., 2013; Smith et al., 2011). One study indicated that only 29% of adult patients seen in a nationally-representative sample of U.S. outpatient clinics who were obese according to their BMI had a diagnosis of obesity documented in their medical chart (Ma et al., 2009). Additionally, only about 50% of primary care physicians (PCPs) from a nationally-representative sample indicated that they regularly record BMI in required clinical documentation (Smith et al., 2011).

Perhaps more troubling are findings related to the provision of appropriate recommendations and treatment for individuals who are overweight or obese. Rates of weight-related counseling provided by PCPs declined between 1995-1996 and 2007-2008, which corresponds to the same time period during which concerns regarding the increasing prevalence of obesity were becoming more widespread (Kraschnewski et al., 2013). In other words, despite greater awareness of high rates of overweight and obesity, the rate at which physicians discussed weight management treatment options decreased, with one study noting that fewer than half of PCPs reported providing their patients with guidance on weight management practices (e.g., diet, physical activity, weight control; Smith et al., 2011). Even when weight-related counseling is provided, research has suggested that it often does not align with what the intervention literature has shown to be effective. Specifically, less than 10% of PCPs reported always referring obese patients for additional evaluation and management and only 22% always tracked patients' weight-related behaviors and concerns over time (Smith et al., 2011). Additionally, when weight-related advice was provided, physicians were significantly more likely to counsel only on

increased physical activity without including a discussion of diet and other weight control considerations (Smith et al., 2011). Taken together, findings suggest that PCPs do not regularly diagnose or recommend interventions for overweight and obesity in their adult patients, and that when recommendations or interventions are provided, they generally are not consistent with the multicomponent interventions that have been shown to be most effective.

Barriers to Obesity Diagnosis and Treatment

To review, rates of overweight and obesity in U.S. adults have been increasing over time, despite awareness of significant individual and societal consequences. And although effective weight management interventions exist, these conditions remain underdiagnosed and undertreated. Accordingly, it is particularly important to understand what may be preventing physicians from providing diagnoses and treatment recommendations. To this end, several studies have been conducted to identify and understand barriers to overweight and obesity-related care.

Based on the hypothesis that suboptimal diagnostic and treatment practices may be related to inadequate physician training, numerous studies have investigated physician knowledge of obesity treatment practices. A systematic review of 43 such studies indicated that many physicians have limited understanding of not only ways to measure and diagnose overweight and obesity, but also of available treatment options and their effectiveness (Hayden, Dixon, Piterman, & Brien, 2008). Specifically, the review noted that physicians often do not know the minimum BMI to diagnose obesity in adults, nor are they aware of the use of waist circumference as an alternative diagnostic measure to BMI (Hayden et al., 2008). Even among physicians who do have adequate knowledge of obesity and treatment options, many report that they do not feel confident or successful in providing treatment. This lack of physician confidence

in treatment success has been attributed to the common stereotyping of overweight and obese patients as lazy, lacking in motivation, and unable or unwilling to adhere to treatment (Hayden et al., 2008).

Indeed, lack of physician knowledge has been examined in relation to a variety of attitudes and treatment-related behaviors. Specifically, in a survey of family physicians from New Jersey, lower overweight/obesity knowledge was positively correlated with various attitudes, including dislike of discussing weight loss with patients and pessimism about the possibility of patient success (Ferrante, Piasecki, Ohman-Strickland, & Crabtree, 2009). In addition, lower knowledge and associated negative attitudes toward weight management were correlated with less frequent weight-related recommendations (Ferrante et al., 2009). Similar to findings noted in Hayden et al. (2008)'s review, this survey also indicated a high overall prevalence of negative attitudes towards overweight and obese patients, particularly in younger physicians (Ferrante et al., 2009). Taken together, these findings suggest that low levels of knowledge about overweight and obesity care are prevalent (Ferrante et al., 2009; Hayden et al., 2008), and may be associated with both negative attitudes toward overweight and obese patients and the infrequency of treatment provision (Ferrante et al., 2009).

Research has also examined characteristics of healthcare professionals that may serve as barriers or facilitators to the provision of diagnoses and/or treatment recommendations for overweight and obesity. Such studies have tended to focus on the weight status of physicians and other healthcare professionals (e.g., nurse practitioners, physician assistants), based on findings from prior literature that professionals with their own healthy habits may be more likely to advocate for healthy behaviors in their patients (e.g., Zhu, Norman, & While, 2011). Indeed, research has indicated that professionals of normal weight are more likely than overweight

professionals to use both obesity-prevention strategies (Zhu et al., 2011) and to provide diagnoses and treatment recommendations to adult patients who are overweight or obese (Bleich, Bennett, Gudzune, & Cooper, 2012). Of note, the findings regarding physician knowledge reported in this systematic review (Zhu et al., 2011) were consistent with prior research, such that greater physician knowledge of overweight and obesity were predictive of improved treatment practices. An important addition of this review was the finding that professional weight status was unrelated to knowledge of obesity treatment (Zhu et al., 2011).

An additional nuance to the literature on barriers to weight management focuses on patient perceptions related to professional weight status. Specifically, results from a national survey of adult patients who were overweight or obese indicated they generally have greater trust in diet advice provided by overweight professionals than by professionals of normal weight (Bleich, Gudzune, Bennett, Jarlenski, & Cooper, 2013). However, they also reported feeling more judgment from an overweight professional compared with a professional of normal weight (Bleich et al., 2013). Despite these nuances, it should be noted that participants generally reported high levels of trust in their professionals with little variability (an average of 8.4 out of a maximum of 10; Bleich et al., 2013), suggestive of possible ceiling effects and/or social desirability. These findings speak to the complex nature of providing weight management treatment and also point to important factors that may contribute to the low rates of making overweight and obesity diagnoses and providing treatment recommendations.

Clinical Practice Guidelines

One strategy aimed at increasing the use of effective interventions across a wide array of health concerns is the use of clinical practice guidelines (Institute of Medicine, 1990). Although clinical practice guidelines have existed in some format for decades, they received renewed

interest in the late ‘80s and early ‘90s (Institute of Medicine, 1990). It was in the context of this renewed interest and in increasing calls for evidence-based practices across the helping professions that the Agency for Health Care Policy and Research (AHCPR) was established in the U.S. in 1989 (Institute of Medicine, 1990). An early focus of the AHCPR was to standardize the process of developing clinical practice guidelines and to create a taxonomy of consistent relevant definitions (Institute of Medicine, 1990). Based on the early work of the AHCPR, clinical practice guidelines have been defined as “systematically developed statements to assist practitioner and patient decisions about appropriate health care for specific clinical circumstances” (Institute of Medicine, 1990, p.8).

Amid burgeoning awareness of high obesity prevalence and increased research on weight management interventions, the development of clinical practice guidelines for adult obesity management was initiated in 2008 and finalized in 2013 (Jensen et al., 2013). These guidelines were developed by a task force comprised of members of the American Heart Association (AHA), the American College of Cardiology (ACC) and The Obesity Society (TOS); as such, the weight management guidelines will be referred to in the remainder of this document as the AHA/ACC/TOS guidelines (Jensen et al., 2013).

The AHA/ACC/TOS guidelines were developed using an evidence-based process outlined in standards published by the Institute of Medicine (Graham, Mancher, Miller Wolman, Dianne Greenfield, & Steinberg, 2011), based on the initial work of the AHCPR. Through an extensive review of the literature on weight management, the following guidelines for adult patients were established: (a) identify patients who could benefit from weight loss using BMI and/or waist circumference; (b) provide identified patients with information on possible risks associated with overweight and obesity; (c) match patients with treatment options based on their

risk profiles; and (d) identify and counsel patients who may be good candidates for bariatric surgery (Jensen et al., 2013). Details to help facilitate specific decisions (e.g., matching of treatment options with risk profiles) are also provided in the AHA/ACC/TOS guidelines (Jensen et al., 2013).

Although clinical practice guidelines have the potential to improve healthcare by acting as simple decision tools for healthcare professionals, research has indicated that they are under-utilized (e.g., Cabana et al., 1999; Francke, Smit, De Veer, & Mistiaen, 2008; Solberg, 2000). As has been shown with evidence-based practices in other fields (e.g., Booth, 2003; Proctor et al., 2009; Robinson, 1998; Walshe & Rundall, 2001), the passive dissemination of clinical practice guidelines has not facilitated widespread uptake, nor has it proven effective in changing the practice-related behavior of healthcare professionals (Solberg, 2000).

Early reviews on barriers to the implementation of clinical practice guidelines (i.e., for any condition, not just obesity) identified factors at the individual physician level that are similar to the aforementioned barriers to overweight/obesity diagnosis and treatment. Such factors included lack of awareness of and familiarity with clinical practice guidelines, low perceived self-efficacy in adhering to the guidelines, a negative expected outcome of following the guidelines, and difficulty in overcoming prior practices that are inconsistent with the guidelines (Cabana et al., 1999). However, such research was criticized for focusing too heavily on individual physician behavior change while neglecting larger system-level and contextual factors that may influence treatment practices (Solberg, 2000), such as insurance mandates and reimbursement practices, clinic policies and procedures, and administrative support. Indeed, this focus on the individual without a consideration for the context in which the individual is embedded, is a common criticism of intervention research across the helping professions (e.g.,

Addington, Kyle, Desai, & Wang, 2010; Chaudoir, Dugan, & Barr, 2013; Templeton et al., 2016). A later review suggested that these criticisms were heard, as numerous barriers to the use of clinical practice guidelines were identified across multiple levels (Francke et al., 2008). Specifically, characteristics of the physicians, of the patients, of the work environment, and of the guidelines themselves were implicated in limiting the implementation of clinical practice guidelines (Francke et al., 2008).

Despite the improved understanding of the multi-level nature of barriers, interventions to improve the use of clinical practice guidelines have still focused primarily on changing individual physician or healthcare professional behavior. Such interventions as applied specifically to the AHA/ACC/TOS guidelines have mainly included additional education to increase professional awareness of the guidelines (e.g, Schuster, Tasosa, & Terwoord, 2008) as well as reminders and feedback when healthcare providers are identified as not regularly using the guidelines (e.g., Barnes, Theeke, & Mallow, 2015). Given that these interventions focused exclusively on provider behavior and did not target multilevel factors identified as barriers to guideline use (Francke et al., 2008), it is perhaps unsurprising that they yielded mixed results. For instance, one study demonstrated statistically greater rates of BMI documentation post-intervention, but no statistically different rates of overweight/obesity diagnoses or weight management planning following the intervention (Barnes et al., 2015). Conversely, a second study demonstrated statistically significant improvements in physician comfort in discussing obesity and increases in actual obesity management discussions when physicians received education on weight management clinical practice guidelines through academic detailing (Schuster et al., 2008). This study also noted statistically significant reductions in patient weight, BMI, and comorbidities (Schuster et al., 2008). While results of the study conducted by Schuster

and colleagues (2008) are promising, it is perhaps time to consider more novel approaches that target barriers at more than just the physician level.

Patient-Professional Interactions

As noted above, a common limitation across the literatures on overweight and obesity treatment provision and on clinical practice guideline use is the primary focus on the behavior and characteristics of health professionals (e.g., Bleich et al., 2013; Ferrante et al., 2009; Hayden et al., 2008; Zhu et al., 2011). While professional behavior is certainly important, healthcare interactions are generally dyadic and the result of a reciprocal interface between patients and healthcare professionals. As such, it is important to consider the patient as an active participant in the healthcare process and to consider the ways in which patient characteristics and behaviors can influence the behaviors of healthcare professionals, and vice versa. To this end, research has identified a variety of patient characteristics within adult samples that can impact health-related communication, including patient race (Gordon, Street, Sharf, & Souchek, 2006; Johnson, Roter, Powe, & Cooper, 2004), literacy (Katz, Jacobson, Veledar, & Kripalani, 2007), and socioeconomic status (SES; Willems, De Maesschalck, Deveugele, Derese, & De Maeseneer, 2005).

Specifically, research has demonstrated that Black patients receive less information in general from their physicians and are less actively involved in conversations compared with White patients (Gordon et al., 2006). In addition, physicians tend to be more verbally dominant, less patient-centered, and exhibit less positive affect toward Black patients than White patients (Johnson et al., 2004). Similarly, physicians interact with adult patients of lower SES using a more directive consulting style, which includes less information-giving and fewer partnership-building utterances (Willems et al., 2005). This is contrasted with adult patients of a higher SES,

with whom physicians communicate more actively and elicit greater reciprocity (Willems et al., 2005). In addition, adult patients with lower literacy ask fewer questions of their physicians, thus eliciting less information from their physicians (Katz et al., 2007).

One commonality across each of these studies is that various patient characteristics can implicitly and explicitly influence physician communication. One study directly examined this reciprocal relationship and noted that physicians have a tendency to match the communication style used by their patients, such that more active patients (i.e., those who asked more questions, were more assertive, and brought up their own concerns) elicited a more active, supportive, and partnership-driven communication style in their physicians (Street Jr., Gordon, Ward, Krupat, & Kravitz, 2005). Taken together, this body of research suggests that adult patients who stand to benefit the most from active physician communication (e.g., those who may have limited resources with which to increase their health-related knowledge, or who may be culturally-inclined to defer to physicians as experts) are the least likely to receive it.

Patient Empowerment

As research on patient-physician communication demonstrates, it is particularly important to focus on fostering an active patient who participates as a shared decision-maker within the healthcare context. This approach is referred to as patient empowerment (Bravo et al., 2015), and has received a great deal of attention in both research and applied settings. In fact, the patient empowerment approach became popular within the U.S. healthcare system in the 1990s with a move away from the more traditional medical model in which the patient was viewed as a passive recipient of medical treatment and expected to comply with physician recommendations with minimal questioning or collaboration (Aujoulat, d'Hoore, & Deccache, 2007). Patient empowerment has been viewed as particularly important for individuals with chronic conditions

that require lifelong management through complex daily treatment regimens and/or lifestyle changes, as the establishment of a collaborative partnership between patients and providers can foster improved treatment adherence (Bodenheimer, Lorig, Holman, & Grumbach, 2002).

Although early research on patient empowerment was complicated by a lack of consensus on definitions and outcomes (Paola et al., 2015), a recent mixed methods study provided a thorough conceptualization of patient empowerment (Figure 1; Bravo et al., 2015). Patient empowerment is a multifaceted construct that is influenced by factors at several levels within the healthcare system, and that can be measured using various combinations of outcomes (Bravo et al., 2015).

It is important to note that patient empowerment does not place the burden of healthcare decisions solely on the patient. Rather, when enacted as intended, patient empowerment should foster shared decision-making between the patient and healthcare professionals (Anderson & Funnell, 2011). When informed by patient empowerment principles, a healthcare professional's role should include increasing patients' abilities to think critically and make informed decisions about their health status and treatment options (Anderson & Funnell, 2011; Aujoulat et al., 2007). Given the interaction between patient empowerment and patient-physician communication, and evidence suggestion that patient empowerment approaches can improve patient engagement in and adherence to long-term healthcare interventions (Bodenheimer, Lorig, Holman, & Grumbach, 2002), research aimed at improving overall healthcare delivery should consider taking a patient empowerment approach.

Mobile Health (mHealth)

One innovative strategy that has recently been applied to improving a broad range of health interventions involves leveraging the use of wireless technologies (e.g., smartphones,

tablets, etc.). Mobile health, or mHealth, refers to the use of such wireless technology for a wide variety of healthcare purposes, including facilitating accurate diagnosing, disease outbreak monitoring, dissemination of disease and treatment information, and monitoring treatment adherence (Nacinovich, 2011). The use of mHealth is appealing for clinicians and researchers alike due to increasing access to mobile devices and their ability to be easily transported by patients and research participants (Kumar et al., 2013).

The majority of mHealth research to date has focused on either improving the process of service delivery (e.g., appointment reminders, doctor-nurse communication, diagnostic accuracy; (Free, Phillips, Watson, et al., 2013) or on mHealth-delivered disease management/behavior change interventions (Free, Phillips, Galli, et al., 2013). Two meta-analyses have been conducted to better understand the effectiveness of mHealth interventions within these two specific domains for adults with a variety of health concerns.

The first meta-analysis included studies that focused on the use of mHealth to improve various aspects of service delivery (Free, Phillips, Watson, et al., 2013). Results indicated that the effectiveness of mHealth for improving service delivery depends on the method in which it is used. For instance, mHealth is generally effective in improving clinic attendance rates, with modest benefits noted through the use of text message appointment reminders (Free, Phillips, Watson, et al., 2013). mHealth was also shown to improve nurse-physician communication and provider-delivered disease management (i.e., not patient self-management, which was the focus of the second meta-analysis). However, results from this meta-analysis also indicated that the use of healthcare images (e.g., X-rays) delivered via mobile technology resulted in fewer correct diagnoses than gold standard methods (Free, Phillips, Watson, et al., 2013). Taken together,

these results suggest that mHealth is better suited for communication aspects of service delivery and may not yet be an effective strategy for improving diagnostic practices.

The second meta-analysis included studies that examined the use of mHealth-delivered interventions to promote health behavior change or disease self-management for adult patients (Free, Phillips, Galli, et al., 2013). Similar to the first meta-analysis, findings from this second meta-analysis also noted variable effectiveness of mHealth interventions targeted at patients, and with differences noted across the different diseases or health conditions. Specifically, some improvements were noted in smoking cessation and adherence to antiretroviral medications for HIV with text message reminders (Free, Phillips, Galli, et al., 2013). More relevant to the current study were results related to physical activity interventions. Results of these studies were inconsistent, with some evidence that text message reminders for physical activity helped to improve Type 2 diabetes control (i.e., a condition often comorbid with overweight or obesity). However, there was no effect of such text message reminders for diet or exercise on reducing body weight (Free, Phillips, Galli, et al., 2013).

While these inconsistent findings may dampen the excitement around the use of mHealth, it is important to note that the interventions described in the meta-analyses are relatively homogenous despite targeting different diseases and conditions (Free, Phillips, Galli, et al., 2013; Free, Phillips, Watson, et al., 2013). This homogeneity is notable in several aspects of the interventions. First, the use of mHealth in these studies consisted of interventions for either the patient or the professional. While there was some evidence of improved communication between nurses and physicians, no intervention was designed to facilitate or improve interactions between patients and professionals (Free, Phillips, Galli, et al., 2013; Free, Phillips, Watson, et al., 2013). Second, interventions that targeted the patient were primarily designed to be used outside of the

clinical encounter. mHealth interventions that were incorporated into the clinical encounter generally consisted of the professional checking data collected by the mobile device without much feedback provided to the patient (Free, Phillips, Galli, et al., 2013). Finally, despite evidence that clinical practice guidelines are under-utilized (Solberg, 2000), no study to date has investigated mHealth as a method for improving the use of clinical practice guideline (Silva, Rodrigues, de la Torre Díez, López-Coronado, & Saleem, 2015). These limitations point to the need for additional research that not only incorporates the use of mHealth for novel purposes (e.g., within the clinical encounter or for implementing clinical practice guidelines), but also incorporates it into the patient empowerment framework that is now the prevailing paradigm of healthcare within the U.S. system.

Current Study

The current study was designed to address common limitations noted across literatures on overweight and obesity diagnosis and treatment practices, clinical practice guidelines, and the use of mHealth. A hybrid type I effectiveness-implementation design (Curran et al., 2012) was used to explore the use of an mHealth application (app) with the goals of: (a) implementing the AHA/ACC/TOS weight management guidelines in primary care settings; (b) facilitating improved communication about weight management between patients and healthcare professionals; and (c) preliminarily assessing the effectiveness of the mHealth app in fostering behavior change for weight management. The focus of the current study is an extension of prior research in a few ways. First, the current study seeks to capitalize on primary care wait times (Anderson, Camacho, & Balkrishnan, 2007) by having patients complete the weight management guideline app in the waiting room prior to their primary care visit. This differs from prior research focusing on patient behavior change that generally required use of the mHealth tool

outside of the clinical setting and monitored by healthcare professionals (e.g., Free, Phillips, Galli, et al., 2013). Second, the use of mHealth within the current study is intended to be a patient empowerment tool rather than strictly a behavior change tool, which was the primary focus of prior studies (Free, Phillips, Galli, et al., 2013). Using mHealth to facilitate patient empowerment will also target patient and physician barriers that have been shown to influence overweight and obesity diagnostic and treatment practices, in contrast to prior studies that generally focused on one level (Francke et al., 2008). Finally, the current study seeks to understand if mHealth may be an effective method of facilitating patient-professional communication, in accordance with patient empowerment principles. To date, mHealth research has focused on facilitating communication between two types of professionals (e.g., surgeons and nurses) rather than between the patient and the professional (Free, Phillips, Watson, et al., 2013).

In addition to contributing a unique patient-empowerment focus to the mHealth literature, a secondary goal of the current study is to understand how mHealth might be used to facilitate the implementation of clinical practice guidelines. Although clinical practice guidelines have been in existence for decades (Institute of Medicine, 1990) they remain under-utilized by practicing professionals (Francke et al., 2008; Solberg, 2000). Improvements in the accessibility, ubiquity, and user-friendly nature of mobile technology make it a promising method for enabling the implementation of clinical guidelines and, in turn, improving patient health. To this end, the current study includes three primary aims.

Aim 1

The first aim of the current study was to assess fidelity to and acceptability of completing the mHealth app in the waiting room prior to a primary care visit. Based on early usability testing

of the app (described in detail below) in which the majority of participants were able to successfully complete various components of the app intervention (T. Haggerty, personal communication, April 6, 2018), it was hypothesized that fidelity to the app intervention would be high, and may be different across physicians based on possible differences in wait times for different physicians. Additionally, based on past mHealth studies (e.g., Free, Phillips, Galli, et al., 2013), it was hypothesized that the app would receive high acceptability ratings by patients. This aim was intended to address questions related to the use of mHealth interventions in implementing clinical practice guidelines, and to understand the extent to which use of the mHealth intervention may be feasible on a larger scale.

Aim 2

The second aim of the current study was to assess for differences in patient-professional communication between patients who completed the app prior to their primary care visit and patients who did not complete the app. It was hypothesized that weight management-related conversations would occur with greater frequency in the app condition than in the control condition. It was also hypothesized that patients in the app condition would be more likely to initiate conversations around weight management than patients in the control condition. These hypotheses were based on patient empowerment principles, particularly the assumption that patients require accurate information about their health status in order to be active participants in healthcare discussions and decisions (Bravo et al., 2015).

Aim 3

The final aim of the current study was to preliminarily assess the effectiveness of the app in promoting weight management-related behavior change. Prior studies have demonstrated mixed success with the use of mHealth interventions for health behavior change (Free, Phillips,

Galli, et al., 2013). However, no prior studies have incorporated the use of mHealh into the actual clinical setting as a patient empowerment tool, with the goal of indirectly influencing health behavior through improved patient-physician communication. Given the unique patient empowerment approach taken in the proposed study, it was hypothesized that a greater proportion of patients who completed the app prior to their primary care visit would demonstrate a reduction in BMI at their next follow-up appointment following their study visit.

Method

Weight Management Guideline App

The weight management guideline app was developed through an iterative process by a West Virginia University (WVU) physician with nearly a decade of experience in family medicine, in collaboration with Media Foundations, LLC. The app was created by translating the AHA/ACC/TOS weight management guidelines (Jensen et al., 2013) into digital interactive content available in three formats: (a) web-enabled, (b) iOS, and (c) Android. For the current study, only the Android version of the app was used in order to control for any possible differences in user interface or overall usability between the three formats. The development of the weight management app was guided by a project advisory board comprised of patient representatives who assisted with the iterative testing and revision of the app. Early usability testing resulted in improved user interface, design, and overall flow through various components of the app (T. Haggerty, personal communication, April 6, 2018).

The current version of the app guides the user through steps that correspond to the AHA/ACC/TOS weight management guidelines. Figures 2-9 in Appendix A are screenshots that depict each step as seen by the patient. These steps include: (a) defining and calculating BMI (Figure 2), (b) using BMI to identify overweight and obese patients and to provide information

on associated risks (Figure 3), (c) providing information on the benefits of sustained weight loss (Figure 4), and (d) providing information on local community resources for weight management, to include dieting for weight loss (Figure 5), increased physical activity (Figure 6), and bariatric surgery (Figure 7). In addition to adhering to the AHA/ACC/TOS guidelines, the app also provides patients with recommendations on how to talk with their healthcare professional (Figure 8) and how to create an individualized weight management treatment plan (Figure 9) to foster greater patient empowerment.

Technical effectiveness and overall usability of the app was assessed in a pilot study with 10 adult patients recruited from a family medicine clinic. Participants were asked to complete six individual tasks that corresponded to the steps described above. The time to complete each task was measured, and any critical errors that resulted in a failure to complete a task were noted. The majority of participants were able to complete all tasks in one attempt (96%). Constructive feedback was provided by participants, which resulted in improvements to the one task that resulted in a critical error for one participant. The amount of time to complete each task ranged from 12.44 second to 83.09 seconds. The task requiring participants to select community resources took the longest to complete. When aggregated across individual tasks, the average time to all steps was less than 10 minutes (T. Haggerty, personal communication, April 6, 2018). With an average primary care wait time of approximately 22 minutes for the state of West Virginia (Vitals, 2017), it was anticipated that patients would have sufficient time to complete the app while waiting for their healthcare professional.

The information and weight management principles included in the app can be helpful in creating a healthy lifestyle regardless of current weight status. Additionally, it is important for all patients to hear information about their weight status regardless of weight classification (e.g.,

underweight, normal weight, overweight, obese), as this can help provide them with a better understanding of their own health and can help to normalize weight-related discussions. As such, patients who were of normal weight or underweight were not excluded from the study, and were presented with the same steps as patients who were overweight or obese. Patients who were of normal weight or underweight still saw their weight classification, but did not see any associated risks (Figure 2). The remaining steps and screens looked the same for patients of normal weight or underweight as for patients who were overweight or obese.

Participants

Participants included physicians and adult patients recruited through the Family Medicine department at WVU. All recruitment procedures were approved by the WVU IRB.

Physicians. In order to be eligible for participation, physicians must have been: (a) credentialed as a physician, and (b) seeing patients 18 years or older within the Family Medicine clinic. The WVU Family Medicine department is part of a larger academic medical center in which patients often meet with medical residents before attending physicians. Medical residents and their patients were excluded from the current study due to concerns for possible differences in the focus of healthcare discussions between the resident and attending, which may have resulted in contamination of data and difficulty in coding and analytic procedures (described below).

Physicians were recruited from the pool of 19 physicians practicing through the WVU Family Medicine department. Though a total of 20 physicians were practicing at the time of recruitment, this total included the physician who developed the app, who was excluded from recruitment to maintain study blindness. Information about the study was presented to all Family Medicine physicians during a regularly scheduled departmental meeting. In order to maintain

study blindness, physicians were informed that the purpose of the study was to examine any differences in patient-physician communication between patients who completed a *patient empowerment* app, and those who did not. Notably, the app was not described as a *weight management guideline* app, and no information specifically regarding weight management was provided. Because the study was looking at patient-physician communication, physicians were informed that clinic visits would be audio-recorded, and that they would be asked to provide some information about their personal and professional histories in order to assess for other factors that have been shown in the literature to influence patient-physician communication.

Interested physicians completed informed consent procedures and enrolled in the study immediately after the departmental meeting. Informational emails were sent to those physicians who were not present at the meeting, and email follow-ups were sent to physicians who were present at the meeting but did not enroll immediately following the meeting. A total of four physicians enrolled following the departmental meeting, and one additional physician enrolled after receiving an email reminder, for a total sample of 5 physicians (26% participation rate). Though reasons for refusal were not systematically collected from all physicians, those who informally provided a reason noted that they were either uninterested in research or did not believe they had the time to complete research activities.

Physicians who enrolled during the meeting completed informed consent procedures face-to-face with the research staff member. The physician who enrolled following the email reminder scheduled a phone call to complete verbal informed consent procedures, and also signed an online informed consent document. Additional information provided during the informed consent phase included that physicians would receive an email with a link to complete online questionnaires. They were also told that patients would be recruited from their active

caseloads, and that they would not receive any advanced notice of when data collection would occur, in order to maintain blindness.

Patients. Patient participants were recruited from the active caseloads of enrolled physicians. Patient eligibility criteria included: (a) 18 years of age or older; (b) able to speak and read English; (c) no known cognitive, vision, or hearing impairments; and (d) an appointment scheduled during the specified time period for active data collection. Pregnant women were excluded from the current study, given differences in weight management recommendations for this population. An equal number of patients per physician were recruited, with efforts taken to maintain a relatively equal distribution of patients in each condition per physician (see Procedures).

Procedures

All procedures were pilot-tested to ensure feasibility. Final procedures were approved by the WVU IRB.

Physician procedures. Enrolled physicians completed a one-time assessment battery including a demographics survey and a knowledge quiz (described below). This assessment battery was designed to assess for a variety of physician characteristics that have been identified in the literature as possibly influencing overweight/obesity diagnostic and treatment practices (e.g., race, gender, weight status, knowledge of weight management treatment practices), as well as patient-professional communication. Once physicians were enrolled in the study, they were emailed a link to complete the assessments through Qualtrics. Reminder emails were sent to physicians who had not completed their baseline assessments within one week of the initial email; no physicians required more than one reminder email. Following completion, physicians

were sent a final email thanking them for their participation and informing them that they would receive a study debriefing following completion of all study procedures.

Patient procedures. Eligible patients were identified through the active caseloads of enrolled healthcare professionals using EPIC, the electronic medical records system used by the WVU Family Medicine department. Patients were called the week of their appointment to provide a brief introduction to the study and to answer any preliminary questions about the study. Once patients arrived at the clinic, a research staff member met with patients to review the study, complete informed consent procedures with patients, and answer any additional questions. As part of informed consent procedures, patients were provided a brief description of the study. As with physicians, some information was omitted to maintain participant blindness. Specifically, patients were informed that the study was designed to examine patient-physician communication and, as such, their primary care visit would be recorded, though they could opt out of recording or could stop the audio recorder at any time during their primary care visit. No information about the app was provided to participants assigned to the control condition, and no information specifically about weight management was provided to participants in either condition.

Following informed consent procedures, patients were provided with instructions on how to work the audio-recording device and were asked to complete a test to demonstrate understanding and to ensure that the device was functioning. They were also reminded that they could pause or stop the recording at any time if they did not want a portion of their visit audio-recorded. Patients were randomly assigned to either the app condition or control condition. Regardless of condition, all patients were asked to complete a baseline assessment, which included a demographics survey and the Rathus Assertiveness Schedule (RAS; Rathus, 1973; see description below). This baseline assessment was designed to collect information on patient

characteristics that have been shown to influence healthcare conversations (e.g., race, gender, education level, assertiveness). Patients randomized into the app condition were then asked to complete the weight management app, while participants randomized to the control condition were asked to wait as usual until called back to the clinic. The typical procedure within this specific clinic is for a nurse or nurse practitioner to bring the patient back to the clinic room and take vitals before the physician meets with the patient. As such, patients in the app condition were informed that they could take the tablet with them and continue working on the app until their physician arrived, if they were unable to complete the app before being called back by the nurse or nurse practitioner. Patients were asked to stop working on the app as soon as their physicians began meeting with them, as completing the app after meeting with their physicians would inhibit the utility of the app in promoting patient empowerment. They were instructed that they should not close out of the app, but rather press the power button once to lock the tablet screen, which would save the step within the app that at which they stopped and would prevent them from continuing at a later date.

Patients in both conditions were instructed to take the audio-recording device with them to the clinic room and were asked to begin recording upon entry into their clinic room. They were asked to stop recording before leaving the clinic room, and were reminded that they could stop recording at any point earlier in the visit. Patients met with research staff again following their clinic visit to return all study materials (i.e., recording devices and tablets), and to complete post-visit assessments. For all patients regardless of condition, this battery included a survey to assess the degree to which they felt they were able to voice their concerns during that visit (i.e., Patient Empowerment Survey; see description below). Patients in the app condition were asked to complete a second survey designed to assess their perceived acceptability of completing the

app prior to their primary care visit (i.e., Acceptability Survey; see description below). Following completion of the post-visit assessment, all participants were thanked for their participation and were provided with a $20 gift card for completion of clinic procedures. Following all in-clinic data collection, a chart review was conducted to verify patient BMI at the time of the clinic visit, and to collect their documented BMI at their next follow-up appointment. Chart review was also used to assess for any other possible health conditions that may contribute to current weight status (e.g., thyroid conditions, women who are post-menopause).

Measures

Please see the Appendix B for all measures used in the current study. All study-developed measures were pilot-tested to ensure an adequate battery length and appropriate readability.

Physicians.

***Demographics*.** Demographics from participating physicians were collected using the Healthcare Professional Background Form. In addition to standard demographic information (e.g., gender, age, race), this form was also used to collect information related to physician characteristics that have been shown to influence healthcare conversations (e.g., height and weight to calculate BMI, education level, years experience) as well as a variety of filler items (e.g., family history of chronic illness, current health behaviors, current caseload characteristics).

***Knowledge*.** As knowledge has been associated with a variety of treatment-related attitudes and behaviors (Ferrante et al., 2009; Hayden et al., 2008), participating physicians completed a knowledge assessment entitled Treatment Practices. This knowledge assessment included 19 multiple-choice questions to assess knowledge of the AHA/ACC/TOS weight management guidelines, including standard diagnostic practices and treatment options. This

measure also included two questions to assess professional attitudes related to obesity treatment. As no established overweight/obesity knowledge assessment is available based on a U.S. sample, the current set of 21 questions was adapted for U.S.-specific guidelines from a recently-published measure developed with a sample of medical students in Norway (Martins & Norsett-Carr, 2018). To maintain study blindness and reduce the possibility of demand characteristics, a variety of filler questions related to the management of other chronic conditions (e.g., Type 1 diabetes, high cholesterol) was included in the knowledge assessment. All items except for the two items assessing attitudes had one correct answer. Only the items pertaining to weight management were used to generate a total knowledge score.

Patients.

Demographics. Standard demographic information (e.g., gender, age, race) was collected from patients using the Patient Background and Contact Form. Information about BMI and other health conditions was obtained through a chart review using EPIC. Notes for two visits were reviewed for data collection purposes: (a) the note corresponding to the study visit (i.e., baseline), and (b) the note corresponding to the primary care visit immediately following the study visit (i.e., follow-up). The duration of time between the baseline and follow-up visits was also documented. Baseline BMI was obtained from the BMI documented within the baseline visit note, while follow-up BMI was obtained from the note for the follow-up visit. All diagnoses (i.e., both weight-related diagnoses such as overweight and obesity and other conditions such as diabetes or high blood pressure) were obtained from the "Problem List" section of the baseline visit note.

***Rathus Assertiveness Schedule*.** As part of the baseline battery, all participants regardless of condition completed the Rathus Assertiveness Schedule (RAS). The RAS is a 30-

item self-report questionnaire designed to assess the degree to which the respondent views a variety of assertive behaviors as characteristic of him/herself (Rathus, 1973). Items are rated on a 6-point Likert-type scale, with anchors ranging from -3 to +3. Responses are summed to form a total score (range: -90 to 90), with higher scores reflective of greater self-reported assertiveness. The RAS has been shown to generate responses with adequate test-retest reliability (r = .79) and concurrent validity (r = .71; Rathus, 1973). Internal consistency reliability within the current sample, assessed with Cronbach's alpha, was strong (α = 0.89). This scale was used to assess for any baseline differences in patient assertiveness that may have influenced the likelihood of initiating a difficult conversation.

Fidelity. Fidelity, defined as "the degree to which an intervention was implemented…as it was intended by the program developers" (Proctor et al., 2011, p. 69), is an outcome commonly assessed in implementation research. Measures of fidelity are used to understand if the practice being implemented was the target intervention as intended, or a deviation from the target intervention. As it relates to the proposed study, fidelity was defined as the number of steps within the app that participants were successfully able to complete prior to meeting with their physician.

Acceptability. Acceptability, defined as the degree to which a new practice is viewed by stakeholders as tolerable and agreeable (Proctor et al., 2011), is another important outcome in implementation research. It is particularly important for the proposed project, as a larger goal is to use the weight management app regularly in family medicine clinics across the state of West Virginia. However, it would not be prudent to ask patients to regularly engage in an intervention that they do not view as acceptable. As such, participants in the app condition were asked to complete an acceptability survey as part of their post-visit battery following completion of their

family medicine visit. Although a variety of acceptability measures exist, most are tailored to specific interventions or practices (Lewis et al., 2015). As such, questions on the acceptability survey used within the current study were developed based on a few different measures, including a measure commonly used to assess the acceptability of mental health interventions (Chafouleas, Briesch, Riley-Tillman, & McCoach, 2009), a measure of technology acceptability (Van Schaik, Bettany-Saltikov, & Warren, 2002), and a measure of the acceptability of computerized self-assessment (Bendtsen & Timpka, 1999). A total of 8 items are rated on a 5-point Likert-type scale and are summed to form an overall acceptability score. An open-ended response box was also included for participants to provide any thoughts or comments they wanted to share about their experience.

Coding method. Audio-recordings of primary care visits were transcribed and coded for the following *a priori* categories based on the AHA/ACC/TOS weight management guidelines: (a) discussion of patient's current weight status (yes/no), (b) who initiated weight status discussion (patient/professional), (c) discussion of associated risks (yes/no/NA), (d) who initiated discussion of risks (patient/professional), (e) discussion of weight management/treatment options (yes/no/NA), and (f) who initiated discussion of treatment options (patient/professional.

***Patient Empowerment*.** Although a number of patient empowerment measures exist, they are all tailored for specific health conditions such as diabetes (e.g., Anderson, Funnell, Fitzgerald, & Marrero, 2000) and cancer (e.g., Bulsara, Styles, Ward, & Bulsara, 2006). A more general patient empowerment scale has been developed and tested with a large sample of older adults with a variety of chronic conditions (Small, Bower, Chew-Graham, Whalley, & Protheroe, 2013). This measure includes three subscales: (a) Positive Attitude and Sense of Control, (b) Knowledge and Confidence in Decision Making, and (c) Enabling Others (Small et al., 2013).

Given that the goal of the current study was to understand the extent to which patient participants feel as though they have adequate knowledge and support related to their healthcare concerns, questions from the Knowledge and Confidence in Decision Making subscale were been adapted for the current study. In addition, questions to assess participants' perceived comfort in and ability to bring up their concerns to their physician have been added. All items are rated on a 5-point Likert-type scale.

Data Analyses

All analyses were conducted in Statistical Package for the Social Sciences (SPSS; IBM Corp, 2017). Descriptive statistics were calculated to understand the demographics of the sample and a series of chi-square tests of independence and one-way ANOVAs were calculated to assess for any baseline differences between the app condition and the control condition. Given that several measures used in the current study were study-developed, Cronbach's alphas were computed to assess for internal consistency reliability. For aim 1, descriptive statistics were used to understand the feasibility and acceptability of completing the app prior to patients' meetings with their physicians. Given that different physicians may take more or less time to see their patients, a chi-square test of independence was used to assess for differences in fidelity based on physician, and a one-way ANOVA was used to assess for differences in acceptability based on physician.

For aim 2, a variety of exploratory analyses were calculated to assess for any differences in weight-related conversations based on variables found in the literature to be influential in overweight and obesity diagnostic and treatment practices. These exploratory analyses included chi-square tests of independence to test for differences in weight-related conversations based on patient gender, patient race, patient education, professional education, and professional weight

status; and point-biserial correlations to test for significant associations between weight-related conversations and patient age, patient assertiveness, professional age, years since completing professional training, and professional knowledge. In order to assess for any differences in weight-related conversations between conditions, a series of chi-square tests of independence were calculated for each of the weight-related conversation variables. The small sample size due to a low base rate for weight-related conversations did not provide sufficient power for more sophisticated analyses, such as logistic regressions.

For aim 3, the difference between baseline BMI and follow-up BMI was calculated for each patient. Using these difference scores, patients were categorized as having decreased BMI category, increased BMI category, or stayed the same. A chi-square test of independence was calculated to assess for any differences in weight change based on condition.

Results

Sample Characteristics

Physicians (n = 5) were White (100.0%) and primarily female (80.0%), and were an average of 35.20 years of age (SD = 3.90) at baseline. With an average BMI of 31.14 (SD = 15.53), one physician was classified as of normal weight, two were overweight, and two were obese. There was an average of 4.60 (SD = 2.90) years since degree completion for this sample, and they scored an average of 67.78% correct (SD = 8.24) on questions assessing weight management knowledge (see Table 1 for physician demographics). One individual item included in the knowledge assessment examined physician attitudes toward weight management practices. On this item, two physicians noted that they feel it is their duty to discuss weight, but the long-term management and follow-up are beyond the scope of what they can provide in the primary care setting. Another two physicians endorsed their belief that obesity is very complex, and they

prefer to focus on the comorbidities while referring out for the weight management piece. The final physician indicated that there is not much that can be accomplished from a weight management perspective in a short primary care visit. Though these responses were not used in any analyses, they provide some context in which to interpret results, as noted in the Discussion.

Patients (n = 97) were primarily White (89.7%) and female (67.0%). According to BMI documented in patient medical records, the majority of patients (n = 80, 82.5%) were classified as overweight (n = 21, 21.6%) or obese (class I or class II; n = 59, 60.8%) at baseline, though only 13 patients (16.3%) had diagnoses of overweight or obesity documented in the note for their baseline visit, and 85.6% had conditions often comorbid with overweight or obesity (e.g., high blood pressure, diabetes) documented in the note for their baseline visit. See Table 2 for full patient demographic information.

Though 100 patients were originally enrolled in the study, two were later excluded as they had been erroneously recruited during an acupuncture visit rather than a primary care visit, and one was excluded due to recently changing primary care physicians to one of the non-participating physicians. During recruitment and enrollment, 28 eligible patients no-showed for their appointments, and 42 eligible patients declined to participate. Although information on reasons for refusal was not systematically collected, anecdotal reasons for refusal included uninterested in research, unwilling for visit to be audio-recorded, and needing to do other things while waiting. Of note, 2 participants who were initially enrolled later withdrew from participation when they were randomized into the app condition due to lack of familiarity with tablet devices.

Of the 97 patients who were included in the study, 48 were assigned to the control condition and 49 were assigned to the app condition. At baseline, there were no statistically

significant differences in the average age (F[1, 96] = 0.15, p = .70) or documented BMI (F[1, 96] = 0.29, p = .60) of patients in each condition. There were also no statistically significant differences between conditions with regard to patient education level (χ^2[6] = 8.55, p = .20), income (χ^2[4] = 0.59, p = .96), or race (χ^2[3] = 1.68, p = .64). Similarly, there were no statistically significant differences between conditions on measures of assertiveness (F[1, 76] = 3.41, p = .07), or patient empowerment (F[1, 92] = 1.36, p = .25). There was a statistically significant difference in patient gender (χ^2[1] = 4.36, p = .04, Cramer's V = 0.21), such that the control condition had a greater percentage of female participants (n = 37, 77.1%) than the app condition (n = 28, 57.1%), while the app condition had a greater percentage of male participants (n = 21, 42.9%) than the control condition (n = 11, 22.9%). See table 2 for demographic breakdown between conditions.

Aim 1: Fidelity and Acceptability

To evaluate the viability of more widespread use of the app in primary care settings, measures of fidelity and acceptability were collected from patients in the app condition (n = 49). Responses on the acceptability survey yielded a Cronbach's alpha of 0.91; as such, responses to individual items were summed to form an overall acceptability score, which is used in the following analyses.

Fidelity Descriptive Results. Three instances of technological malfunction were reported by participants completing the app; these participants were excluded from all other fidelity analyses for a sample size of n = 46 (though they were included in acceptability analyses below). Although there was variability in the number of steps successfully completed by participants, the greatest proportion of participants were able to complete all nine steps (n = 16, 34.8%), and approximately half of the sample completed either step eight or step nine prior to

meeting with their physicians (n = 25, 52.2%). The distribution of steps successfully completed by all participants is depicted in Figure 10.

Fidelity Comparative Results. Given that the weight management app was intended primarily as a communication and patient empowerment tool, fidelity scores were dummy-coded such that participants who completed anywhere between steps 1 and 4 (inclusive) before meeting with their physician were coded as 0 and participants completed anywhere between steps 5 and 9 (inclusive) were coded as 1. The decision to split participants in this way was based on differences in content covered between steps 1-4 and steps 5-9. Specifically, content covered in steps 1-4 focuses on educating participants about their current weight status, associated risks, and benefits of making healthy lifestyle changes, whereas steps 5-9 focus on providing specific recommendations for weight loss options, goal setting, and ways to discuss weight with their physicians. Given this qualitative difference, it is possible that there would be meaningful differences in outcomes for participants who were only able to complete up to step 4 versus those who were able to complete at least one step related to specific recommendations. A total of 19.6% of participants (n = 9) completed anywhere between 1-4 steps, while a total of 80.4% of participants (n = 37) completed anywhere between 5-9 steps.

A series of exploratory analyses were calculated to assess for any patient characteristics that may have influenced fidelity. Chi-square tests of independence indicated no statistically significant differences in fidelity based on patient gender ($\chi^2[1] = 0.68$, $p = .41$), race ($\chi^2[3] = 1.63$, $p = .65$), ethnicity ($\chi^2[1] = 1.18$, $p = .28$), education level ($\chi^2[5] = 2.55$, $p = .77$), or weight class ($\chi^2[3] = 3.09$, $p = .38$). Results of a one-way ANOVA to assess for differences in fidelity based on patient age approach statistical significance ($F[1, 44] = 4.01$, $p = .05$, $\eta^2 = 0.08$), such

that participants who completed fewer steps were older on average (M = 54.35, SD = 9.34) than participants who completed more steps (M = 46.32, SD = 14.45).

A chi-square test of independence was computed to assess for any differences in fidelity based on the specific physician being seen, based on the hypothesis that different physicians would likely have different wait times and therefore patients would have different amounts of time to complete the app. Contrary to hypotheses, there was no statistically significant difference in fidelity based on physician ($\chi^2[4] = 3.59$, $p = .47$). Figure 11 shows the percentage of each physician's patients who completed between steps 1-4 and steps 5-9.

Acceptability Descriptive Results. Overall acceptability scores ranged from 17 to 40 (possible range: 8 to 40), with a mean of 29.39 (SD = 5.63). Descriptive findings for individual items indicated that the majority of participants (n = 29, 59.2%) either *agreed* or *strongly agreed* that the information presented in the app was relevant to them. However, participants were more split on whether the app was a good way to spend their time in the waiting room. Specifically, approximately half the sample disagreed or was neutral (n = 24, 49.0%) and approximately half (n = 25, 51.0%) agreed or strongly agreed that it was a good way to spend their time.

Acceptability Comparative Results. A series of one-way ANOVAs was computed to assess for differences in acceptability based on patient characteristics and specific physician. No statistically significant differences were found in acceptability ratings based on patient gender ($F[5, 38] = 16.43$, $p = .80$), race ($F[3, 44] = .04$, $p = .99$), ethnicity ($F[1, 47] = 0.29$, $p = .60$), education level ($F[5, 38] = 0.01$, $p = .81$), or physician ($F[4, 48] = 0.29$, $p = .89$). However, there was a statistically significant difference in acceptability scores based on patient weight status ($F[3, 48] = 4.50$, $p = .008$, $\eta^2 = 0.23$). Bonferroni post hoc tests indicated that patients who were classified either as Obesity Class I (M = 31.84, SD = 4.49) or Class II (M = 30.59, SD = 4.95)

had on average, statistically greater acceptability scores at the $\alpha = .05$ level than participants who were classified as normal weight ($M = 23.57$, $SD = 5.16$). No other pairwise comparisons were statistically significant. See Figure 12.

Aim 2: Patient-Physician Communication

To understand the impact of the weight management app on patient-professional communication, six different categorical dependent variables were measured: (a) discussion of patient's current weight status (yes/no), (b) who initiated (patient or physician), (c) discussion of associated risks (yes/no), (d) who initiated (patient or physician), (e) discussion of weight management/treatment options (yes/no), and (e) who initiated (patient or physician). A three-step approach was taken to understand each of these dependent variables.

First, descriptive statistics were calculated to understand the rate at which each categorical dependent variable occurred within each condition. Second, a series of chi-square tests of independence was calculated to assess for any differences in each of the categorical dependent variables based on condition. Finally, a variety of exploratory analyses were conducted to assess for associations between the categorical dependent variables and a variety of patient and physician characteristics that have been identified in past studies as influencing patient-physician communication. Specifically, a series of chi-square tests of independence was calculated to assess for associations between dependent variables and categorical variables (i.e., patient gender, patient race, patient education, patient weight status, physician gender, and physician weight status). For analyses examining patient or physician weight status, binary codes were created to categorize participants as either under/normal weight or overweight/obese. A series of point-biserial correlation coefficients was calculated to assess for associations between dependent variables and continuous variables (i.e., patient age, patient assertiveness scores,

physician years of practice, and physician obesity knowledge scores). Exploratory chi-square tests of independence were also calculated to assess for any differences in weight status conversations based on those who fully completed the app prior to meeting with their physicians compared with those who did not fully complete the app. For these analyses, patients were coded as *app completers* if they completed all steps prior to meeting with their physicians, while patients who completed anywhere between steps 1-8 were coded as *non-completers*. A total of 9 patients turned off their audio-recording devices during their clinic appointment, and were therefore excluded from the following analyses.

Weight status discussion.

Preliminary analyses. In total, discussions regarding patients' current weight status occurred in 42.7% of primary care visits (n = 38). These discussions occurred in 33.3% (n = 14) of control condition visits and in 51.1% (n = 24) of app condition visits. Contrary to hypotheses, there was not a statistically significant difference in the occurrence of a weight status discussion based on condition, $\chi^2(1) = 2.85$, $p = .09$, Cramer's V = 0.18.

Exploratory analyses. There were no statistically significant differences in the occurrence of a weight status discussion based on app completion vs. non-completion ($\chi^2[1] = 0.70$, $p = .40$), patient gender ($\chi^2[1] = 0.02$, $p = .88$), patient race ($\chi^2[3] = 2.21$, $p = .53$), patient education ($\chi^2[6] = 11.91$, $p = .06$), physician gender ($\chi^2[1] = 0.49$, $p = .48$), or physician weight status ($\chi^2[3] = 0.62$, $p = .89$). There were also no statistically significant correlations between occurrence of a weight status discussion and patient age ($r = -0.01$, $p = .95$), patient assertiveness scores ($r = 0.03$, $p = .83$), physician years of practice ($r = 0.05$, $p = .62$), or physician obesity knowledge ($r = 0.05$, $p = .64$).

There was a significant difference in the percentage of visits in which weight status discussions occurred based on patient weight ($\chi^2[1] = 9.57$, $p = .002$, Cramer's V = 0.33). Specifically, weight status discussions occurred in a statistically higher percentage of visits for patients who were classified as overweight or obese ($n = 37$, 50.0%) than in visits for patients who were classified as underweight or normal weight ($n = 1$, 6.7%).

Initiation of weight status discussion.

Primary analyses. Overall, there was an equal split between who initiated weight status discussions, with physicians initiating in 50% ($n = 19$) of visits and patients initiating in 50% of visits ($n = 19$). There was a significant difference in who initiated based on condition ($\chi^2[1] = 4.07$, $p = .04$, Cramer's V = 0.33). As hypothesized, patients (62.5%) in the app condition initiated weight status discussions more often than physicians (37.5%), while physicians (71.4%) in the control initiated weight status discussions more often than patients (28.6%).

Exploratory analyses. There were no statistically significant differences in who initiated a discussion of the patient's current weight status based on app completion vs. non-completion ($\chi^2[1] = 0.12$, $p = .73$), patient gender ($\chi^2[1] = 1.81$, $p = .18$), patient race ($\chi^2[2] = 2.03$, $p = .36$), patient education ($\chi^2[4] = 2.86$, $p = .58$), patient weight status ($\chi^2[1] = 1.30$, $p = .31$), physician gender ($\chi^2[1] = 1.31$, $p = .25$), or physician weight status ($\chi^2[3] = 4.19$, $p = .24$). There were also no statistically significant correlations between who initiated a weight status discussion and patient assertiveness scores ($r = 0.04$, $p = .83$) or physician obesity knowledge scores ($r = 0.2$, $p = .91$).

There were significant correlations between who initiated a weight status discussion and patient age ($r = 0.44$, $p = .006$), such that older patient age was associated with a greater likelihood of the physician initiating the conversation. There was also a significant correlation

between who initiated a weight status discussion and physician years of practice (r = -0.33, p = .04), such that fewer physician years of practice was associated with a greater likelihood of the patient initiating the discussion.

Associated risks discussion.

Primary analyses. Discussions of risks associated with patient weight status occurred in 26.1% (n = 23) of all primary care visits. Contrary to hypotheses, there was not a statistically significant difference in the occurrence of a discussion of associated risks based on condition, $\chi^2(1) = 0.25$, p = .62, Cramer's V = 0.05.

Exploratory analyses. There were no statistically significant differences in the occurrence of discussions regarding risks associated with patients' current weight statuses based on app completion vs. non-completion ($\chi^2[1] = 0.004$, p = .95), patient gender ($\chi^2[1] = 0.31$, p = .58), patient race ($\chi^2[3] = 2.82$, p = .42), patient education ($\chi^2[6] = 6.63$, p = .36), physician gender ($\chi^2[1] = 0.18$, p = .67), physician weight status ($\chi^2[3] = 0.52$, p = .91). There were also no statistically significant correlations between discussions of risks associated with weight status and patient age (r = 0.09, p = .42), patient assertiveness scores (r = 0.06, p = .62), physician years of practice (r = -0.08, p = .47), or physician obesity knowledge (r = -0.04, p = .71).

There was a significant difference in the percentage of visits in which risks associated with weight status were discussed based on patient weight ($\chi^2[1] = 6.40$, p = .01, Cramer's V = 0.27). Specifically, discussions of risk associated with patient weight status occurred in a statistically higher percentage of visits for patients who were classified as overweight or obese (n = 23, 31.5%) than in visits for patients who were classified as underweight or normal weight (n = 0, 0.0%).

Initiation of associated risks discussion.

Primary analyses. Overall, patients initiated discussions of associated risks in 8.7% (n = 2) of visits, while physicians initiated these discussions in 91.3% (n = 21) of visits. Contrary to hypotheses, there was not a statistically significant difference in who initiated a discussion of associated risks based on condition, $\chi^2(1) = 0.004$, $p = .95$, Cramer's V = 0.01.

Exploratory analyses. There were no statistically significant differences in who initiated a discussion of risks associated with current weight status based on app completion vs. non-completion ($\chi^2[1] = 1.93$, $p = .17$), patient gender ($\chi^2[1] = 0.40$, $p = .53$), patient race ($\chi^2[1] = 2.64$, $p = .10$), patient education ($\chi^2[4] = 4.21$, $p = .38$), patient weight status ($\chi^2[1] = 2.20$, $p = .14$), physician gender ($\chi^2[1] = 1.62$, $p = .20$), physician weight status ($\chi^2[3] = 2.53$, $p = .50$). There were also no statistically significant correlations between who initiated discussions of risks and patient age ($r = 0.36$, $p = .09$), patient assertiveness scores ($r = -0.29$, $p = .21$), physician years of practice ($r = -0.16$, $p = .46$), or physician obesity knowledge ($r = -0.09$, $p = .69$).

Weight management discussion.

Primary analyses. Overall, discussions of weight management and treatment options occurred in 38.2% (n = 34) of visits. Contrary to hypotheses, there was not a statistically significant difference in the occurrence of weight management and treatment options based on condition, $\chi^2(1) = 3.13$, $p = .08$, Cramer's V = 0.19.

Exploratory analyses. There were no statistically significant differences in the occurrence of discussions regarding weight management/treatment options based on app completion vs. non-completion ($\chi^2[1] = 1.05$, $p = .31$), patient gender ($\chi^2[1] = 0.10$, $p = .92$), patient race ($\chi^2[3] = 2.85$, $p = .42$), patient education ($\chi^2[6] = 10.40$, $p = .11$), physician gender ($\chi^2[1] = 0.37$, $p = .54$), physician weight status ($\chi^2[3] = 0.55$, $p = .91$). There were also no statistically significant

correlations between discussions regarding weight management/treatment options and patient age (r = -0.02, p = .84), patient assertiveness scores (r = 0.07, p = .55), physician years of practice (r = 0.06, p = .54), or physician obesity knowledge (r = -0.02, p = .83).

There was a significant difference in the percentage of visits in which discussions of weight management/treatment options occurred based on patient weight status ($\chi^2[1] = 11.15$, p = .001, Cramer's V = 0.35). Specifically, weight management/treatment option discussions occurred in a statistically higher percentage of visits for patients who were classified as overweight or obese (n = 34, 45.9%) than in visits for patients who were classified as underweight or normal weight (n = 0, 0.0%).

Initiation of weight management discussion.

Primary analyses. Overall, patients initiated discussions of weight management and treatment options in 47.1% (n = 16) of visits, while physicians initiated these discussions in 52.9% (n = 18) of visits. Contrary to hypotheses, there was not a statistically significant difference in who initiated discussions on weight management and treatment options based on condition, $\chi^2(1) = 1.40$, p = .24, Cramer's V = 0.20.

Exploratory analyses. There were no statistically significant differences in who initiated a discussion of weight management/treatment options based on app completion vs. non-completion ($\chi^2[1] = .49$, p = .48), patient gender ($\chi^2[1] = 0.95$, p = .31), patient race ($\chi^2[2] = 1.92$, p = .38), patient education($\chi^2[4] = 3.84$, p = .43), physician gender ($\chi^2[1] = 3.28$, p = .07), or physician weight status ($\chi^2[3] = 3.39$, p = .34). There were also no statistically significant correlations between who initiated discussions regarding weight management/treatment options and patient age (r = 0.34, p = .09), patient assertiveness scores (r = 0.02, p = .88), physician years of practice (r = -0.20, p = .25), or physician obesity knowledge (r = -0.09, p = .61).

Aim 3: Weight Management Outcomes

Follow-up data was collected for 72.2% of the original sample; a total of 27 patients (27.8%) were lost to follow-up for a variety of reasons. From what could be gleaned from the chart review, 2 patients changed to a new primary care provider with a follow-up appointment for a physician who was not participating in the study, 3 patients no-showed all of their scheduled follow-up appointments, 9 had follow-up appointments for other health concerns (e.g., cancer) but no primary care follow-up appointments, and 14 had no follow-up appointment scheduled. The amount of time between the study visit and the next follow-up visit ranged from 37 days to 441 days, with an average of 200.38 days (SD = 109.95). At the time of follow-up chart review, the majority of patients (n = 60, 87.0%) were classified as overweight (n = 15, 21.7%) or obese (class I or class II; n = 45, 65.2%). Based on changes from BMI documented in medical records at baseline and at follow-up, 84.1% (n = 58) of patients remained in the same BMI classification, 11.6% (n = 8) increased in classification (e.g., from normal weight to overweight), and 4.3% (n = 3) decreased in classification (e.g., from Obesity II to Obesity I; Table 3). Contrary to hypotheses, there was no statistically significant difference in the change in classification for patients who participated in the control condition versus those who participated in the app condition, $\chi^2(2) = 3.56$, $p = .17$ (Table 4).

Discussion

The purpose of this study was to explore the novel use of mHealth as a tool to both facilitate the implementation of weight management clinical practice guidelines and to improve patient-physician communication and patient empowerment with adult primary care patients. To that end, this study had three primary aims: (a) to examine fidelity to and acceptability of patients completing the mHealth intervention prior to meeting with their physicians, (b) to assess

for any differences in weight management discussions between patients who completed the mHealth intervention and those who did not, and (c) to assess for evidence of changes in weight between the study visit and follow-up visits. Results from this study have important implications for researchers and clinicians interested in expanding the use of mHealth for innovative purposes and in new settings.

Aim 1: Fidelity and Acceptability

The first aim was to assess fidelity to and acceptability of completing the weight management guideline app in the waiting room prior to patients' primary care visits. Given the possibility of more widespread use of the weight management app, it was important to understand whether patients found it feasible and tolerable to use their time in the waiting room to work through the app.

Overall fidelity results were promising, with slightly more than half of patients (52.2%) able to complete either the second-to-last or the last step of the app prior to meeting with their physicians. For those who completed the second-to-last step, this means that they received information on their current weight status and associated risks, local options for a variety of weight management interventions, and recommendations for how to speak with their physicians, though they did not create an individualized weight management plan prior to meeting with their physicians (the final step). Though these results are promising, it is important to note that 47.8% of the sample did not make it to the step that included recommendations for how to speak with their physicians about weight-related concerns, with likely implications for the impact of the app on patient-physician communication (Aim 2) which are discussed in later sections of this manuscript.

Although no hypotheses were made regarding possible differences in fidelity based on patient characteristics, a series of exploratory analyses were computed to assess for the any such differences. While no results reached statistical significance, it is important to note that a comparison of fidelity scores based on participant age approached statistical significance, such that older patients had lower fidelity scores on average (i.e., completed fewer steps) than younger patients. Given a relatively small sample size and low statistical power within the current study, it is possible that this difference may have reached statistical significance with a larger sample size, and is further supported by research demonstrating lower technological literacy and proficiency among older adults (Charness & Boot, 2009; Friemel, 2016). This is an important consideration for possible future use of the weight management app, as older individuals may require additional time or assistance to successfully complete the app.

Contrary to hypotheses, there were no statistically significant differences in app fidelity based on specific physician. Underlying this hypothesis was the assumption that physicians have differences in their practice styles (e.g., spending more time in between patients to review charts or complete documentation) despite working in the same clinic, resulting in different wait times for their patients. Given that there were no differences in the number of steps patients were able to complete based on physician, it is possible that any differences in physician practice styles did not substantially impact wait times to the point of interfering with patients' abilities to complete the app. It is also possible that the use of one clinic site within the current study resulted in sufficiently standardized practices across physicians, and perhaps differences in wait times were less influenced by individual physician practices and more influenced by organizational-level factors. An important area for future research would be to examine differences in fidelity across different clinic sites.

Though fidelity results are promising, some minor changes to the app may help to ensure that patients are exposed to all steps of app, which is particularly important given that these steps correspond to current clinical practice guidelines for weight management. These potential changes are discussed in the Future Directions section below, and will be important to explore as more widespread use of the app is considered. An additional factor that is important to consider prior to more widespread use is patient perceptions of app acceptability. To that end, consistent with hypotheses based on early usability testing of the app, acceptability ratings were relatively high with modal responses of 4/5 ("Agree") on all acceptability questions and an overall average acceptability score of 29.39 (highest possible score = 40).

While overall acceptability scores were high, it is important to note that they were statistically greater, on average, for patients who were classified as obese (either Type I or Type II) than for patients who were classified as normal weight. It is possible that this difference was driven primarily by questions regarding the personal relevance of information (e.g., risks of being overweight, weight management recommendations) presented in the app, which might be perceived as more relevant for individuals of heavier weight than for individuals of normal weight.

Though reliability analyses indicated sufficient reliability to collapse all items into one score, exploration of individual items revealed some interesting nuances. Specifically, individual items with the lowest modal scores (3/5; "Neither agree nor disagree") were two questions pertaining to whether or not participants viewed the app as a good way to spend their time in the waiting room. Conversely, items that asked about ease of use and relevance of information all received modal scores of 4/5 ("Agree"). It is possible that participants may have planned to use their wait time for other purposes, thus contributing to lower ratings on questions regarding

completing the app during their wait time. However, it is important to keep in mind that the majority of participants did not respond with "disagree" or "strongly disagree" to these questions, but rather were more ambivalent about using their wait time to complete the app with modal responses of "neither agree nor disagree." Future research may consider a more qualitative or mixed methods approach to understanding acceptability, such as the use of interviews following primary care visits or the inclusion of free-response sections on acceptability questionnaires.

Aim 2: Patient-Physician Communication

The second aim of the current study was to assess for any differences in patient-physician communication between the app condition and the control condition, given the primary purpose of the app as a communication tool to enhance patient empowerment. Overall, patient weight status was discussed in 42.7% of all primary care visits regardless of condition, which is consistent with prior research noting low rates of BMI documentation (Ma et al., 2009) and, more specifically, consistent with earlier research demonstrating regular provision of weight management counseling by less than half of all PCPs from a nationally-representative sample (Smith et al., 2011).

Given that weight management guidelines recommend weight status discussions only for those who are classified as overweight or obese (Jensen et al., 2013), it is important to consider the proportion of visits in which weight-related discussions occurred relative to the need for such discussions within this particular sample. Unfortunately, a significant majority (82.5%) of individuals in the current sample were classified as overweight or obese. This means that in order to adequately meet this sample's needs and to follow clinical practice guidelines for weight

management, weight-related discussions should have occurred in closer to 80% of all visits, as opposed to the 42.7% in which they actually occurred.

Although the current weight management clinical practice guidelines recommend weight status discussions only for those patients who are overweight or obese, it is important to consider the possible benefits of more regular weight status discussions for all patients. Notably, there are significant negative health consequences for individuals who are chronically underweight (Uzogara, 2016), and as such, it may be helpful to consider discussions of weight status and management essential for this population as well (Williams, Goodie, & Motsinger, 2008). For patients who fall within the normal weight category, physicians providing information about current weight status could help to normalize the conversation, thus making it easier to have conversations in the future should weight status change. Specifically within the family medicine subspecialty, of which a defining feature is the sustained patient-physician relationship, regular discussions of weight status can help to strengthen trust in the relationship (Parchman & Burge, 2004), thus facilitating improved patient empowerment and adherence to treatment recommendations. Additionally, providing support and positive feedback for healthy behaviors has been shown to further strengthen the patient-physician relationship (Beck, Daughtridge, & Sloane, 2002). As such, both the patient-physician relationship and long-term health outcomes can improve when patients are provided with positive information about healthy weight status (Beck et al., 2002). Using the app during new patient appointments at the outset of the patient-physician relationship, as explored in greater detail in the Future Directions section, may further help to normalize these conversations for all patients, regardless of current weight status.

Despite the evidence suggesting that all patients, particularly those seen for primary care services within a Family Medicine setting, would likely benefit from regular weight status

discussions, the focus of the current study was on weight management for individuals who are overweight or obese, in line with current weight management clinical practice guidelines. As such, it is important to note that there was a significant difference in the occurrence of discussions of weight status and associated risks based on patient weight status, such that these conversations were more likely to occur for patients who were overweight or obese than for patients who were of normal weight or underweight. Thus, while the goal – as specified by the AHA/ACC/TOS weight management guidelines – would have been for weight management conversations to have occurred for all patients who were overweight or obese, these findings indicate that such conversations were more likely to happen for patients who could serve to benefit from them.

In addition to overall low rates of weight-related conversations, findings did not support hypotheses regarding the impact of condition on the occurrence of any weight-related conversations (i.e., weight status, risks, or weight management options). However, findings were in the hypothesized direction, such that discussions of weight status occurred in 51.1% of app condition visits and in 33.3% of control condition visits, and discussions of treatment options occurred in 46.8% of app condition visits and 28.6% of control visits, though this trend did not hold for the percentage of visits in which discussions of risks (23.9% app condition vs. 28.6% control condition) occurred.

In addition, there was a statistically significant difference in who initiated the discussion of patients' current weight statuses. This finding supported the hypothesis that the weight management app may foster patient empowerment, as a greater percentage of patients in the app condition (62.5%) initiated discussion, while a greater percentage of physicians in the control condition (71.4%) initiated the discussion. Given the lack of statistically significant differences

in the initiation of other topics (i.e., associated risks and treatment options), it is possible that patients are most comfortable bringing up initial domains of concern and trust that physicians will bring up other relevant topics (e.g., risks, treatment options) related to those initial concerns. However, it is important to note that there was not a statistically significant difference in scores on the patient empowerment questionnaire between participants in the app condition and those in the control condition, which somewhat weakens the possibility that the app was useful in promoting patient empowerment. These discrepant findings suggest the need for additional research to further explore the role of the mHealth in changing patient-physician communication.

One possible explanation for the lack of statistically significant findings and inconsistencies with prior research was the small sample size, which likely resulted in limited power to detect statistically significant differences and precluded the use of more sophisticated analyses to account for multiple simultaneous factors influencing the occurrence of weight-related conversations (e.g., regression or structural equation modeling). It is also important to note that, although data was collected on physician characteristics (e.g., weight status, weight management knowledge) that have been shown to influence weight discussions and treatment practices, the sample size was too small and homogenous to control for any of these conditions in analyses.

Other possible explanations for the current findings also warrant consideration. As previously noted, though most patients were able to work through a majority of the app, nearly half of participants did not complete step eight, which provided recommendations for how to speak with their physicians about weight-related concerns. It is possible that findings would have supported hypotheses if more patients had been exposed to recommendations for how to speak with their physicians.

It is also notable that a vast majority (85.6%) of the entire sample had conditions other than overweight or obesity (e.g., asthma, cardiac problems, mental health concerns, chronic pain) documented in their current "problem list" within the medical record. Prior research has noted that comorbidities with overweight and obesity are common, and are often barriers to weight-management specific treatment (Lyznicki, Young, Riggs, Davis, & Dickinson, 2001; Mauro, Taylor, Wharton, & Sharma, 2008). Given such high prevalence of other comorbidities, it is possible that patients and/or their physicians were more concerned about these comorbid conditions than about the underlying issue of weight status, thus directing the conversation to topics other than weight-related issues, regardless of app completion.

In a similar vein, prior research found that primary care physicians expressed a greater desire to help patients with weight management than patients themselves expressed (Ruelaz et al., 2007). Rather than seeking input from medical professions, this study suggested that patients believe weight is something that should be handled personally (Ruelaz et al., 2007). If patients in the current sample held similar beliefs, it is possible that the app provided them with important information that could help to foster improved weight management practices on their own, precluding the need for a discussion with their physicians. Findings from aim 3, discussed below, could serve to further strengthen or weaken this possibility.

Although Ruelaz and colleagues (2007) did not explicitly examine the role of weight-related stigma in their study, it is possible that this stigma may impact patients' willingness to engage in discussions with their providers. Indeed, other research has specifically examined stigma related to weight, with a recent review summarizing this prolific literature (Vartanian & Porter, 2016). Consistently, experimental research has demonstrated that priming individuals with weight-stigmatizing information is associated with greater self-reported desires to engage in

unhealthy eating and feeling less capable of controlling weight (Vartanian & Porter, 2016). While the information presented through the app in the current study was not explicitly weight-stigmatizing in the same way as the information used in the studies reviewed by Vartanian and Porter (2016), weight is often a personal and sensitive topic, and it is possible that patients in the current study did perceive it as stigmatizing or threatening, thus diminishing their perceived self-efficacy and desire to discuss weight-related concerns. Given that the information in the current study was presented in a neutral way and was subject to usability testing to ensure that it was palatable to users prior to use in the current study, future research may consider assessing for negative interpretation bias (e.g., Hindash & Amir, 2012) or threat sensitivity in participants to avoid the possibility of unintentionally activating stigma and shutting participants down to weight-related discussions.

Another important consideration is that the current patient sample was recruited from the established caseloads of the physician participants, and none were establishing care for the first time. Given that overweight and obesity are complex, multifactorial, and chronic conditions (Lyznicki et al., 2001), it is unlikely that weight-related concerns were new for a majority of the patients within this sample. As such, it is reasonable to consider that perhaps weight-related discussions had occurred in prior visits, earlier in the patient-physician relationship or closer in time to when weight first became a concern. It is possible that patients, physicians, or both, became frustrated with the lack of any weight change over time and simply chose to stop discussing the problem or to shift the focus of their discussions to other areas of concern. This hypothesis draws some support from prior research demonstrating high rates of physician pessimism regarding the possibility of success from physician-driven weight management in the primary care setting (Ferrante et al., 2009). However, it is also possible that, if initial weight

discussions did indeed occur earlier in the patient-physician relationship, that the discussion resulted in referrals to outside providers for additional management and follow-up of weight concerns, thus reducing the physician's sense of responsibility to bring up weight in later sessions. This hypothesis is supported in part by physician responses to one question assessing attitudes toward weight management practices included on the Treatment Practices survey. While this question was not used in any of the primary aims or analyses, it bears mentioning. Though there was some variability in physician responses on this item, no physician indicated that they felt confident and comfortable focusing on weight management in the primary care setting. Specifically, two physicians indicated that it is their duty to discuss weight, but the long-term management and follow-up are beyond the scope of what they can provide in the primary care setting. Another two physicians indicated that obesity is very complex, and they prefer to focus on the comorbidities while referring out for the weight management piece. The final physician noted the brief time allotted for visits as a barrier to weight management within the primary care setting. Though this is a very small sample size, it is important to consider the physician responses in the context of their established relationships with their patients and in the cross-sectional design of the current study.

Aim 3: Weight Management

The third aim of the current study was to assess for any changes in BMI classification from the study visit to the next primary care follow-up visit. Contrary to hypotheses, there was not a statistically significant difference in the percentage of patients who decreased BMI classification between conditions from study visit to follow-up, which would have been indicative of improved weight management. In fact, the majority of patients (84.1%) remained in the same classification, with 21.7% classified as overweight and 65.2% classified as obese (type

I or type II). Thus, although the majority of patients in the app condition were able to complete most of the app prior to meeting with their physicians, these findings suggest that completion of the app was not sufficient to improve individual weight management practices.

There is substantial research describing barriers to effective weight management and recommending the use of a multidisciplinary approach to promote the best long-term outcomes (e.g., Middleton, Anton, & Perri, 2013). As with many chronic conditions, overweight and obesity can be challenging to treat, requiring long-term, multifaceted interventions that map onto the multitude of factors that can influence the onset and maintenance of these conditions (Fujioka, 2002; Logue et al., 2005; Lyznicki et al., 2001; World Obesity Federation, 2017). Within this context of prior research, it is important to note that the app used within the current study was not itself a multifaceted intervention, but rather a tool with the intent of fostering improved communication and greater engagement in the types of multifaceted interventions that are generally recommended. As such, current findings demonstrating no significant change in weight management associated with a simple, one-time app-delivered educational and communication intervention are consistent with prior research (Fujioka, 2002; Jensen et al., 2013; Logue et al., 2005; Lyznicki et al., 2001; World Obesity Federation, 2017).

Indeed, theories of both health behavior change (Ryan, 2009) and chronic disease management (Rippe, Crossley, & Ringer, 1998) note that simple, educational interventions are generally not effective in promoting long-term success. Unfortunately, recommended approaches to weight management seem to be at odds with the aforementioned study which reported general patient preference to manage weight individually rather than in conjunction with their medical providers (Ruelaz et al., 2007). Even for individuals who are highly-motivated to lose weight, research suggests that brief weight loss-specific interactions with providers (e.g., face-to-face

interactions, individualized emailed feedback, phone calls) can improve the effectiveness of otherwise relatively minimal weight management interventions (Johnson et al., 2008; Tate, Wing, & Winett, 2001).

One goal of the current study was to help patients overcome hesitancies in bringing weight-related concerns to their physicians and to provide them with additional information on the benefits of a multidisciplinary approach to weight management in order to facilitate improved patient-physician communication. While results suggest that most patients were indeed exposed to the information, mere exposure to information was not sufficient to significantly influence the occurrence of weight-related discussions. This is consistent with prior research and theories on health behavior change, for which knowledge is a necessary though not sufficient component (Ryan, 2009). However, findings did suggest that the app may have fostered greater patient empowerment, with patients in the app condition more likely to initiate discussions regarding weight status. Given this finding, it is important to keep in mind that patient-physician interactions are dyadic and reciprocal in nature. Once patients do bring up concerns, it is crucial that physicians have the knowledge and confidence to appropriately address patient concerns. Unfortunately, low weight management knowledge scores within the current sample of physicians indicates that perhaps they did not have the requisite knowledge necessary to continue the weight management discussion in a way that is consistent with current weight management clinical practice guidelines. This in turn may have contributed to the lack of significant change in patient BMI classification from baseline to follow-up.

Increasingly, stakeholders interested in improving access to and engagement in effective interventions for a variety of conditions have emphasized the importance of understanding contextual and organization-level influences on such services (e.g., Damschroder & Lowery,

2013; Greenhalgh, Robert, Macfarlane, Bate, & Kyriakidou, 2004; Phillips, Morrison, Andersen, & Aday, 1998; Solberg, 2000). These contextual factors include features of the healthcare delivery system, the organizational structure of the specific clinic, reimbursement policies and practices, and even cultural and community characteristics that can influence individual physician and patient behaviors within the healthcare system (Phillips et al., 1998). Contextual factors are often implicated as accounting for some of the research-practice gap, given the mismatch in contextual factors between settings in which outcome research is conducted (e.g., tightly-controlled conditions, researcher-provided administrative support) and community settings in which real-world interventions are delivered (Curran et al., 2012).

More researchers, including those examining weight management interventions, are beginning to assess contextual factors. For example, one large-scale evaluation of a weight management program implemented across Veterans Administration treatment facilities settings noted that programs with specific administrative features, including available resources and leadership engagement, tended to have a greater success in implementing the weight management program (Damschroder & Lowery, 2013). Perhaps more analogous to the current study, a systematic review of weight management programs within primary care settings noted that, although there are no simple strategies to improve weight management practices within primary care, studies that yielded the greatest patient engagement and most promising health-related outcomes incorporated some level of administrative support (Tsai & Wadden, 2009). This support often took the form of office staff providing educational materials to patients and flagging reminders to providers prior to appointments. Given these findings, one potential future avenue for the use of the app would be to use it as more of an administrative/supportive

component as part of a larger weight management program for patients who are interested and motivated to engage in such services.

Taken together, findings from the current study suggest that patients largely found the app to be an acceptable use of their time in the waiting room. While fidelity to the app was promising, it appears as though fidelity was not high enough to significantly influence patient empowerment and subsequent health behavior change. As such, there is room for improvement in order to ensure that patients are exposed to all portions of the weight management clinical practice guidelines, and to information that should serve to foster greater patient empowerment. With such improvements, explored in the Future Directions section below, it is hypothesized that there would be larger effects on patient-physician communication and, ultimately, on weight management behavior changes.

Strengths

There were a few strengths to the current study that warrant mentioning. As previously noted, this study examined the use of mHealth in a novel setting and for novel purposes. Namely, this study was the first to the author's knowledge to employ mHealth (a) in the waiting room, (b) to implement clinical practice guidelines, and (c) to foster patient empowerment. As technology becomes increasingly accessible, it is important for clinicians and researchers to continue exploring innovative uses that may serve to facilitate the implementation of evidence-based practices such as clinical practice guidelines and to ultimately improve patient care.

The use of in vivo session recordings and transcriptions to assess patient-physician communication was also a strength of the current study. Research in healthcare settings often relies on chart review to collect information regarding session content. While this strategy can save time and resources, there may be differences in the quantity and quality of information

documented by different providers, resulting in gaps in information or underestimation of specific content included in clinic visits. Additionally, a recent review of studies examining the impact of weight status discussions noted a relative paucity of studies using direct observation to assess patient-physician communication (McHale, Laidlaw, & Cecil, 2016). Thus, the use of in-vivo session recordings within the current study provided highly accurate data on the topics of conversation discussed, and allowed for more precision than what can be gleaned through chart review alone.

Limitations

It is important for the findings and strengths of the current study to be considered in the context of several limitations. Although the use of in vivo session recordings was a strength of the current study, the method of coding session transcripts focused on the presence or absence of specific topics of discussion. This is a limitation, as it did not allow for any nuanced understanding of more qualitative features of the discussions such as duration, depth, or intensity (Roter & Larson, 2002). As such, briefer, more simplistic discussions and longer, more in depth discussions were all group into the same category. The use of a more sensitive coding system would have provided more detailed information about the nature of weight-related discussions, which could have resulted in a different pattern of findings. It is also important to consider that, despite best efforts to maintain study blindness and allow for patient control of audio-recorders, the use of in vivo data collection may have prompted reactivity effects, with patients less likely to discuss sensitive topics such as weight while being audio-recorded.

As noted throughout, a relatively small patient sample size resulted in limited power, rendering regression analyses and sophisticated multilevel modeling untenable. The unique mixed-method, hybrid design of the current study made sample size estimation challenging. The

goal of 20 patients per physician for a total of 100 patients with 50 per condition was made based on a combination of prior studies with similar designs, and with logistical considerations in mind. Unfortunately, this sample size did not result in sufficient power to use multilevel modeling, which would have been particularly useful given the large number and nested structure of variables hypothesized to influence primary outcome variables related to patient-physician communication. However, the current study was considered a pilot study for future trials that will have larger samples and greater power.

In addition to a relatively small patient sample, the current study recruited a very small physician sample, with a participation rate of only 26%. Due to this small sample, there was insufficient variability to allow for analyses of physician characteristics that have been shown in the literature to influence both patient-physician communication and weight management practices, particularly physician weight status and knowledge of weight management. Analyses accounting for these important covariates would have afforded a more nuanced understanding of the extent to which different variables influenced patient-physician communication, as well as possible interactions between variables. With only five participants, it is also important to consider a strong likelihood of self-selection bias. Due to the method of recruitment and enrollment, it was not possible to systematically collect information regarding reasons for participation refusal. However, it is a reasonable hypothesis that physicians who did elect to participate were likely more open to research in general, as well as being more open to having their patient interactions recorded, and therefore may have felt more confident in their communication style with patients. As such, results of the current study may have differed with a larger and more diverse physician sample.

Where possible, the current study used existing measures with strong psychometric properties (e.g., the Rathus Assertiveness Schedule; Nevid & Rathus, 1979). However, measures did not exist for several of the constructs (e.g., feasibility, acceptability) assessed within the current study, or did exist but assessed the constructs in relation to specific illnesses or treatment settings that did not map on closely to the current study. As such, a number of measures used were study-developed or were adapted from existing measures. Though reliability analyses of these study-developed measures indicated strong reliability, additional research to further assess the reliability and validity of responses generated by these measures would help to ensure sufficient psychometric properties.

The use of BMI as a primary outcome within the current study was also somewhat of a limitation. Research has suggested that BMI is generally strongly correlated with waist circumference and is considered a valid measure of body fat (Flegal et al., 2009). However, waist circumference has been found to be more highly and reliably correlated with body fat percentage than BMI, and there is evidence that BMI can be an overestimation of body fat in individuals who have greater muscle density, particularly if they are shorter in stature (Flegal et al., 2009). Though waist circumference is often used as an alternative to BMI, the choice to use BMI within the current study was made despite its limitations, due to standard practices within the primary care setting for the current study as well as BMI as the current method for classifying individuals as overweight or obese according to the AHA/ACC/TOS weight management guidelines.

While the use of in-vivo session recordings was a strength for patient-physician communication outcomes, the method of collecting follow-up data and assessing change from baseline to follow-up presents a few limitations. First, the use of chart review to collect BMI data, may have resulted in inaccurate data, as it is possible that BMI information may have been

missed at one visit and copied forward from the prior visit's documentation. It is also important to note that there was significant variability between patients in the amount of time between study visit and follow-up, with a range from 37-441 days between visits. As such, patients with a longer delay between visits may have had more time to lose weight (and possibly regain weight; Middleton et al., 2013) than patients who had a shorted delay between visits. A more standardized approach to collecting follow-up data, such as distributing questionnaires within a specific period of time following the initial study visit, would have provided afforded greater control in follow-up analyses. In addition, the operationalization of improved weight management as "change in BMI classification" was made based on literature demonstrating clinically meaningful changes in comorbidities and associated morbidity and mortality with a change in classification (e.g., Fujioka, 2002). However, it takes a great deal of weight loss for an individual to move into a lower classification (e.g., from Obesity Type I to overweight). Given that the intervention within the current study was a communication intervention rather than a weight management intervention, it is possible the chose outcome measure was not sensitive enough to detect smaller changes in weight that could have been indicative of early changes in weight management practices.

Finally, it is important to consider some contextual factors that may limit the generalizability of the current study findings. First, the current study took place exclusively in West Virginia, a state which consistently ranks having one of the highest rates of overweight and obesity (Centers for Disease Control and Prevention, 2019; National Center for Chronic Disease Prevention and Health Promotion, 2016). Recent estimates place the rate of obesity alone (i.e., not obesity and overweight combined) in West Virginia close to 40%, which is 5-10% greater than the national average (Centers for Disease Control and Prevention, 2019). This high rate of

obesity, and increasing trends that exceed those on a national scale (Centers for Disease Control and Prevention, 2019) suggest that West Virginia is an ideal target for renewed attention and focus on novel weight management strategies. However, West Virginia consistently ranks near the bottom economically and near the top in terms of poverty (U.S. Census Bureau, 2018), with close to 80% of the state's counties designated as medically-underserved areas (Harris & Neal, 2009). As such, it is important to consider that perhaps the patients within the current sample have limited access to weight management treatment options (e.g., dieticians, personal trainers, etc.) and possibly to healthy food options given the high density of food deserts across the state (Miller et al., 2016). Even for those who live in close proximity to important resources for weight management, high rates of poverty suggest that it may not be feasible for to pay for services that are provided outside of the healthcare setting, such as gym-based weight loss programs or healthy food options, which have been shown in the U.S. to be more costly than calorie-dense, highly processed food options (Drewnowski & Darmon, 2005). Taken together, the findings from the current study within the larger context of West Virginia suggest traditionally underserved states, like West Virginia, may require more substantial system- and community-level change to promote greater access to needed resources and to foster improved collaboration between service providers. It is possible that results from the current study would not generalize to communities with greater availability of services and improved finances to pay for such services.

The second contextual factor that bears additional consideration within the current study was the use of only one clinic site. While this allowed for greater control over recruitment and study procedures, there are organization- and system-specific factors that likely influence weight management practice across different clinic settings. At the system-level, it is important to

consider that some insurance companies and employers have started offering financial incentives for individuals completing weight management programs (Giles, Robalino, McColl, Sniehotta, & Adams, 2014). The role of such incentives, or other insurance or system-level factors within the current study was not directly assessed, which is a limitation.

At the organizational level, different clinics have different administrative structures that may prioritize or even incentivize certain practices over others (Damschroder et al., 2009; Phillips et al., 1998). It is possible that top-down policies within the current clinic prioritize the treatment of common comorbidities, thus influencing individual provider behaviors, while other clinics may prioritize treating the underlying weight concerns. As such, it is important to consider that findings from the current study may have been different in a clinic with different priorities or differences in standard practices surrounding weight management and related issues.

Future Directions

Findings from and limitations of the current study suggest a number of directions for future research. First, although fidelity results within the current study were promising, some changes to the app itself or to the way in which it was completed may improve its effectiveness in promoting patient empowerment. Specifically, it may be helpful to move the step that provides information about talking to healthcare providers to earlier in the process, in order to ensure that more patients are able to receive those recommendations prior to meeting with their physicians. It may even be worth considering splitting the app into two sections; the first to provide information on current weight status, associated health risks, benefits of weight management, and recommendations for talking to providers; and the second to include information on local weight management options, setting goals, and developing an individualized plan.

This strategy would increase the likelihood that patients would receive relevant information regarding their current health status and associated risks, as well as strategies for bringing concerns to their physicians prior to meeting with their physicians. It would also provide the opportunity for part one could be completed individually by the patient before the visit and part two could be completed in collaboration with the healthcare provider. This collaboration on developing an individualized treatment plan would also be more consistent with recommendations for successful long-term health behavior change (Middleton et al., 2013).

Future research should also consider assessing readiness to change (Holt, Helfrich, Hall, & Weiner, 2010; Morera et al., 1998) either embedded within the app, or prior to asking patients to complete the app. It is possible that readiness to change may influence not only patients' interest in discussing weight management, but may also impact their perceived acceptability of completing the app in the waiting room. Having a greater understanding of the ways in which readiness for change might influence patient engagement with mHealth interventions could help to tailor the delivery of such interventions to those who are most likely to benefit.

The use of a more integrated mixed-methods approach (Fetters, Curry, & Creswell, 2013) would also serve to further strengthen current findings. Specifically, the use of post-session interviews would provide rich information on perceived acceptability of app completion and patient empowerment that were unattainable through simple surveys. Similarly, this would provide an opportunity to assess patient barriers to initiating weight-management discussions with their physicians. A thorough understanding of barriers could also provide useful feedback for restructuring the app in order to better promote patient empowerment.

Additional avenues for future research include using the app in different ways than were explored within the current study. One such option would be to use the weight management app

in conjunction with a larger weight management program within the primary care setting. This use would be more consistent with prior research demonstrating the effectiveness of educational materials handed by office staff out to patients enrolled in a weight management program (Tsai & Wadden, 2009). However, this would be contingent upon the availability of an established weight management program within the specific primary care setting of interest.

An additional option would be to regularly administer the app prior to initial visits in which patients are establishing care with their PCPs for the first time. One possible hypothesis for the lack of significant findings within the current study was the use of established patient-physician relationships, in which it is possible that weight management had been discussed in prior visits. The use of the weight management app at the outset of the patient-physician relationship may help to normalize the conversation during the early establishment of the relationship (May et al., 2009), setting the stage for more regular communication about weight concerns.

Conclusion

Despite substantial research documenting the increasing worldwide and national prevalence of overweight and obesity (Hill & Peters, 1998; James, 2008; National Institute of Diabetes and Digestive and Kidney Diseases, n.d.), as well as significant health (e.g., Visscher & Seidell, 2001) and financial consequences (e.g., Withrow & Alter, 2011) associated with these conditions, provision of appropriate diagnoses and treatment options by healthcare professionals remain low (Kraschnewski et al., 2013; Smith et al., 2011). The current study examined the novel use of a mobile technology-based intervention within the primary care waiting room to facilitate improved implementation of evidence-based clinical practice guidelines for weight management, with the overarching goal of fostering patient empowerment to increase

conversations around weight-related concerns and ultimately improve weight management practices. Findings were mixed, with high rates of acceptability to completing the app, though unclear evidence about the extent to which it influenced patient-physician conversations and no evidence that it improved weight management practices. Given the high degree of patient acceptability, it is important for future research to explore the potential benefits of minor changes to the app that may increase its effectiveness and ultimately improve weight management practices.

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Table 1
Physician Demographics

	Physicians n (%)
Gender	
Male	1 (20.0%)
Female	4 (80.0%)
Race	
Asian	0 (0.0%)
Black	0 (0.0%)
Native American/Alaska Native	0 (0.0%)
Native Hawaiian/Pacific Islander	0 (0.0%)
White	5 (100.0%)
Not Reported	0 (0.0%)
Ethnicity	
Hispanic/Latino	0 (0.0%)
Not Hispanic/Latino	5 (100.0%)
BMI Class	
Underweight	0 (0.0%)
Normal Weight	1 (20.0%)
Overweight	2 (40.0%)
Obesity Class I	1 (20.0%)
Obesity Class II	1 (20.0%)
	M (SD)
Age	35.20 (3.90)
Years since degree completion	4.60 (2.90)
Knowledge score (percent correct)	67.78% (8.24)

Table 2
Patient Demographics

Variable n (%)	Full Sample n = 97	Control n = 48	App n = 49
Gender			
Male	32 (33.0%)	11 (22.9%)	21 (42.9%)*
Female	65 (67.0%)	37 (77.1%)*	28 (57.1%)
Race			
Asian	1 (1.0%)	0 (0.0%)	1 (2.0%)
Black	6 (6.2%)	4 (8.3%)	2 (4.1%)
White	87 (89.7%)	43 (89.6%)	44 (89.8%)
Other	2 (2.1%)	1 (2.1%)	1 (2.0%)
Did not report	1 (1.0%)	0 (0.0%)	1 (2.0%)
Ethnicity			
Hispanic/Latino	2 (2.1%)	0 (0.0%)	2 (4.1%)
Not Hispanic/Latino	94 (96.9%)	48 (100.0%)	46 (93.9%)
Did not report	1 (1.0%)	0 (0.0%)	1 (2.0%)
BMI Class			
Underweight	1 (1.0%)	1 (2.1%)	0 (0.0%)
Normal Weight	16 (16.5%)	9 (18.8%)	7 (14.3%)
Overweight	21 (21.6%)	9 (18.8%)	12 (24.5%)
Obesity Class I	26 (26.8%)	13 (27.1%)	13 (26.5%)
Obesity Class II	33 (34.0%)	16 (33.3%)	17 (34.7%)
Education			
Some high school	2 (2.1%)	2 (4.2%)	0 (0.0%)
High school graduate/GED	33 (34.0)	20 (41.7%)	13 (26.5%)
Some college	7 (7.2%)	2 (4.2%)	5 (10.2%)
Associate degree	6 (6.2%)	4 (8.3%)	2 (4.1%)
Bachelor's degree	20 (20.6%)	9 (18.8%)	11 (22.4%)
Master's degree	11 (11.3%)	6 (12.5%)	5 (10.2%)
Doctoral degree	3 (3.1%)	0 (0.0%)	3 (6.1%)
Did not report	15 (15.5%)	5 (10.4%)	10 (20.4%)
Household Income			
$14,999 or less	10 (10.3%)	6 (12.5%)	4 (8.2%)
$15,000 to $29,999	13 (13.4%)	8 (16.7%)	5 (10.2%)
$30,000 to $49,999	18 (18.6%)	9 (18.8%	9 (18.4%)
$50,000 to $74,999	17 (17.5%)	10 (20.8%)	7 (14.3%)
$75,000 or more	15 (15.5%)	8 (16.7%)	7 (14.3%)
Did not report	24 (24.7%)	7 (14.6%)	17 (34.7%)
Variable *M (SD)*	Full n = 97	Control n = 48	App n = 49
Age	49.00 (15.23)	49.60 (15.68)	48.41 (14.91)
BMI	33.07 (8.42)	32.60 (8.24)	33.53 (8.66)
Acceptability Score	--	--	29.39 (5.63)
Patient Empowerment	51.03 (10.01)	52.23 (10.82)	49.83 (9.10)
Rathus Assertiveness Score	-7.00 (44.47)	2.92 (45.25)	-15.50 (42.69)

* Statistically greater at the $\alpha = .05$ level.

Table 3.
Patient BMI at Follow-up

Variable	n (%)
BMI Class	
Underweight	1 (1.4%)
Normal Weight	8 (11.6%)
Overweight	15 (21.7%)
Obesity Class I	19 (19.6%)
Obesity Class II	26 (26.8.0%)
Change in BMI	
Decrease in classification	3 (4.3%)
No change	58 (84.1%)
Increase in classification	8 (11.6%)

Table 4.
Change in BMI from Baseline to Follow-Up by Condition

Variable	App	Control
Change in BMI	n (%)	n (%)
Decrease in classification	3 (8.8%)	0 (0.0%)
No change	28 (82.4%)	30 (85.7%)
Increase in classification	3 (8.8%)	5 (14.3%)

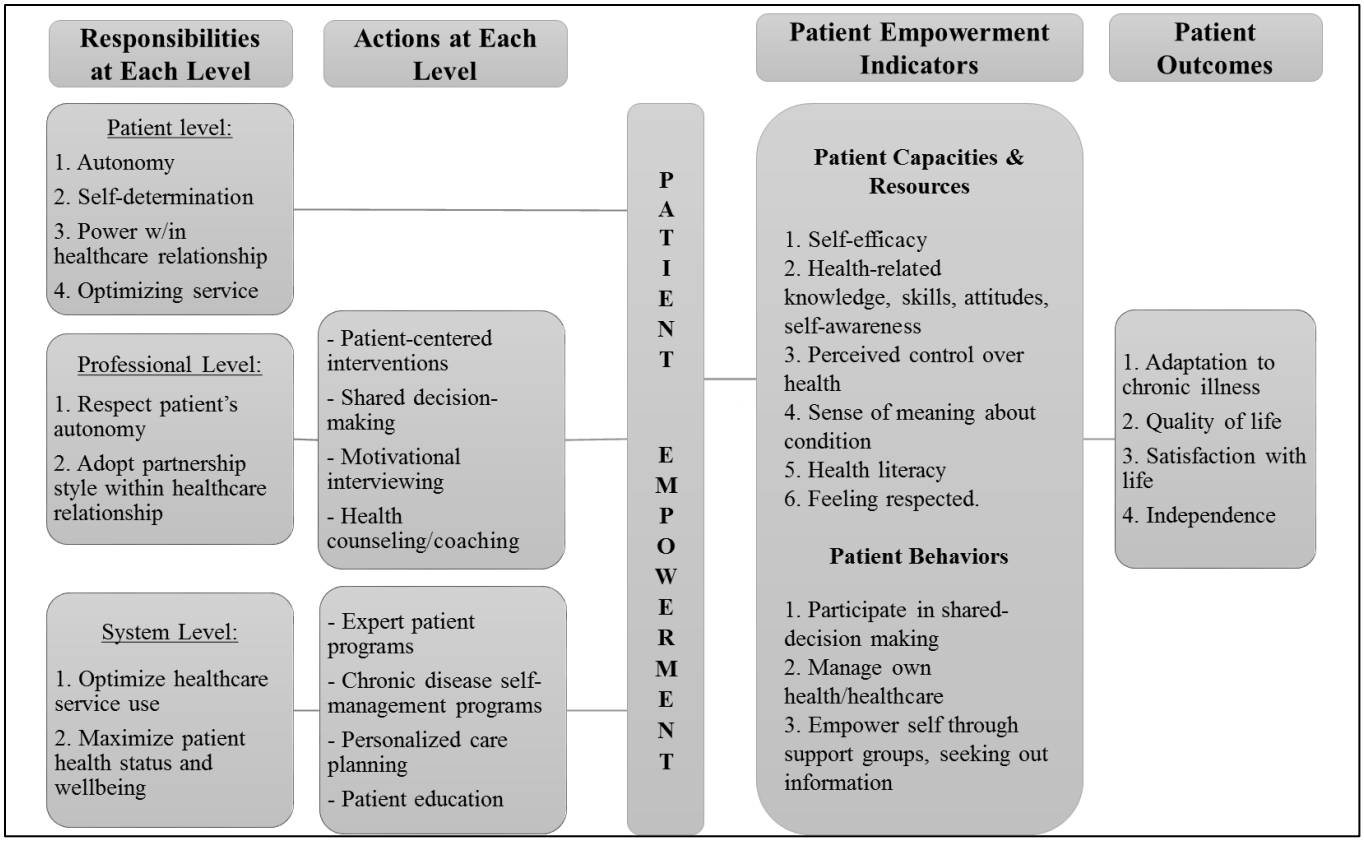

Figure 1. Conceptual model of patient empowerment.

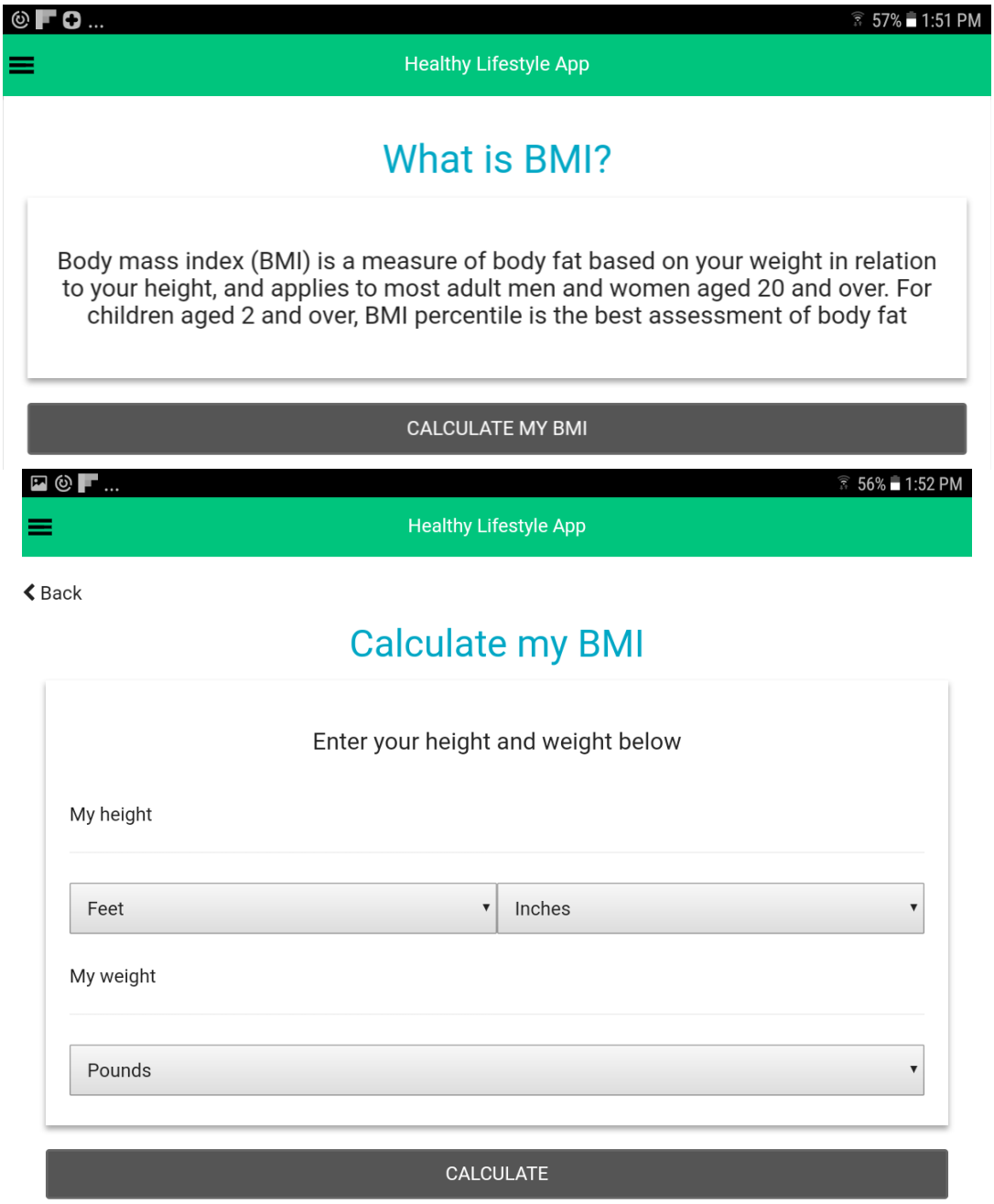

Figure 2. Steps 1-2 in completing the weight management app: define and calculate BMI.

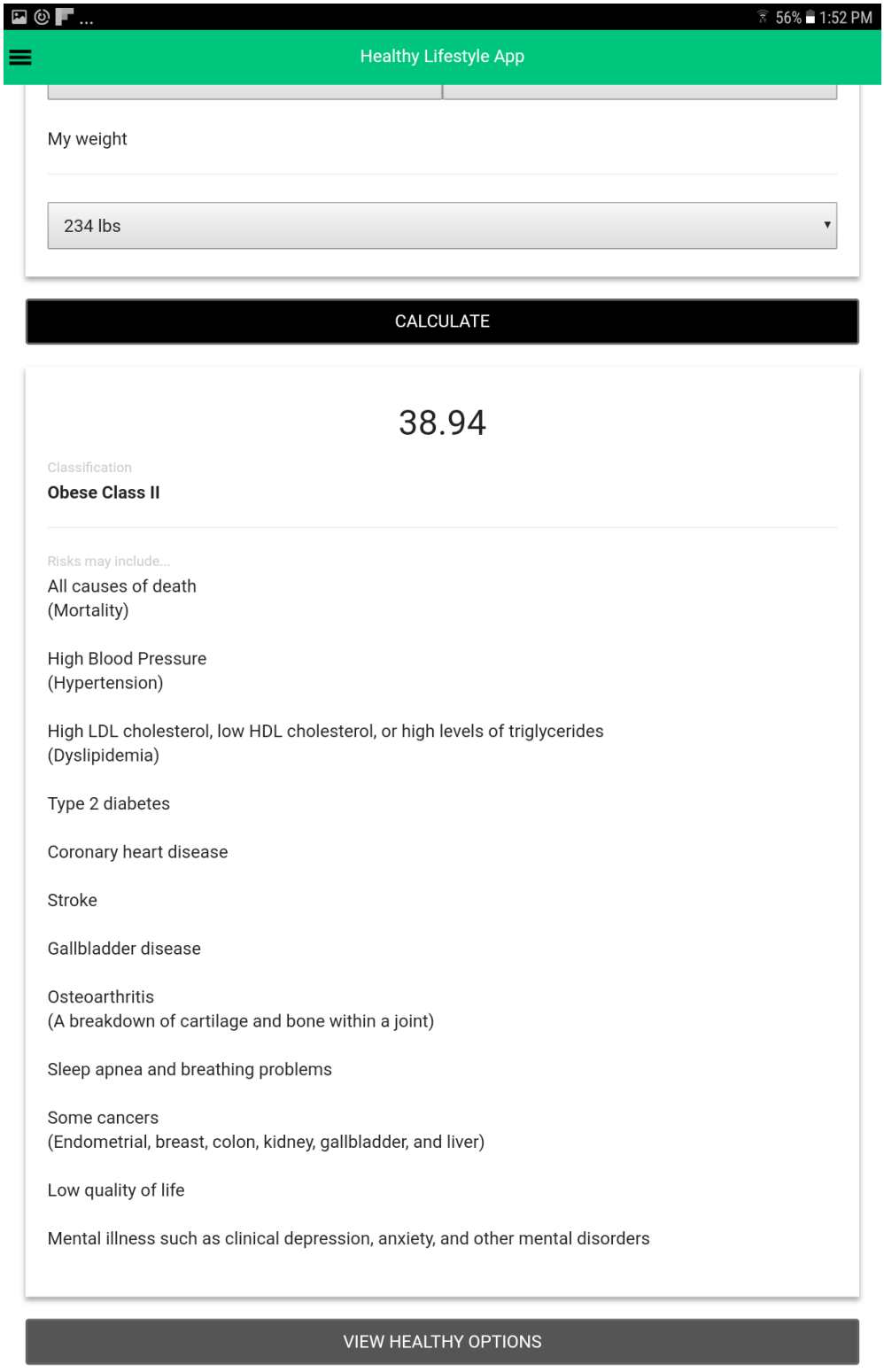

Figure 3. Step 3 in completing the weight management app: identify overweight and obese patients, provide information

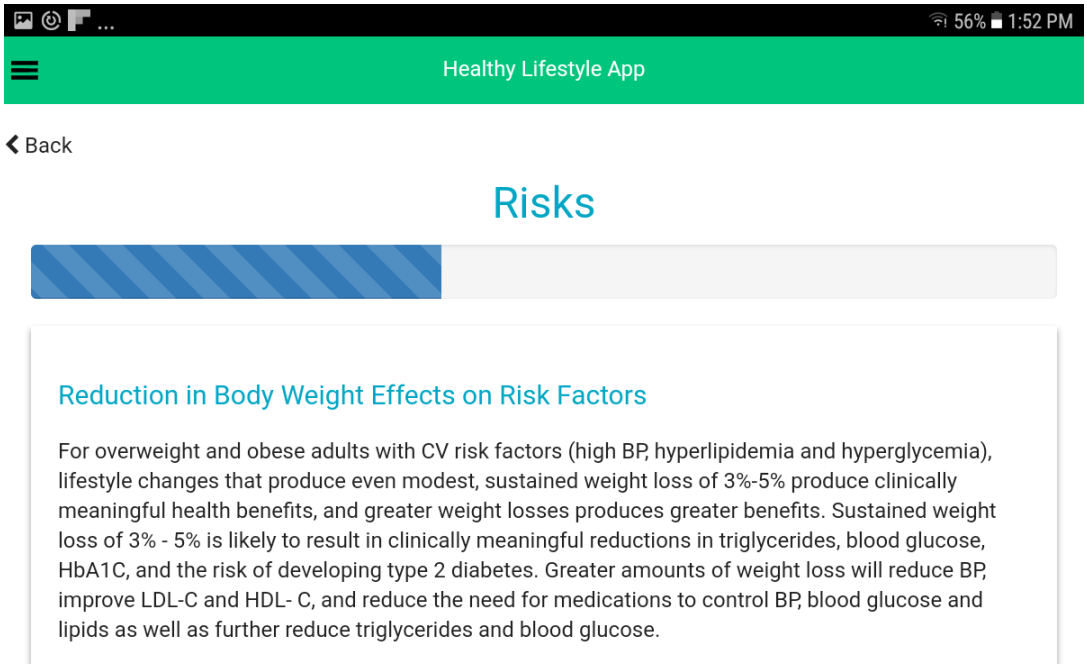

Figure 4. Step 4 in completing the weight management app: provide information on benefits associated with weight management.

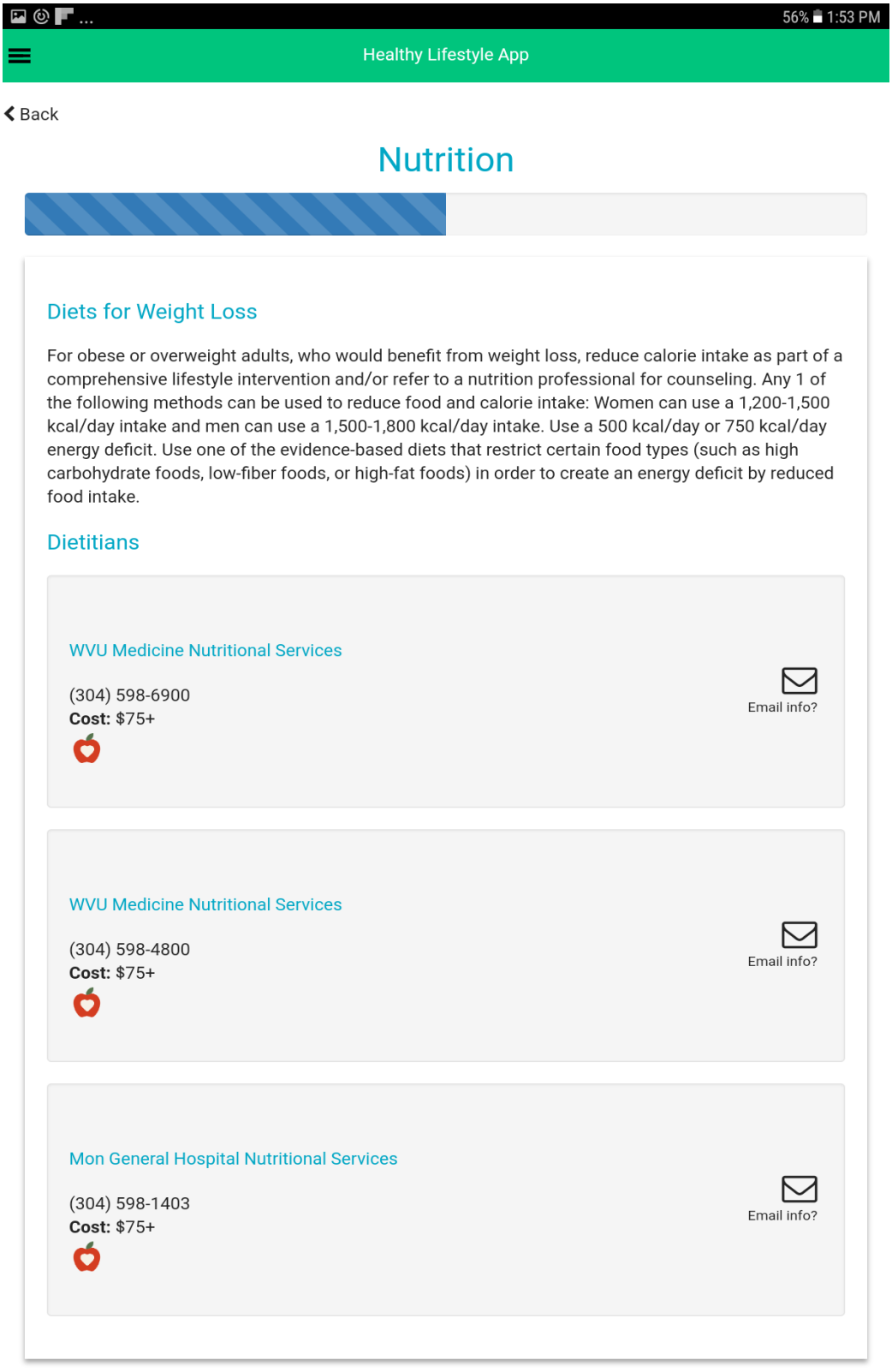

Figure 5. Step 5 in completing the weight management app: provide information on local weight management options (nutrition).

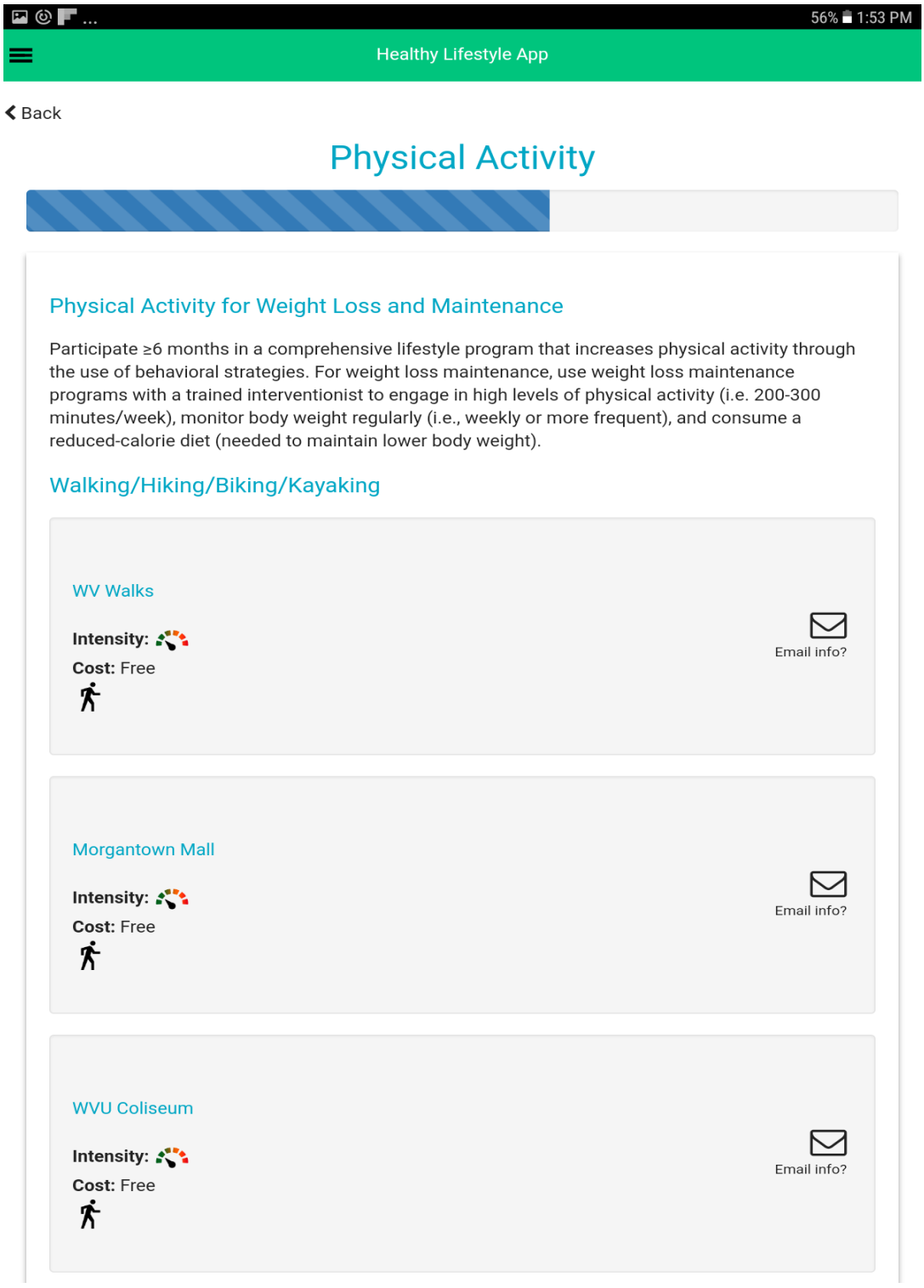

Figure 6. Step 6 in completing the weight management app: provide information on local weight management options (physical activity).

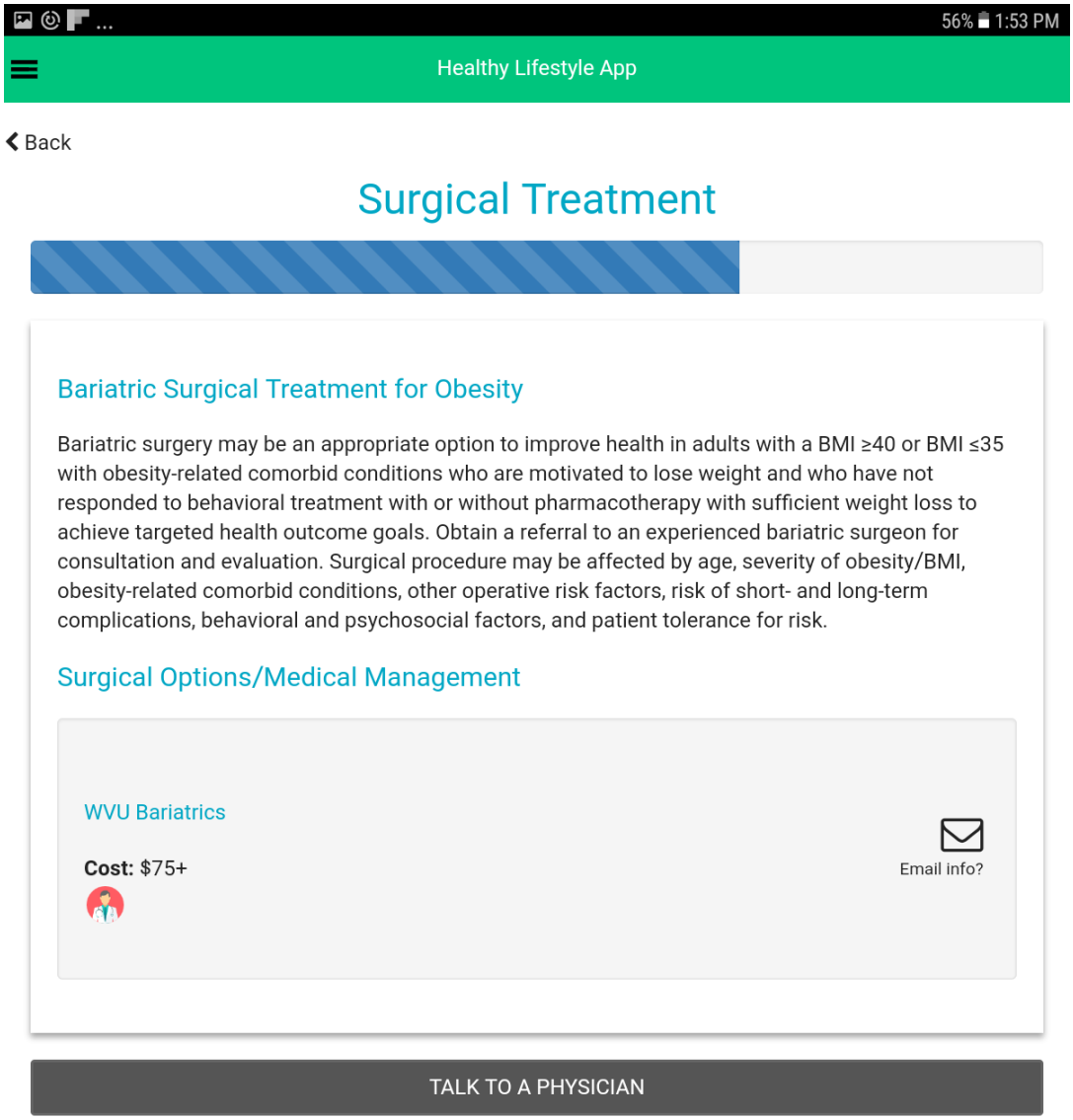

Figure 7. Step 7 in completing the weight management app: provide information on local weight management options (bariatric surgery).

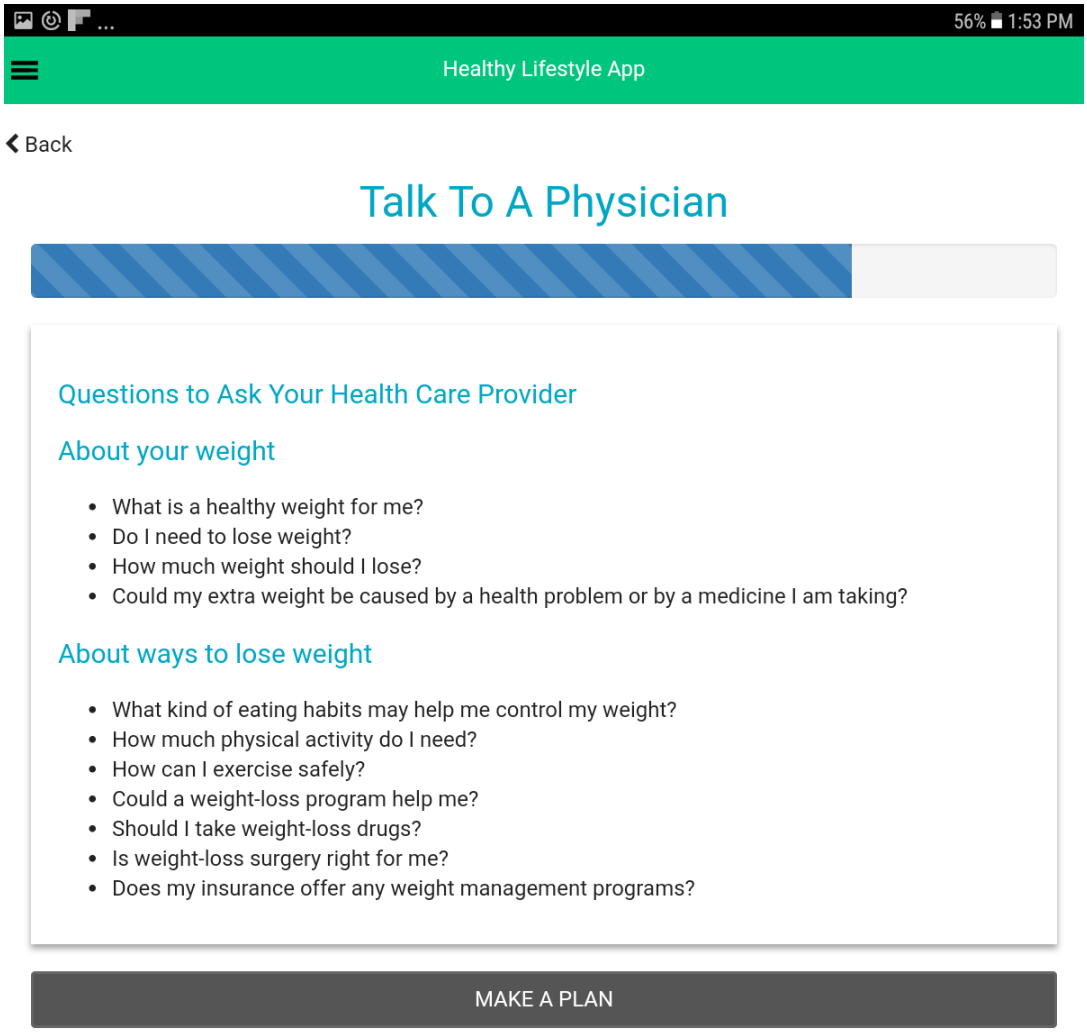

Figure 8. Step 8 in completing the weight management app: Recommendations for patients to speak with their healthcare professionals

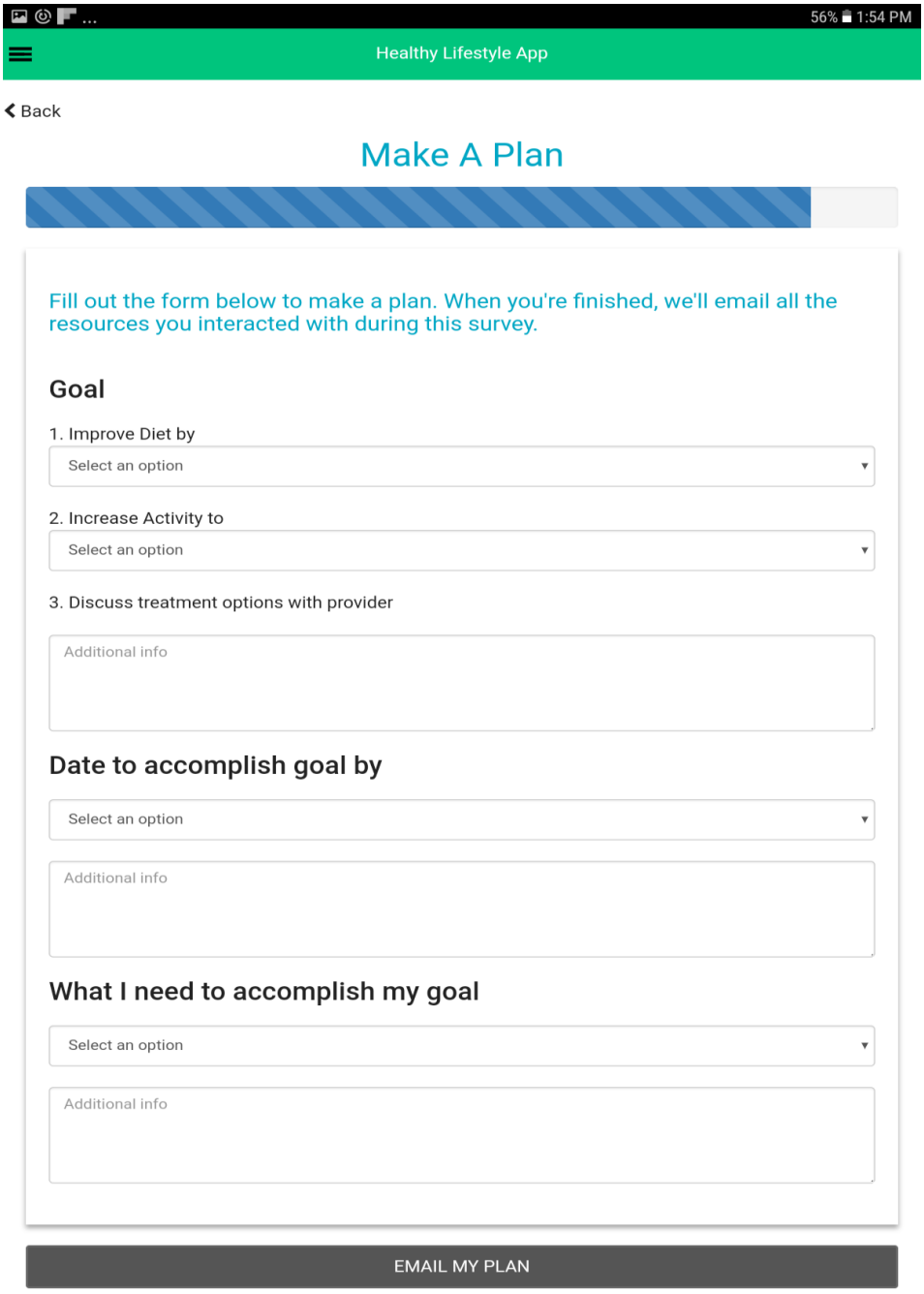

Figure 9. Step 9 in completing the weight management app: creating an individualized weight management treatment plan.

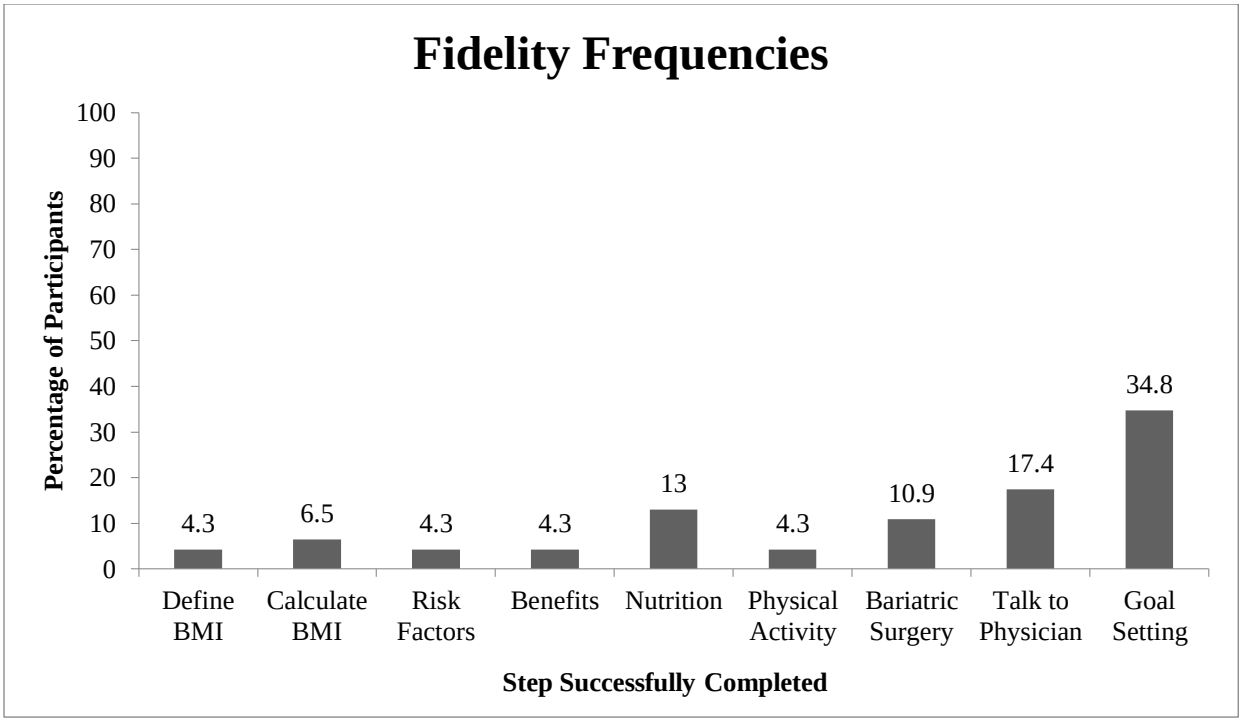

Figure 10. The figure denotes the final step of the app that patients fully completed prior to meeting with their physicians.

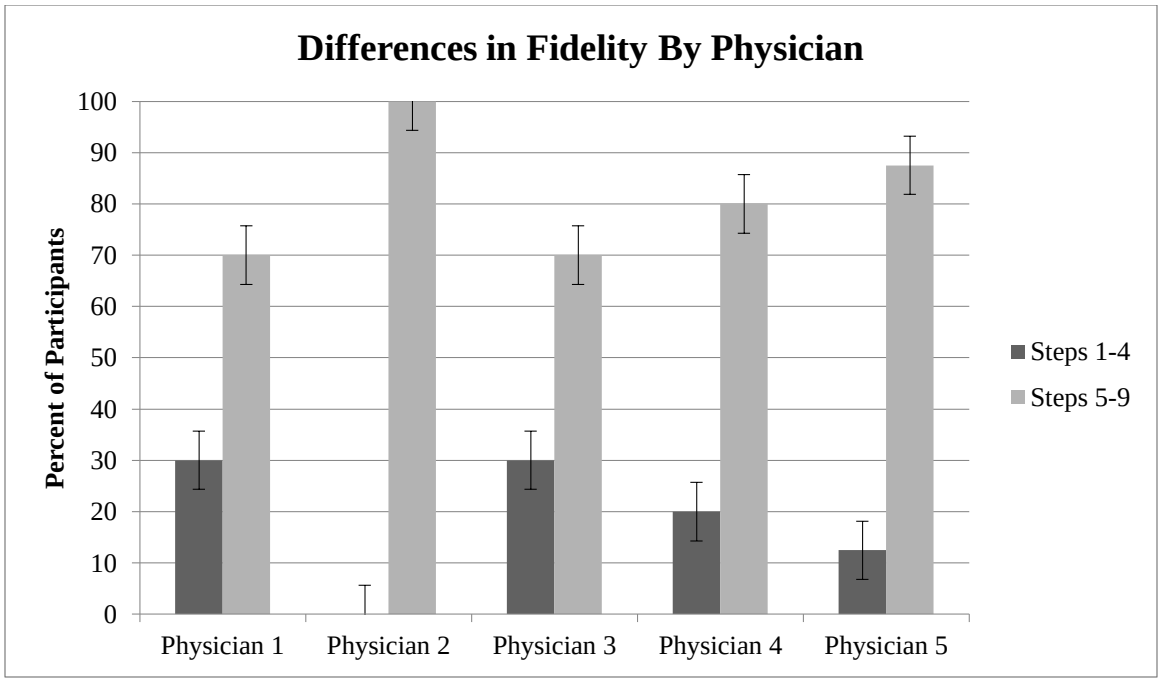

Figure 11. This figure demonstrates the percentage of each physician's patients who finished either between steps 1-4 or steps 5-9 prior to meeting with their physicians. Steps 1-4 correspond to providing information about patients' current health status and risks, while steps 5-9 include information about local treatment options and recommendations for how to speak with physicians about weight management concerns.

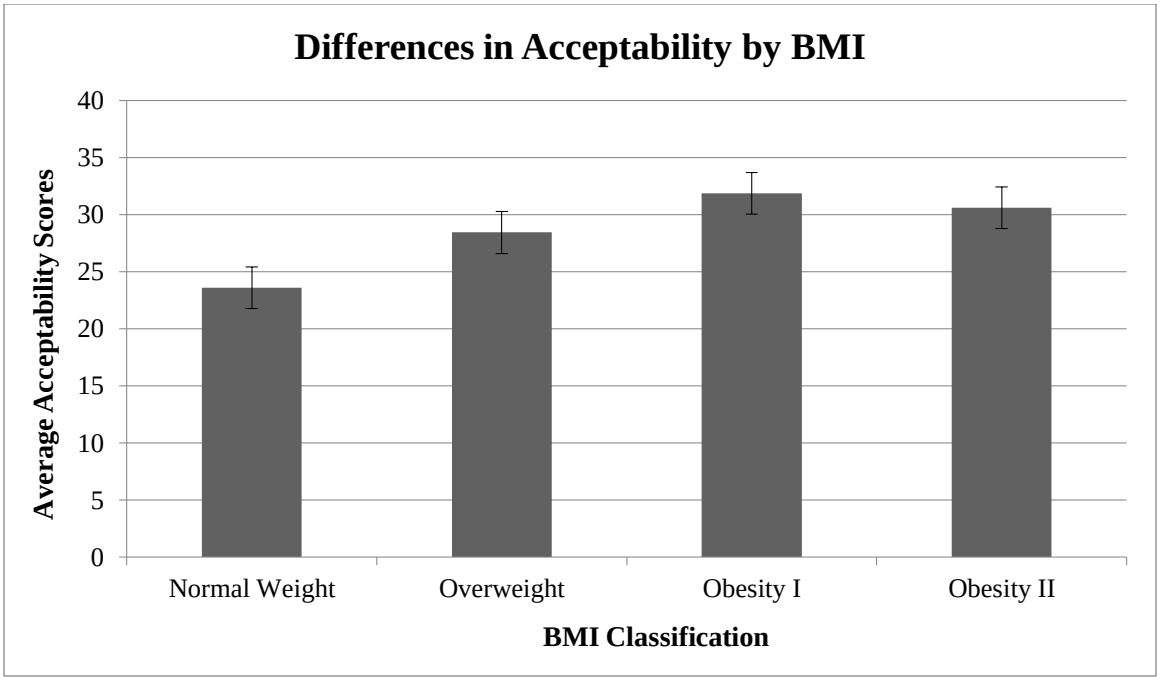

Figure 12. This figure depicts differences in acceptability scores based on patient BMI classification. Patients who were classified as Obesity Type I or Obesity Type II had statistically greater acceptability scores on average than patients who were classified as normal weight.

Appendix

Healthcare Professional Background and Contact Form

Please answer the following questions about your demographic information, your professional background, your health background, and your current job.

Your Gender:
□ Male
□ Female
□ Other (please specify): _____

Your Date of Birth:
Month / Day / Year
_____ / _____ / _____

0	⓪ ⓪	⓪ ⓪	⓪⓪⓪⓪
1	① ①	① ①	①①①①
2	② ②	② ②	②②②②
3	③ ③	③ ③	③③③③
4	④ ④	④ ④	④④④④
5	⑤ ⑤	⑤ ⑤	⑤⑤⑤⑤
6	⑥ ⑥	⑥ ⑥	⑥⑥⑥⑥
7	⑦ ⑦	⑦ ⑦	⑦⑦⑦⑦
8	⑧ ⑧	⑧ ⑧	⑧⑧⑧⑧
9	⑨ ⑨	⑨ ⑨	⑨⑨⑨⑨

Profession type:
□ Nurse Practitioner
□ Physician
□ Physician Assistant
□ Other (please specify): _____

Your Race:
(fill in all that apply)
□ American Indian/Alaska Native
□ Asian
□ Native Hawaiian or Pacific Islander
□ Black or African American
□ White
□ Unknown
□ Other: _____

Your Ethnicity:
□ Hispanic or Latino/a
□ Not Hispanic or Latino/a
□ Unknown

Do you currently smoke tobacco products?
□ No
□ Yes
If yes, how many per week?
_____

Do you currently exercise regularly?
□ No
□ Yes
If yes, how many times per week?
_____

Current height:

_____ft.	_____ in.
0 ⓪ ⓪	⓪ ⓪
1 ① ①	① ①
2 ② ②	② ②
3 ③ ③	③ ③
4 ④ ④	④ ④
5 ⑤ ⑤	⑤ ⑤
6 ⑥ ⑥	⑥ ⑥
7 ⑦ ⑦	⑦ ⑦
8 ⑧ ⑧	⑧ ⑧
9 ⑨ ⑨	⑨ ⑨

Current weight:

_____ lbs.
0 ⓪ ⓪ ⓪
1 ① ① ①
2 ② ② ②
3 ③ ③ ③
4 ④ ④ ④
5 ⑤ ⑤ ⑤
6 ⑥ ⑥ ⑥
7 ⑦ ⑦ ⑦
8 ⑧ ⑧ ⑧
9 ⑨ ⑨ ⑨

Do you current have any chronic medical conditions?

□ No

□ Yes

If yes, please specify: _____

_____

Are there any chronic medical conditions that run in your family?

□ No

□ Yes

If yes, please specify: _____

_____

Patient Background and Contact Form

Please answer the following questions about your demographic information.

Your Gender:
□ Male
□ Female
□ Other (please specify): _____

Your Date of Birth:
Month / Day / Year
_____ / _____ / _____

0	⓪ ⓪	⓪ ⓪	⓪⓪⓪⓪
1	① ①	① ①	①①①①
2	② ②	② ②	②②②②
3	③ ③	③ ③	③③③③
4	④ ④	④ ④	④④④④
5	⑤ ⑤	⑤ ⑤	⑤⑤⑤⑤
6	⑥ ⑥	⑥ ⑥	⑥⑥⑥⑥
7	⑦ ⑦	⑦ ⑦	⑦⑦⑦⑦
8	⑧ ⑧	⑧ ⑧	⑧⑧⑧⑧
9	⑨ ⑨	⑨ ⑨	⑨⑨⑨⑨

What level of education have you completed?:
□ Some high school
□ High school graduate
□ Some college
□ Associates degree
□ Bachelors degree
□ Master degree
□ Doctoral degree

Which of the following ranges best describes your household income? (Include child support payments, disability payments, and all other sources of income)

□ $14,999 or less □ $15,000 to $29,999 □ $30,000 to $49,999

□ $50,000 to $74,999 □ $75,000 or more

What is your current occupation?
_____

Your Race:
(fill in all that apply)
□ American Indian/Alaska Native
□ Asian
□ Native Hawaiian or Pacific Islander
□ Black or African American
□ White
□ Unknown
□ Other: _____

Your Ethnicity:
□ Hispanic or Latino/a
□ Not Hispanic or Latino/a
□ Unknown

Contact Information:
Email address: _____
Phone number: _____
Preferred method for follow-up survey:
□ Email/Internet □ Phone

Treatment Practices (Knowledge Survey)

Please choose only one answer for each one of questions below

Physiology

1. Which of the following alternatives best characterizes people with obesity (BMI ≥ 30 kg/m2), compared to normal-weight individuals?
    A. A lower resting metabolic rate (RMR)
    B. Lower total energy expenditure (TEE) during physical activity given similar intensity and duration
    C. A higher TEE
    D. A decrease in carbohydrate metabolism
2. Which of the following alternatives is correct in terms of TEE and RMR?
    A. Degree of fat-free mass (FFM) is crucial for RMR
    B. RMR is not affected by gender, age or BMI (kg/m2)
    C. RMR accounts for approximately 50% of TEE in inactive individuals with obesity
    D. Exercise-induced energy expenditure accounts for approximately 50% of TEE in an inactive individual with obesity

Etiology

3. Which of the following alternatives is considered to be the main reasons for an increase in overweight and obesity?
    A. Lack of self-control
    B. Genetics
    C. Genetic predisposition in addition to inactivity and overabundance of food
    D. Increasing use of medications that can lead to weight gain
    E. Endocrine causes
4. Weight gain (WG) after a period of weight loss (WL), is one of the most profound challenges in obesity management. Which
5. of the following alternatives represents the most likely contributor?
    A. Reduction in motivation and lack of compliance
    B. Reduction in RMR and a decrease in energy expenditure related to PA
    C. Increase in hunger sensation and a decrease in satiety due to physiological adaptations to appetite control systems
    D. Combination of A+B+C

Diagnosis

6. Which diagnostic criterion regarding obesity represents the current standard?
    A. BMI (kg/m2)
    B. Presence of comorbidities
    C. Body composition (fat-free mass vs. fat mass)
    D. Amount of visceral adipose tissue (VAT)
7. When diagnosing obesity in children, which of the following tools is considered to be the best one to use?
    A. BMI curve
    B. Waist-to-hip ratio
    C. Iso-BMI curve
    D. Percentiles

8. Which of the patients would you most likely prioritize in terms of treatment for obesity?
    A. Female 38 years old, BMI 50 kg/m2, mild hypertension, knee and lower back pain
    B. Male 34 years old, BMI 35 kg/m2, diabetes type II, obstructive sleep apnea (OSAS)
    C. Female 48 years old, BMI 32 kg/m2, physically active, minor joint discomforts
    D. Male 36 years old, BMI 45 kg/m2, impaired fasting glucose, mild depression

Goals for Obesity Treatment

9. Which alternative in terms of reduction in body weight is considered to give significant improvements in health?
    A. 10–15 kg WL
    B. 5–10% WL from baseline weight
    C. A reduction in BMI category (e.g. from WHO class III to WHO class II)
    D. A reduction in waist circumference (cm) by 10%

Conservative Treatment of Obesity

10. What is considered to be the most optimal form for exercise in treating obesity?
    A. 4 × 4 high-intensity interval training (HIIT)
    B. Combined endurance and resistance exercise
    C. Resistance exercise
    D. Exercising in the moderate intensity zone/fat burning zone
11. What is considered to be the most optimal strategy for lifestyle treatment of obesity?
    A. Changing dietary habits
    B. Combination of diet and exercise
    C. Increasing physical activity levels (PALs)
    D. Cognitive behavioral therapy (CBT)
    E. Combination of diet, exercise and CBT
12. When considering long-term weight reduction, which diet is believed to be the most effective one?
    A. Low carbohydrate – high fat (LCHF)
    B. Low fat
    C. Mediterranean diet
    D. Any diet can give the same weight reduction given equal negative energy balance and long term compliance
13. Which of the following alternatives is considered to be the most appropriate recommendation when looking at conservative treatment of obesity?
    A. A negative energy deficit of approximately 600 kcal/day
    B. <20% of the energy in the diet comes from fat as a macronutrient
    C. A weight loss of >1.0 kg/week
    D. A diet very low in energy (<800 kcal/day)

Surgery (Non-Conservative Treatment of Obesity)

14. Which of the following alternatives is *the most correct one* when looking at long-term outcomes of surgical treatment of obesity (gastric bypass, GBP)?
    A. GBP improves the metabolic risk profile, but not primarily cardiovascular risk
    B. Approximately 15% of patients experience suboptimal weight loss or significant weight regain
    C. GBP does not produce a more significant WL after two years when compared to lifestyle treatment of obesity
    D. Approximately 95% of patients who undergo GBP respond well when looking at WL
15. Which of the following alternatives represents the most common complication experienced after GBP?
    A. Hypertension
    B. Dyslipidemia
    C. Low levels of vitamin B12, vitamin D, calcium, and iron
    D. Osteoporosis

Consequences of Obesity

16. Which of the following alternatives are least associated with obesity?
    A. DM2
    B. Osteoporosis
    C. Male infertility
    D. Non-alcoholic fatty liver disease (NAFLD)

Weight Loss Maintenance – Long-Term Perspective

17. Which level of physical activity is recommended for individuals with obesity in order to maintain weight loss?
    A. 30 min/day moderate intensity
    B. Short 10 min bouts with high intensity 3 times/week
    C. 45–60 min/day moderate intensity
    D. 30 min HIIT 3 times/week
18. On average, which percentage do individuals who have lost weight through lifestyle changes are able to maintain a clinically significant WL for at least 1 year?
    A. 20%
    B. <10%
    C. 30%
    D. >40%
19. Which of the following alternatives is most associated with long-term WL maintenance?
    A. A diet high in carbohydrates (≥55% of total energy intake)
    B. Exercising at high intensity > 3 times/week
    C. Eating breakfast > 5 days/week
    D. Self-weighing ≥ 1 times/month

Subjective Questions

20. Choose the alternative you *agree the most with* regarding possible reasons for you as a doctor feeling resistant to initialize treatment of obesity
    A. There is not much I can accomplish during a 10-min consultation
    B. Obesity is a very complex condition, so I prefer to focus on treating the comorbidities
    C. There are few economic incentives in promoting public health/obesity prevention, and it is difficult charging fees for suggesting simple changes in diet and exercise routines
    D. It is my duty to discuss weight issues with the patient, but long term follow-up and frequent consultations are beyond my capacity in busy surgery
    E. I believe that most patients with obesity live in denial, and few methods are effective in maintaining weight, so I give them general advice and move on
21. Choose the alternative you *agree the most with* regarding your role as a medical professional who treats patients with obesity
    A. I trust my acquired knowledge from university education and I know how to treat this patient
    B. I prefer to refer the patient to tertiary care/specialist health care services because I suggest that obesity is a self-inflicted condition and it is beyond my reach to treat
    C. I can handle treating the medical aspects of comorbidities, but not the complexity of the lifestyle issues
    D. I fear that I may create poor doctor-patient dynamics by bringing up weight and lifestyle issues. The subject of body weight is such a sensitive topic, and discussing it may make the patient reluctant to keep me as their GP

22. A fasting blood glucose greater than or equal to ____ on two (2) separate occasions confirms the diagnosis of diabetes.
    A. 100
    B. 121
    C. 126
    D. 130
23. According to the Ault Treatment Panel II, the LDL coal in diabetics *without* known heart disease should be less than _____.
    A. 70
    B. 100
    C. 150
    D. 90
24. According to the American Diabetes Association (ADA), target blood pressure for people with diabetes is:
    A. Less than 130/80
    B. Less than 140/90
    C. Less than 120/80
    D. None of the above

25. Which oral anti-diabetic agent is *absolutely* contraindicated in renal insufficiency?
    A. Glyburide
    B. Rosiglitazone
    C. Prandin
    D. Metformin
26. A diabetic patient on glipizide, rosiglitazone and Novalin 70/30 insulin develops CHF. Which agent should be discontinued?
    A. Novalin 70/30
    B. Rosiglitazone
    C. Glipizide
    D. None – they are all OK to continue
27. The longest acting insulins are:
    A. Lantus (glargine) and Levemir (detemir)
    B. Novaline 70/30
    C. NPH
    D. Novolog (aspart) and Humalog (lispro)
28. What is the peak time of action of regular insulin?
    A. 30 minutes
    B. 1 hour
    C. 2-4 hours
    D. 6 hours
29. Novalin 70/30 insulin is 70% _____ and 30% _____.
    A. NPH and regular
    B. Regular and NPH
    C. Lantus (glargine) and Novolog (aspart)
    D. Novolog (aspart) and Lantus (glargine)
30. Precipitating factors that can cause diabetic ketoacidosis (DKA):
    A. Insulin omitted to avoid hypoglycemia, especially when home along or during active work days
    B. Insulin dose reduced or omitted when ill
    C. Using insulin that is outdated, improperly stored, inaccurately measured, or incorrectly injected
    D. All of the above
31. An asymptomatic, alert patient who is able to eat is found with a blood glucose of 35 mg/dL. What is the best treatment approach?
    A. Fruit juice or glucose tablets
    B. Peanut butter sandwhich
    C. 1 amp D50
    D. Skim milk and graham crackers
32. A patient is on Novolin 70/30 and is prescribed 40 units twice a day. The first dose is given in the morning. When should the patient administer the second dose?
    A. At lunch
    B. At dinner
    C. At bedtime
    D. Whenever he/she remembers to take it

33. One reason sliding scale insulin administration is less desirable as a pattern management approach is:
    A. It is based on a patient's current weight
    B. It varies according to the patient's food intake
    C. It may contribute to rapid shifts in glucose levels
    D. It may confuse patients trying to remember amounts of insulin to administer
34. Hyperglycemia is a good index of the severity of DKA
    A. True
    B. False
35. Sliding scale insulin is the single best option of management of diabetes
    A. True
    B. False
36. Pattern management is a useful tool in managing diabetes. The items one would review are: a blood glucose review book, food types, quantity and timing, physical activity, and events that could affect blood glucose levels.
    A. True
    B. False
37. Adults with type 1 diabetes are also prone to other autoimmune disorders such as
    A. Graves disease
    B. Hashimoto thyroiditis
    C. Addision disease
    D. Celiac sprue
    E. All of the above
38. Using beta-blockers in people with diabetes can potentially mask the symptom of hypoglycemic-induced tachycardia.
    A. True
    B. False
39. What is the recommended dose of glucagon in adults having a severe hypoglycemic episode?
    A. 1 mg SC/IM and repeat in 15 minutes if needed
    B. 0.5 mg SC/IM and repeat in 15 minutes if needed
    C. 5 mg IV and repeat in 15 minutes if needed
    D. Glucagon is not used to treat severe hypoglycemia
40. Glucagon is a hormone that stimulates hepatic production of glucose. It will produce transient hyperglycemia. Once the patient is able to swallow, he/she will need to ingest carbohydrates to prevent another hypoglycemic episode.
    A. True
    B. False
41. What is the Somogiy Phenomenon?
    A. A typhoon
    B. An exaggerated counter-regulatory response following a late night hypoglycemic episode
    C. Low blood glucose in the morning, hours before breakfast
    D. Unexplained blood glucose elevations throughout the day

Acceptability Survey

Please rate each statement based on your experience with the app you completed during your visit today.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1	2	3	4	5

1. This app was a good way to spend my time in the waiting room	1	2	3	4	5
2. I was able to use the app without any problems	1	2	3	4	5
3. I worry about the confidentiality of using the app	1	2	3	4	5
4. Interacting with the app was clear and easy	1	2	3	4	5
5. I didn't mind completing the app while I was waiting for my healthcare professional	1	2	3	4	5
6. The information in the app was relevant for me	1	2	3	4	5
7. The app took too much time to complete	1	2	3	4	5
8. I did not find the information in the app to be helpful for me	1	2	3	4	5

Please provide any comments or feedback you have about the app you completed:

_____
_____
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Patient Empowerment Survey

Please rate each statement based on how you feel about your healthcare *in general:*

Strongly Disagree 1	Disagree 2	Neither Agree nor Disagree 3	Agree 4	Strongly Agree 5

1. I know enough about my current health	1	2	3	4	5
2. I have all the knowledge I need to be healthy	1	2	3	4	5
3. I would feel able to refuse a recommendation made by my healthcare professional about my health or treatment	1	2	3	4	5
4. I find it difficult to ask my healthcare professional questions about my health or current treatment	1	2	3	4	5
5. I know how to control my health	1	2	3	4	5
6. I participate in decisions concerning my healthcare	1	2	3	4	5
7. I am confident in choosing among different treatment options related to my health with my healthcare professional	1	2	3	4	5
8. When given test results, I know what they mean	1	2	3	4	5
9. I can talk to my doctor if I change my mind about healthcare treatment	1	2	3	4	5

Please rate each statement based on how you feel about your healthcare *during today's visit:*

Strongly Disagree 1	Disagree 2	Neither Agree nor Disagree 3	Agree 4	Strongly Agree 5

1. I was able to ask my healthcare professional all of my questions today	1	2	3	4	5
2. I received good recommendations from my healthcare professional today	1	2	3	4	5
3. I wish my healthcare professional had more time to spend on my concerns today	1	2	3	4	5
4. My healthcare professional was more in control of today's visit than I was	1	2	3	4	5
5. There was something I wanted to talk to my healthcare professional about today that I didn't have a chance to bring up	1	2	3	4	5

Rathus Assertiveness Schedule

Directions: Indicate how characteristic or descriptive each of the following statements is of you, using the following scale:

+3 very characteristic of me, extremely descriptive
+2 rather characteristic of me, relatively descriptive
+1 somewhat characteristic of me, slightly descriptive
-1 somewhat uncharacteristic of me, slightly nondescriptive
-2 rather uncharacteristic of me, relatively nondescriptive
-3 very uncharacteristic of me, extremely nondescriptive

	1. Most people seem to be more aggressive and assertive than I am
	2. I have hesitated to make or accept dates because of shyness
	3. When the food served at a restaurant is not done to my satisfaction I complain about it to the waiter or waitress
	4. I am careful to avoid hurting other people's feelings, even when I feel that I have been injured
	5. If a salesman has gone to considerable trouble to show me merchandise which is not quite suitable, I have a difficult time saying "no"
	6. When I am asked to do something, I insist upon knowing why
	7. There are times when I look for a good argument
	8. I strive to get ahead as well as most people in my situation
	9. To be honest, people often take advantage of me
	10. I enjoy starting conversations with new acquaintances and strangers
	11. I often don't know what to say to attractive persons
	12. I will hesitate to make phone calls
	13. I would rather apply for a job or for admission to a college online than by going through with personal interviews
	14. I find it embarrassing to return merchandise
	15. If a close a respected relative were annoying me, I would smother my feelings rather than express my annoyance
	16. I have avoided asking questions for fear of sounding stupid
	17. During an argument, I am sometimes afraid that I will get so upset that I will

	shake all over
	18. If a famed and respected lecturer makes a statement which I think is incorrect, I will have the audience hear my point of view as well
	19. I avoid arguing over prices with clerks and salesmen
	20. When I have done something important or worthwhile, I manage to let others know about it
	21. I am open and frank about my feelings
	22. If someone has been spreading false and bad stories about me, I talk about it with them as soon as possible
	23. I often have a hard time saying “no”
	24. I tend to bottle up my emotions rather than making a scene
	25. I complain about poor service in a restaurant and elsewhere
	26. When I am given a compliment, I sometimes don’t know what to say
	27. If a couple near me in a theater were conversing loudly, I would ask them to be quiet or to talk their conversation elsewhere
	28. Anyone attempting to push ahead of me in a line is in for a good battle
	29. I am quick to express an opinion
	30. There are times when I just can’t say anything