Creating an Interactive Aid to Mediate Obesity Diagnoses and Management Through Visualization

BY

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LIST OF ABBREVIATIONS

WHO	World Health Organization
CDC	Center for Disease Control and Prevention
AMA	American Medical Association
BMI	Body Mass Index
PCP	Primary Care Physician
UI/UX	User Interface and User Experience
iOS	Internetwork Operating System
UIC	University of Illinois at Chicago

SUMMARY

This study was conducted to understand and develop an app made to elucidate nutrition, exercise, and obesity knowledge to a patient population with obesity. This study was conducted in two phases to maximize opportunities for iterative design, prototyping, and usability testing.

Phase 1 was conducted in the Cardiac Rehabilitation Center at the University of Illinois at Chicago. Five healthcare providers were recruited to recount their experiences with the patient population at the Cardiac Rehabilitation Center, the Bariatric Surgery Center, as well as overweight and obese individuals. They were also asked to test and provide feedback on paper prototypes of the app. In Phase 2, the app, called MyWellness, was developed in Unity. Two patients from the Cardiac Rehabilitation Center were recruited to test the app. A pre-test of nutrition and exercise knowledge was administered at time of recruitment, followed by a week-long trial period of the app (or a paper handout for the control group). A post-test was administered a week from the date of the pre-test. Results from Phase 1 were vital in making design, content, and functionality decisions for the final version of the app. Feedback from the experts was vital in testing usability from the perspective of individuals that have worked with the patient population.

Data collected during the pre- and post- tests were inconclusive that the treatment was more effective at delivering nutrition, exercise, and obesity information. While there were some results that indicated that patients were more comfortable talking with their health care providers and more comfortable with their nutrition, there was not enough data to draw conclusions. However, qualitative data from patient and healthcare feedback in both phases contributes significantly to biomedical visualization and healthcare in increasing the knowledge base

surrounding design and content of healthcare apps. This study also strongly supports the importance of iterative design and prototyping in user-centered interactive design.

I. INTRODUCTION

A. Overview of research problem

Internationally, obesity is a detrimental condition that is becoming increasingly prevalent in people of all ages. As of July 2017, the United States has the highest obese population in the world and these rates are rapidly and consistently increasing (World, 2017). Moreover, the rise in obesity has caused the national cost of healthcare in the US has increased by approximately $147 billion. According to the World Health Organization (WHO), obesity is defined as "abnormal or excessive fat accumulation that may impair health" (Obesity, 2018). However, general health impairment is not the only detrimental effect; obesity is also associated with numerous additional comorbidities. Complications arising from obesity include diseases such as type 2 diabetes, cardiovascular disease, and cancer (Overweight, 2017). According to data from the Center for Disease Control and Prevention (CDC) approximately 36% of American adults had been diagnosed with obesity as of 2014, and that number is only continuing to rise (Ogden, 2015). In 2012, the American Medical Association (AMA) declared obesity a disease (Funk, 2016) with the intention of having more treatments covered with insurance and increasing perception of the seriousness of this condition. However, physicians still fail to correctly diagnose patients with obesity and to give them the necessary information to manage the condition appropriately.

The results of a study titled "Impact of Physician BMI on Obesity Care and Beliefs" show that only 20% of patients diagnosed with obesity receive guidance from their doctors on potential changes to nutrition and lifestyle (Bleich, 2011). Additional studies also show that physicians are more likely to give their patients only exercise counseling rather than accompanying diet counseling, although research demonstrates that diet and exercise together have a much greater impact on weight loss and overall health than exercise alone (Foster-Schubert, 2011). Because of

this evident lack of information, patients may not have the tools they need to take steps towards managing their weight and lifestyle.

This study aimed to develop a mobile application for a lay audience that focuses on the science behind obesity and the potential health consequences of the condition. The app provides users with nutrition and lifestyle management help to address their condition. There are mobile apps that currently exist for weight loss that deal with nutrition and lifestyle management, but they lack a key motivating factor for obesity patients: the health implications of weight loss, lifestyle change and the consequences of no change (Davis, 2018). Although there are many publicly available resources that address these health implications, they are often written at a much higher reading level than that of the average population, making them unfit for these patients to use as their primary sources of information (David, 1994). This study aimed to solve both problems by designing an app for obesity-diagnosed patients that incorporates visual and interactive features that have been shown to most successfully influence users.

B. Significance of the problem

Since physicians do not often give advice on both diet and exercise (Foster-Schubert, 2011), patients with obesity are left with inadequate knowledge of the different ways to manage their nutrition and lifestyle. This gap in knowledge is highly problematic, leaving patients overwhelmed and unaware of the preliminary steps towards treating this ever-growing disease. Additionally, most nutrition and health-related information (on the internet and/or in print form) is usually written at least at a tenth-grade reading level (David, 1994). Given that most Americans can only comprehend about sixth to eighth grade level reading materials (Walsh, 2008), this inconsistency can force patients to feel helpless and uncomfortable about healthcare, creating a lack of understanding that can lead to other life-threatening conditions. In order to

begin solving this problem, efforts must be made to offer more accessible and easy-to-understand healthcare information. One way of beginning this process is ensure that all patients diagnosed with obesity have access to the following information:

- The importance of their diagnosis
- Preliminary nutrition and lifestyle guidelines
- A list of resources for further inquiry about management and counseling

By making this information easily understandable and accessible, patients diagnosed with obesity can be better informed about their own health and have the confidence to make educated lifestyle and nutrition decisions to manage their weight and related health issues.

II. LITERATURE REVIEW

A. Obesity and the societal epidemic

Obesity is a disease characterized by excessive weight. It is usually diagnosed by looking at various factors, the most common being body mass index (BMI). BMI is a measurement that compares a person's height to their weight (kilograms to meters) to define a general proportion indicating body composition. According to the 2013 Obesity Guidelines normal BMI is in the range of 18.5 to 24.9, whereas a BMI in the range of 25 to 29.9 is considered overweight (Jensen, 2013). There are three classes of obesity that are determined by an individual's BMI: Class I from 30 to 35; Class II from 35 to 40; and Class III above 40 (Obesity, 2018). Obesity is also characterized by excessive visceral fat, which can be measured by waist circumference. While obesity is an issue of excessive fat, it has many more health implications than simply a negative body image. It is known to be a cause for cardiovascular disease, type 2 diabetes, and even some types of cancers (Obesity, 2018). Over the past two decades, obesity has been steadily on the rise, and currently one out of every three Americans has been diagnosed as obese or overweight.

Within this population, the disease can impact millions through physical and psychological ramifications. In addition to these innumerable personal consequences, obesity has a negative impact on the economy as well. It has been estimated that obesity increases healthcare costs by over $147 billion (Overweight, 2017). In 2012, the AMA declared obesity a disease in order to make it more accessible for treatment (Funk, 2016). Obesity's classification as a disease was meant to open up more avenues for insurance companies to fund treatments and to motivate patients to take their condition more seriously and seek help (Funk, 2016).

While this disease is widely recognized as problematic, an unexpected additional factor has

recently been brought to the social spotlight, complicating solutions towards this national problem. Social and societal backlash against "fat shaming" has opened new avenues for discussion. Fat shaming is described as a societal prejudice against those who are overweight or obese, exemplified through a lack of representation in clothing stores, commercials, and modern media. The term is often also used to describe the incessant encouragement of an individual to lose weight without the context of their own history, preferences, or lifestyles**.** In a study done at the University of California in Santa Barbara, students who were overweight or obese were sent an email offering them a free fitness and nutrition program (Robinson, 2018). This email was met with criticism by many students that felt it was an example of "fat shaming." Though the email only employed traditional health promotion tactics, "targeting a specific group of people about a specific solvable problem" (Robinson), it was considered a problematic vocalization of opinions towards only these obese students without considering their individual backgrounds or needs. This incident sheds light on the larger problem of physician-topic intimidation, or the risk of making a patient feel discriminated against by addressing the health issues associated with weight or obesity, regardless of the physician's knowledge of the vital personal factors of the patient's health, their current condition, and their past medical history. Many physicians face this issue when they confront patients with obesity.

It is also important to note that in a recent National ACTION Study, only 54% of patients diagnosed with obesity felt that their excess weight could lead to future health complications (Kaplan, 2017). This means that fewer than half of patients diagnosed with obesity are actively involved in their weight management. Patients who are not actively involved in the issue at hand, in this case the health complications from their excess weight, are more likely to be receptive to more positive messages rather than loss-framed messages (Rothman, 2016). A loss-framed

message is one in which subjects are told how much they would lose as a consequence of a certain decision, whereas a gain-framed message emphasizes why making a certain decision could offer positive outcomes. This same study found that when promoting prevention behaviors (such as exercise for overweight and obese populations), gain-framed messages are also more effective (Rothman). While both of these statements lead to the conclusion that healthy lifestyle promotion materials should be presented in gain-framed messages, physicians and health care providers consistently approach most messaging in a loss-framed manner (Rothman).

Given these findings, it can be inferred that approaching health promotion in a loss-based framework could lead to negative responses from those receiving it. In this case, if patients are unaware of potential health consequences of obesity, they could feel "fat shamed" because of loss-framed disease prevention messaging targeted towards those people with excess weight. However, it is important to make a distinction here between "fat shaming," which causes negative body image and feelings of helplessness, and a medical diagnosis, that aims to help and empower the patient to be in control of their health. Messaging must be approached in an appropriate manner, and gain-framed messages may reduce the likelihood of a medical diagnosis being misinterpreted as fat shaming.

B. Diagnosis and treatment of obesity

Generally, a patient is diagnosed as obese by their primary care physician (PCP) unless they see other specialists for extenuating health problems (Starfield, 2005). Patients with obesity often have other comorbidities that can be even more life threatening (Overweight, 2017). To address these issues, they are often advised by their primary care physicians to see specialists (C. Ozemek, personal communication, May 24, 2018). For example, a patient with high risk factors such as a history of heart attack, or a patient exhibiting cardiovascular complications such as

heart failure, will often be referred to a cardiovascular specialist by their PCP. After these comorbidities are treated, patients are advised to go to rehabilitation centers to help their healing process. One such program is the Cardiac Rehabilitation Center at the University of Illinois at Chicago (UIC). This center sees patients that either have a history of heart attacks or have undergone serious procedures regarding their cardiac health such as a heart transplant or valve replacement. Approximately 75% of the patient population in this clinic is either overweight or obese, since cardiac health impact is such a common comorbidity of obesity (C. Ozemek, personal communication, May 24, 2018).

A patient's first visit to the UIC clinic consists of an initial assessment and a discussion about ways the patient can improve their cardiac health through exercise and lifestyle management. When leaving their initial visit, patients receive home exercise prescriptions, including a list of exercises to perform and the frequency and intensity with which to perform them. In addition to home exercises, patients also have one-hour sessions at the clinic three times a week. During these sessions, they perform aerobic exercises and continue to discuss nutrition and lifestyle guidance with the facilitators of the clinic. They remain in this program for a total of 12 weeks.

Though this timeline of obesity diagnosis and specialist treatment is common in US healthcare, there are still many physicians who fail to even inform their patients of their obesity diagnosis. A study titled "The prevalence of obesity documentation in primary care electronic medical records" demonstrated that only about 11% of patients that fall under the BMI range for obesity are made aware of their own diagnosis (Mattar, 2017). This study also showed that physicians were more likely to diagnose only patients who had morbid obesity (class III obesity) than those with a lower level of obesity (Mattar, 2017). Furthermore, in a study conducted at Johns Hopkins University, researchers found that only a third of patients with obesity are

actually diagnosed as obese (Bleich, 2011). Because failure to diagnose patients with obesity directly hinders the patients' abilities to take steps towards treatment, it is imperative that physicians are given the tools and confidence to accurately diagnose patients with obesity and inform them of this diagnosis. Bleich also found that while a third of patients with obesity were diagnosed, only 17% were given weight reduction counseling, only 20% exercise counseling, and 25% dietary counseling (Bleich). This shows that while diagnosis rates are low, weight-specific counseling rates do not even match the number of people diagnosed. In fact, in the National ACTION Study, researchers found that only 38% of patients diagnosed with obesity discussed a weight loss plan with their physician (Kaplan, 2017). This major lack of professional advice is problematic because weight loss is a direct and immediate management tool for obesity (Carvajal, 2013). Neglecting to talk about weight loss directly hinders a patient's ability to manage their obesity.

C. Nutrition and Health Literacy

In the United States, literacy of the general population is surprisingly low. The average reading level of Americans is at the 6th to 8th grade level (Walsh, 2008). While this is an alarming statistic, there are far worse implications than just the state of our education system. Scientific and health material is often written at a 10th grade reading level at minimum (David, 1994). Although this is not a significant literacy gap, the result is that many Americans are not aware of basic health information and have what is referred to as low health literacy.

Furthermore, most Americans see only one healthcare provider regularly, if that (Starfield, 2005). This healthcare provider is usually the patient's primary care physician. Unfortunately, medical school education today does not provide students sufficient nutrition education to be able to confidently handle giving dietary guidance to their future patients. In fact, between 2004

and 2010, the percentage of medical schools that offered a dedicated nutrition course decreased, as did the contact hours of nutrition instruction (Adams, 2010). Additionally, most physicians' offices are not staffed with dieticians or nutritionists for patients to discuss their own lifestyle choices and future nutritional management options (Asselin, 2016).

In a study done by Petrin in 2015 that examined physicians' and patients' interactions in discussions about weight management, results confirmed that many physicians do not diagnose their overweight or obese patients as such. The study also showed that even if the rates of diagnosis were accurate, it would be difficult for the two groups to have a fruitful talk about their treatment, as the results stated that most physicians do not have the expertise and appropriate language bank to talk about the issue (Petrin, 2015). Without a strategic approach to this topic, physicians risk negative impacts on patients that could result further stigmatizing their condition and shaming them (Petrin 2015).

Consequently, Americans do not receive the necessary amount of nutrition education or guidance to confidently and appropriately manage their dietary lifestyles. While it is important for everyone to have a baseline level of nutrition knowledge, this gap in education can end in life-threatening future health issues for some.

D. Comfort level and motivation of patient

Comfort, as a verb, is defined as "to give hope to" a population (Merriam-Webster, n.d.). According to a study, patients who heard medical terms in discussions with their healthcare providers were more comfortable with their diagnosis than patients who heard euphemisms from them. When hearing medical terms instead of euphemisms, patients in one study were more likely to feel that their condition was not their fault and that they could seek help for their condition and future outcomes. Therefore, they did not feel the helplessness often faced by other

patients when considering management plans and options (Ogden, 2017).

In a 2015 study, obesity-related risk factors, such as high blood pressure and high cholesterol, were managed specifically using medication (Ogden 2015). After patients saw improvements in these risk factors, they were more motivated to lose weight than patients that did not see improvements because they had a better understanding of their weight problem. Additionally, these patients may have been more motivated to lose weight since they had already seen progress in other areas of their health as a result of their medications. It is possible these individuals were motivated or inspired to continue making progress after reaching this initial goal, encouraged by concrete evidence of their efforts or initiatives taking effect. The achievement of multiple smaller goals in order to reach a larger goal is commonly known as scaffolding. This principle is used in a variety of educational or task-based fields and is primarily used to build confidence and motivation by breaking a larger goal into smaller chunks and providing acknowledgement throughout the process. In teaching, the term "task scaffolding" is referred to as the practice of teachers progressively giving students larger tasks and more responsibilities with support at each step of the way (Allen, n.d.). Using this approach to motivate and empower obesity patients could be useful as comfort and confidence are necessary building blocks for making progress.

E. Current Applications

There has been much effort put into creating health, weight loss, and exercise software applications, or *apps*. There were over 325,000 health apps on the Android app store as of 2017 (325000 Mobile Health Apps, 2017). Unfortunately, a drawback of many of these apps is that they do not explain the reasoning behind the "work" being done, whether it is exercise or diet. The apps tend to assume that their user population is knowledgeable enough to know the

importance behind the tasks (Davis, 2018). However, in the case of populations with obesity, it is important to note that most patients, if not all, are already aware of the fact that they have more weight than most other people. The key difference is that losing weight may not yet be a priority because the patients are not aware of the other highly potential negative health consequences.

Mobile apps can be appropriate for distributing scientific facts as a way of providing engagement and interactivity with complex material. It has already been shown that apps are effective in aiding people to make better lifestyle choices (Turner-McGrievy, 2013). In a 2013 study, patients were put into groups according to whether they used self-monitoring apps, and which app they used if any (Turner-McGrievy, 2013). Results from this study indicated that those monitoring physical activity by using some kind of app reported performing more physical activity than those not using an app (Turner-McGrievy, 2013). Additionally, those using an app to monitor their diet consumed significantly fewer calories than those that were not using an app (Turner-McGrievy, 2013). This study found that a mobile app's interactivity and malleability allowed patients to continuously refer back to prior information as their needs changed (Turner-McGrievy, 2013).

Currently, existing apps for weight loss and lifestyle change are missing a number of key components. Apps that attempt to highly motivate the user tend to not have sufficient scientific information that addresses reasons for use and the seriousness of this issue (Krebs, 2015). One possible reason could be that it is difficult to consolidate scientific information into lay terms, resulting in loss of interest in reading the information. Another important consideration is data entry and privacy breeches. Many consumers are reluctant to input their personal data into apps because they are worried that their privacy will be breeched (Krebs, 2015). To counteract this weariness, app developers have limited data input into the app, resulting in a less effective app

(Krebs, 2015).

Through an app's interactivity, without sacrificing motivational interaction and design mechanics, patients can learn in lay terms: what their diagnosis means; why it is important; and exactly how losing weight and exercising will positively affect their bodies.

F. App Development

After understanding and defining the purpose and techniques of the user experience, the first step in designing an app is to make a wireframe that shows how the app will function according to the user. Wireframing, a technique in User Interface/User Experience (UI/UX) design, ensures that the flow of the app is intuitive, performs the tasks users want it to, and does not require an excessive amount of navigation to perform those tasks. In order to test whether navigation is easy and intuitive for users, the next step to making an app is to create a low fidelity prototype. According to the Usability First Glossary, a low fidelity prototype is a prototype that is simple but conveys enough of the functionality of the deliverable so that users can grasp the concepts (Glossary, n.d.). Low fidelity prototypes must be simple and easily editable to allow for flexibility and critique. Though these protypes are modest, they allow for the testing of broader concepts and usability of the app and can be easily modified to test (Virzi, 1989).

After many of the larger concepts have been solidified, the next step in app development is the creation of a high-fidelity prototype. A high-fidelity prototype allows the user to experience the look and feel of the app as well as test the functionality. At this stage, it is also crucial to test whether the look and feel of the tool is appropriate to the content and the audience. Aspects of the look and feel of an app include but are not limited to colors, graphic elements, images, and word choice. Revisions to both the low fidelity and high-fidelity prototypes are unlimited and are meant to continuously improve the app and ensure it meets its goals for the

user. This looped process of developing, testing, and refining is referred to as *iterative design* (Nielson, 1993)**.**

There has been extensive research on color psychology and color choices for use in specific settings. One book discussing the topic is *Color Voodoo: A Guide to Color Symbolism* by Jill Morton (Morton, 1997). Morton discusses the fact that materials viewed on a screen, such as online materials or apps, will use RGB (red/green/blue) color, and these colors will appear differently on different monitors or screen types (Morton, 1997). A way to correct for these differences is by using a 216-color web-safe palette. A digital color palette refers to the set of colors that a certain device is able to display. A web safe color palette refers to a set of colors that will display consistently over the entire web space and in different browsers (What is a Color Palette, n.d.). Even though this research involves a mobile app, a web safe color palette would be safe to use (Morton, 1997). iPhone models (version 6.0 and above) can display a full sRGB color palette (Soneira, 2014), and most other phones smart phones can do the same.

As well as the digital manifestation of color, *Color Voodoo* reviews the ways in which different colors are viewed in different contexts and in different cultures (Morton, 1997). For example, green is often viewed as nourishing, healthy, and fresh (Morton, 1997). Because of these strongly positive associations, green and its corresponding hues and tones could be appropriate for health and fitness applications. Blue is generally perceived as calming, trustworthy, and clean (Morton, 1997). Orange is often perceived as energetic, cheerful, and friendly (Morton, 1997). These are all positive emotions that one would hope to invoke from a health and wellness app. Within these three color groups, there are also many different variations of value and hue that should be considered (Morton, 1997).

In addition to the look and feel of an app, the wording utilized in an app and they style of

type should also be carefully chosen. As mentioned earlier, the average literacy level of the American population is 6th to 8th grade (Walsh, 2008), and word choice of the text content within apps for a general population should reflect that audience need. Additionally, some of the patient populations with obesity diagnoses are older and therefore may have poorer eyesight. Because of this, apps targeting this population should use an adequately large font size, and there should be an effective balance between images, graphic elements, and words. According to Apple's Human Interface Guidelines for iOS, the default setting for an app is the Large type face setting (Glossary, n.d.). The suggested sizes for all the sections are listed in the table below:

Style	Weight	Size (Points)	Leading (Points)
Large Title	Regular	34	41
Title 1	Regular	28	34
Title 2	Regular	22	28
Title 3	Regular	20	25
Headline	Semibold	17	22
Body	Regular	17	22
Callout	Regular	16	21
Subhead	Regular	15	20
Footnote	Regular	13	18
Caption 1	Regular	12	16
Caption 2	Regular	11	13

Table 1. Adapted from "Font sizes for mobile apps" (Glossary, n.d.). Table shows recommended font sizes for different types of text for an app.

G. Gamification

As well as adding technical features important to an app's functional purpose, another aspect of app development is ensuring it offers a purpose and drive to its users through motivational and

interface-level techniques. If the use of an app is prescribed by a physician from the Cardiac Rehab Program, a patient's motivation for its use would be simply to fulfill their prescribed task. Generally, a non-pharmaceutical prescription involves a task that patients "have" to fulfill but is not necessarily something the patients want to do or would find enjoyable. In recent years, there has been much research about making required tasks enjoyable so that people want to do them. One way to achieve this is through *gamification*. According to Yu-Kai Chou, a pioneer in the field, gamification is "the act of making something game-like" in order to make "existing tasks more intriguing, motivating, and even 'fun'" (Chou, 2017, pg. 6). Gamification is often a major component of design in the development of online games and mobile games for general audiences (*Gamification)*. To gamify an app, one must carefully design incentives to draw users into the game and nurture the driving factors to maintain them.

Gamification is also becoming increasingly popular in dealing with real world health issues. Game designer Jane McGonigal has made immense leaps in this field. The most famous game she has developed is *SuperBetter,* in which users "tackle challenges like depression, anxiety, insomnia, chronic pain and traumatic brain injury" (McGonigal, n.d.). In a study done at the University of Pennsylvania, this game was found to be very effective as it reduced six symptoms of depression in six weeks (McGonigal, n.d., p. 6). In another randomized control study, the standard *SuperBetter* game was tested against a *SuperBetter* game designed specifically to target depression (Roepke et al., 2015). Results for both games were similar in that the subjects had significantly decreased symptoms of depression than those of the control group (who did not play the game) (Roepke et al., 2015).

Gamification is powerful because it uses "principles that optimize for human motivation" (Chou, 2017, p. 20). Essentially, this means that these games strategically implement tactics that

play on what motivates the user, such as the rush one feels from overcoming a difficult task, or the joy of "beginner's luck." In order to develop games that use this way of thinking, it is important for the developer to have that mindset from the very conception of the game. Chou says that the very first thought a game developer should have in their head is what emotion they want to incite in the user, as opposed to what types of features they want to have in the app (2017). In this case, the app should ideally incite hope, motivation, and comfort in obesity patients in order for it to be successful.

Different games have used different motivations behind keeping users engaged. Yu-Kai Chou calls these different motivations '*core drives'* (2017). He has broken down this idea to a science to create a tool to help other app and game developers make better games using gamification concepts (Chou, 2017). Chou's tool boils down motivational factors for humans into eight specific core drives that can be grouped together according to their characteristics (2017).

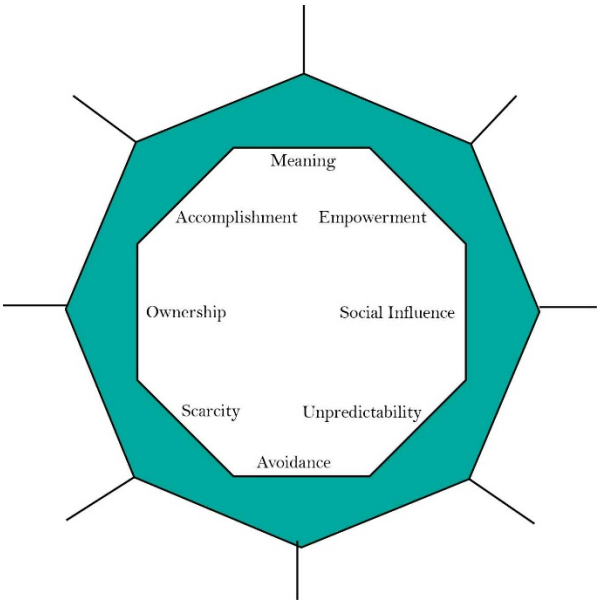

Figure 1. Adapted from A Gamification Design Framework for Everyone. Chou, Y. (2017, p. 23). *Actionable Gamification: Beyond points, badges, and leaderboards*. Milipitas, CA: Octalysis Media. This figure outlines the eight core drives of Octalysis in a basic way. More detailed layers of Octalysis build upon this framework.

The words in the middle of Octalysis are the eight core drives, which are:

1) Epic Meaning and Calling
2) Development and Accomplishment
3) Empowerment of Creativity and Feedback
4) Ownership and Leadership
5) Social Influence and Relatedness
6) Scarcity and Impatience
7) Unpredictability and Curiosity

8) Loss and Avoidance (Chou, 2017, p. 25-28)

Chou also mentions a ninth core drive called Sensation, which is pleasure through senses (2017).

Most successful games utilize at least one, if not most, of these concepts. The core drives can be further grouped into categories such as intrinsic and extrinsic drives (Chou, 2017). Intrinsic drives are those that are rewarding by nature, such as using one's creativity to make something new, or solving a complicated problem (Chou, 2017). Extrinsic drives are those that are driven by forces outside of you such as winning points or money when a task is completed or being socially validated for tasks done such as on social media (Chou, 2017). Other categories that these eight core drives can be grouped into are black hat gaming vs. white hat gaming (Chou, 2017). Black hat gaming is a method in which the motivating factor behind playing a game is the fear of losing something, or a certain obsession or addiction to playing that game (Chou, 2017). This is not necessarily a bad game design strategy because this is a motivator that people use in the real world to achieve results in areas of lifestyle modification (Chou, 2017). On the other hand, white hat gaming employs tactics that make users feel better about themselves after they play, in turn causing them to want to play the game more (Chou, 2017). Because there is no proven "best" way to create games, mixing and matching in all of these categories has great potential.

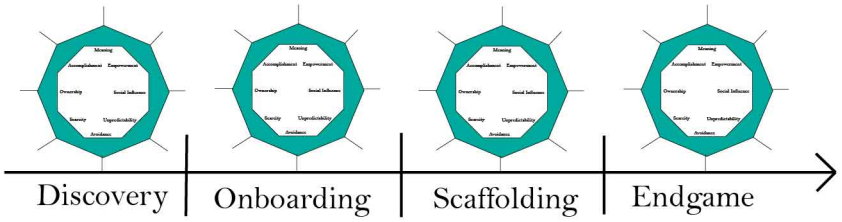

Figure 2. Adapted from Level II Octalysis: Factoring in the 4 Phases of a Player's Journey. Chou, Y. (2017. p. 40). *Actionable gamification: Beyond points, badges, and leaderboards*. Milipitas, CA: Octalysis Media.

Chou writes about the importance of combining of all four of these subcategories (extrinsic and intrinsic factors, and black hat and white hat gaming) to create a successful game that keeps users engaged (2017). However, Chou mentions a common error that game developers make when developing a game: "Most people treat their product as one experience" (Chou, 2017, pg. 18). It is important to note that a user's relationship with a game changes over the period of time that they play it. According to Chou, there are four distinct stages in a user/game relationship and during each of them, the roles that both the user and the game play are distinct (2017). Figure 2 demonstrates the four stages of a user's experience that are important for the developer to keep in mind.

The *discovery* phase of the user experience is the period of time during which users discover and try a new game (Chou, 2017). During this phase, the role of the app is to keep the user engaged and excited to find out what the new features are and to venture into the unknown

(Chou, 2017). It is also important that the game stimulate Core Drive #2, development and accomplishment, and make the user feel like they are 'good at' the game so that they continue to use it (Chou, 2017). For this project, the discovery phase would begin as patients are introduced to the app by their healthcare providers, and would continue as they peruse through the app and learn more about it.

As users continue to use a game, they move into the *onboarding* phase. This phase is one in which the user acquires a better grasp of the features of the game features and are enticed by components such as rewards and surprises. For this project, these features included daily log-in rewards and unlocking health facts.

The third phase is the *scaffolding* phase in which players would begin to comprehend and engage in higher goals in the game such as accomplishing challenges they cannot reach yet, but can reach eventually with ongoing commitment to smaller tasks. The higher goals with the app made for this project were health and fitness related since reaching them would give users more points. Finally, during the *endgame* phase players play primarily to maintain their achievements during the time they have played. At this phase, they have put enough time and effort into the game that stopping would result in a greater loss. This most closely aligns with Core Drive #8, loss and avoidance (Chou, 2017).

While there are five levels of Octalysis, incorporating only these two levels into app development is useful in keeping users engaged with an app (Chou, 2017). These methods for acquiring user engagement have been shown to lead to higher success rates of the app. Consequently, not only would users of the app developed for this research adhere to these "prescriptions" better, they would have greater potential for successful weight loss. This is because it would ensure users are engaged in the app for more reasons than simply their

healthcare provider telling them to do their exercises or eat healthy meals.

H. Specific functionality of app

In order to motivate the user and to add interest to the experience, there are certain necessary functions an app must incorporate. One of the Core Drives from Octalysis is ownership and possession (Chou, 2017). In order to make a user feel like the app is really theirs, they must be able to customize it in some capacity. Customizing an app could involve simply changing the colors and text size, or incorporating the ability for the user to interact with something customizable on the app. For example, research has shown that employing avatars in online games and learning tools improves player's sense of belonging, social presence, and investment in the learning (Annetta 2008). There are many different styles of avatars with varying levels of life-likeness. While it may seem that the more life-like the avatar is, the more a user will relate to it and thus be more engaged, studies have shown that preferences differ between ages (Rice 2013). In fact, one study shows that adults seem to prefer more cartoon-like characters with bright colors rather than silhouetted, or even life-like characters (Rice, 2013).

I. Research gap

Though much research has been done to investigate the medical prevalence of obesity, the causes, impacts, and comorbidities of obesity, and the use of interactive media for lifestyle change, little research has been done regarding the appropriate combination of these topics. Current patient education materials also fail to combine health information with health management guidelines in patient materials, and many existing apps do not have elements of gamification proven to keep the user engaged (Lister et al., 2014).

This study addressed these shortcomings in current techniques on nutrition and lifestyle management for patients with obesity. The application created for this study incorporated a

reading level appropriate for the general public, with simple sentence structure and minimal scientific jargon. The app is free and in a format that is accessible to anyone with a smartphone. The goal behind creating this app was to help obesity patients understand the reasons obesity is a serious disease and that a diagnosis from their physician is an important step in treatment. An additional goal was to help these patients understand lifestyle changes they can make to manage this disease and to motivate them to make these changes.

III. RESEARCH SIGNIFICANCE

A. Significance of research study

This research aimed to address issues and questions about educational material development in not only the biomedical visualization field, but also in the fields of nutrition and patient care. This research study explored methods of designing apps to make them both educational and comforting while using elements of gamification to increase users' motivation, inspiration, and engagement.

In recent years, obesity has become one of the leading causes of other highly fatal diseases. While obesity prevention is extremely important, appropriate treatment is of equal, if not greater, importance. However, it is difficult to treat a disease if patients have a difficult time accepting the diagnosis. By explaining the magnanimity of an obesity diagnosis, as well as motivating users to address it, this app aimed to increase comfort levels of the patient and empower them by providing them with more information. This study contributed valuable information on addressing the problems of lack of diagnosis and delayed management in the field of nutrition.

Lastly, this research would improve physician-patient interactions. Physicians would be able to talk about nutrition education more with their patients, because of the information provided in the app. This kind of open communication and accessibility of information is a vital, but highly neglected aspect of healthcare professions.

There were three specific aims of this study. The first was to create a patient friendly, useful app for an obese population utilizing an iterative design in the app development process. The second was to test the efficacy of the app in increasing patients' knowledge about nutrition and lifestyle management. The third aim was to test the efficacy of that app in increasing comfort level of patients by providing them with the importance of their diagnosis.

B. Research question

How can a visual communication tool be developed to deliver nutritional and lifestyle knowledge to patients newly or recently diagnosed with obesity?

IV. METHODS

A. Research study design

This research study took place in three parts. First, pre-phase discussions were held with groups of experts in nutrition, bariatrics, and cardiac rehabilitation to ask them questions about the content, aesthetics, and feasibility of the app. Discussions took place in the Applied Health Sciences building at the University of Illinois at Chicago.

PRE-PHASE

During this time, health professionals discussed what they would like to see in the app, general daily interactions they have with a patient, what kinds of questions patients commonly asked, and what patients' most pressing concerns are. Information from these discussions was used to make informed decisions about the general structure of the app and what kinds of content should and should not be included.

The first step to creating an app is organizing the information into *site maps* and *wireframes.* A site map is a type of flow chart that organizes information that will be put into a non-linear interactive platform to ensure that the organization its most efficient for usability and delivery. Wireframes are skeletons of the user interface that begin to incorporate graphic elements of the interactive so they more closely resemble the planned final version of the app. The site map for MyWellness was created on paper (Figure 3) and it went through multiple iterations before the content and organization was finalized. The wireframes were first created on paper as pencil sketches.

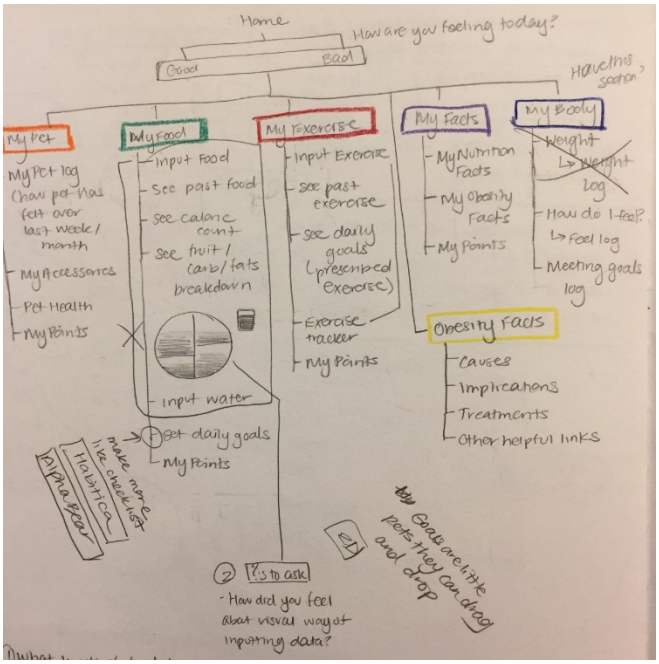

Figure 3. First draft site map. This first iteration of the site map before revision. Comparing this to the revised draft shows the difference in scope and organization of app.

After developing this site map, it was reviewed by a panel of experts for scope of research study, feasibility, and usability both before making wireframes, and after the next phase of testing. Many sections of the map had to be removed because the scope was too broad and too complicated. Additionally, certain functions were removed for privacy purposes. Altering the site map also increased the organizational efficiency of the app and placed more emphasis on important features. The three main changes in the site map, and the reasoning behind them, were as follows:

1. As part of the original layout, the place to input goals, the *MyGoals* section, was hidden under the *MyBody* tab. While it might have been intuitive to locate these goals, placing them here defeated the purpose of motivating users through point increases. In the new layout, the *MyPoints* is not housed under any tab. Instead it is free-floating on each page, so that it is visible no matter where in *MyWellness* the user is. This way, when a user does something that increases their points, they will receive a visible indicator of this increase immediately. This instant gratification will be a motivating factor.
2. The *MyGoals* section plays a crucial role in motivation and keeping patients on track with their treatment. This was not included as a tab on the original home screen of the app. While participants had no problem locating it during user testing, users are more likely to input, look at, and complete their goals if they can see the prompt right on the home screen. Making the *MyGoals* section accessible from the home screen will make it easier for users to remember to check their goals. While *MyGoals* did not change location, direct access to it from the home page will increase commitment to reaching the goals.
3. Participants in the Phase 1 assessment were confused by the presentation of multiple sets of facts in the app. The app houses facts related to the *MyNutrition*, *MyExercise*, and

MyCondition sections. The first two sets of facts are stored in the *MyFacts* section, whereas the facts related to *MyCondition* were stored in a separate tab. While this was not a hindrance to the usability of the app, the more intuitive and less confusing its organization, the more user-friendly the app will be. For this reason, all the facts have been moved under the same tab, titled *MyFacts*. There are three separate tabs under the *MyFacts* tab, one for each of the three kinds of facts. Users will still be able to navigate to the *MyNutrition* and *MyExercise* facts directly from the home page.

PHASE 1, PART A: Production

In keeping with the iterative design process of app development, the site map was revised to show the new organization structure, as is shown in Figure 4. This figure shows the final outline of the entire app. The next step of the process was creating low fidelity wireframes to map out the general layout of the app. Examples are shown in Figures 5 and 6. After refining low-fidelity wireframes, high-fidelity wireframes were created that functioned as prototypes of the app.

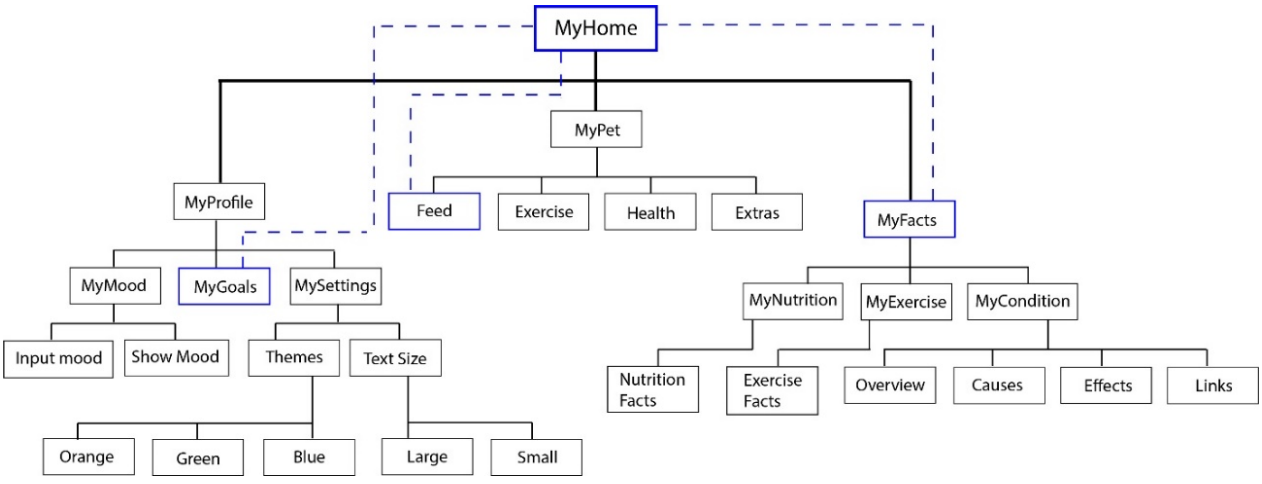

Figure 4. Updated Site Map. Changes from Phase 1 testing were incorporated to create the new site map.

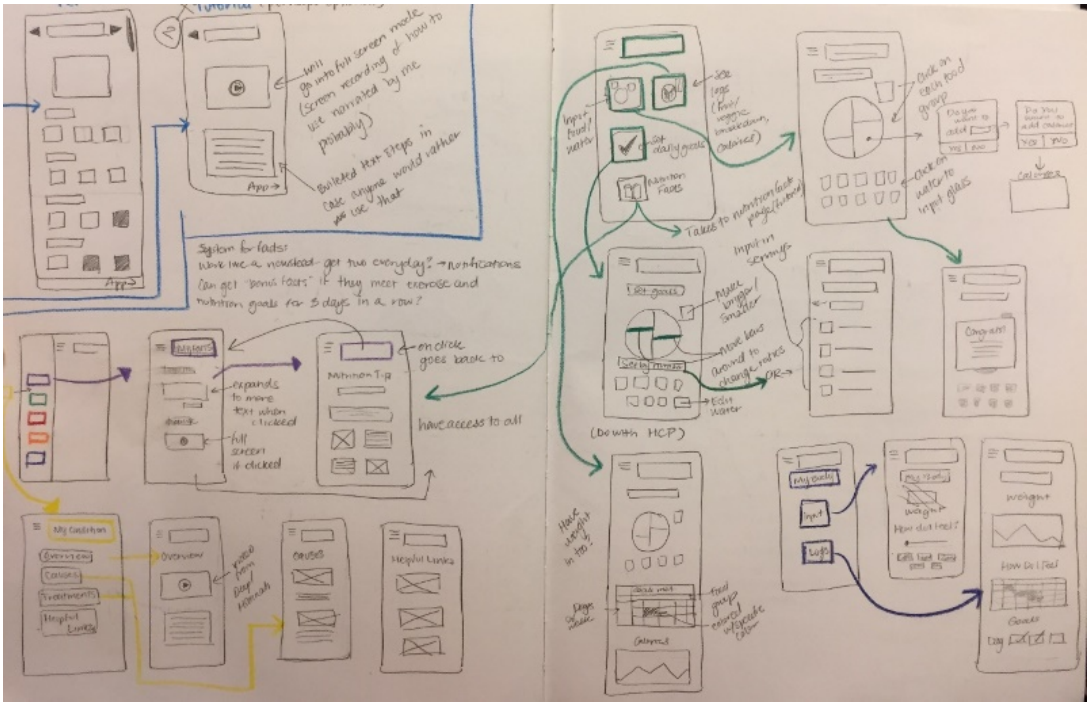

Figure 5. Wireframe 1a. First iteration of wireframe created from first iteration of site map. This iteration contained data entry for food intake.

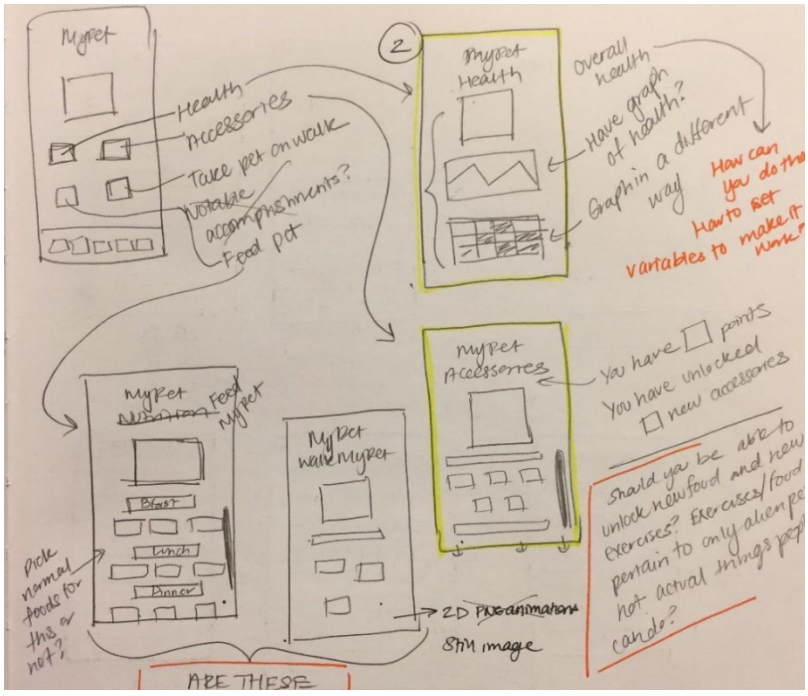

Figure 6. Wireframe 1b. First iteration of wireframe created from first iteration of site map.

PHASE 1, Part B: Testing

These prototypes were then tested via one-on-one interviews with members of the expert panel. For the first part of the interview, as shown in Figure 7, subjects were asked questions about their healthcare (see Appendix A) and specific interactions with patients. In the second part of the interview, subjects were given an opportunity to complete tasks on the prototype, and asked specific questions about their experience with the prototype (Figure 8). Testers were also asked to express their thoughts out loud as they completed the tasks. These spoken thoughts were recorded to be reviewed at a later time for more thorough assessment of the ways each tester

interacted with the prototype. Video recordings were also made to capture the movement of the testers' hands navigating the prototype to complete the tasks.

Figure 7. Phase 1 Testing General Questions. Figure shows placement of camera and scene setting for general questions

Figure 8. Phase 1 Testing Prototyping. Figure shows placement of camera and scene setting for paper prototyping. Each screen was around the size of a modern smartphone phone. The subject sat in the chair directly in front of the paper prototype.

PHASE 2, PART A: Production

Phase 2 involved the formal production of the *MyWellness* app, and its testing on a patient population newly or recently diagnosed with obesity. The design choices in the production of the app were informed by the prototype testing conducted in Phase 1. The app was

built in Unity, a gaming engine. Then, it was exported to a file type that was downloadable and playable by Android devices.

PHASE 2, PART B: Testing

In order to determine the efficacy of the app, patients were tested about their knowledge of nutrition and lifestyle before using it and after using it. Patients that were seeking treatment in the Cardiac Rehabilitation Center were approached by the recruiter, who explained the study to them. They were asked if they wanted to be a part of the study, and if they had access to an Android phone. If they were willing, they signed a consent form, and took a pre- test (Appendix B, p. 72-74) to determine their comfort level with their diagnosis and their general knowledge of nutrition and exercise. After the pre- test, they were separated into two groups- the control group and the intervention group. Patients with access to Android devices were in the intervention group. They were helped with downloading the *MyWellness* app onto their phone, and shown how to use it. The control group was given printed information about nutrition, exercise, and obesity. Both the app and printed materials provided the same information about obesity, nutrition, and lifestyle management. Subjects took home the printed material or app for one week in order to interact with it. For the control group, this meant simply reading the material whenever they saw fit. The intervention group was requested to interact with the app every day, or as often as they could. After this, subjects visited the clinic again for their routine visit, where, at the one-week mark, they took a post-test. Identifiable data from the pre- and post- tests were not shared with healthcare providers.

By testing and comparing both increase in knowledge and comfort level of diagnosis, this phase of the study addressed the research question: “How can a visual communication tool be developed to deliver nutritional and lifestyle knowledge to patients newly or recently diagnosed

with obesity?”

B. Stimulus design

PHASE 1 STIMULUS

In Phase 1, a prototype was produced applying suggestions made during discussions held in the pre-phase to low fidelity wireframes. The initial low fidelity wireframes were revised again with scope of research, scope of technology, and privacy considerations in mind. Through an iterative design process, high fidelity, digital wireframes were created in Adobe Illustrator (Figure 9). These were printed out to approximate modern phone size (Figure 10) and cut with rounded corners to resemble a phone to give testers a true feeling of using the app (Figure 11).

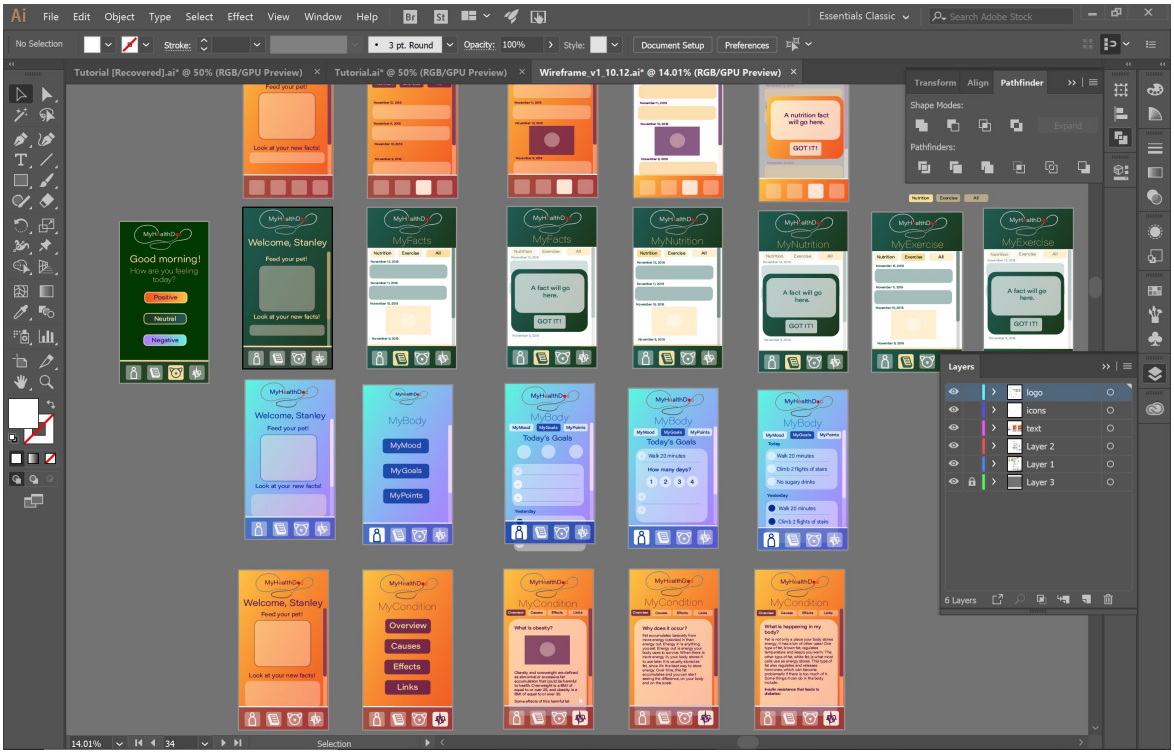

Figure 9. Screenshot of Illustrator file. Figure shows the creation of high fidelity wireframes that will be printed out to create the prototype.

Figure 10. Cut out MyGoals section. Figure shows the layout of the prototype and the rounded edges.

PHASE 2 STIMULUS

The app development was parallel in timeline and decision-making to the creation of the prototype. After completing the testing with the prototypes, changes were incorporated into the app. The app was developed in Unity2D over the course of one month. The visuals for the app, such as graphic elements and small illustrations, were created in Adobe Illustrator.

Figure 11. Prototype in hand. Figure shows how the prototype is sized and shaped to resemble a smartphone.

The interface for this app uses two-dimensional images, so it was built in Unity 2D. In Unity, a scene is a space in which all content in a certain screen of a Unity file is stored. A game or app can consist of many scenes. When a certain screen for an app is opened, the entire Unity scene that screen belongs to is loaded on that device. Multiple scenes were used to create the app and organize information. In general, content areas have faster loading times if they are built using more scenes, each containing less information, rather than fewer scenes with more information per scene. Breaking content up this way also helps keep the information organized. An example of the organization of visual and text elements in Unity, called the hierarchy, can be

seen in Figure 12, which shows the organization of the app's home screen.

The hierarchy of *MyWellness* contained four main elements. First and foremost, the *Main Camera* is an element that is always necessary in any Unity scene. It is what dictates what is viewed in the game window. Next, are the items named *Buttons* and *Event System*. *Buttons*, in this case, is the name given to a *canvas.* A *canvas* is the container that holds all of the UI elements in the Unity scene. In order to view the UI elements in a *canvas* on the camera, the scene requires an *Event System*. The final element in this scene is a folder called *ScriptContainer*. This folder contains the code for various actions in the scene, as can be seen in Figure 10. Using empty game objects to contain code is an organized method of knowing exactly where that code is housed, for ease of putting it on something else.

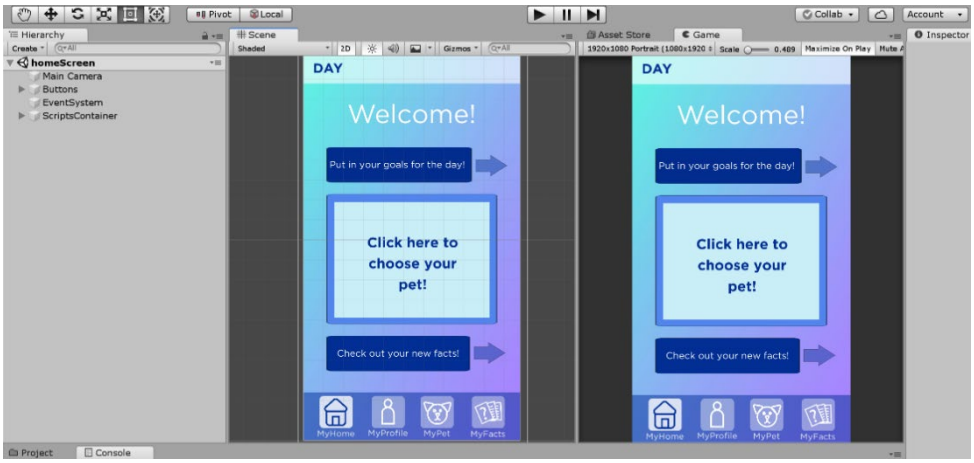

Figure 12. Unity home screen. This is an example of the overarching elements of each scene in this app development folder.

Figure 13. Unity hierarchy close-up. Most scenes in the app contain all of these elements.

C. Evaluation plan

The testing of the prototype was evaluated using qualitative measures. Tasks that required the use of the main functionality of the app were assigned to the test subjects, and their hand movements and comments were recorded while they performed these tasks on the prototype. Testers were encouraged to speak through their decision-making process for how they moved through the app and vocalize any confusion they experienced while using the app. They were also asked open-ended questions to determine how helpful and user friendly they thought the app was.

The final app was evaluated by patient testing. Patients were given two-part pre- and post-tests in order to gauge the efficacy of the app. The first part tested for their level of comfort with their diagnosis, since that is a factor that deters physicians from giving their diagnoses. The

second addressed the effectiveness of delivery of the nutrition and lifestyle information and how likely patients are to implement it in their lives.

1. Study setting

Pre-Phase: An informal discussion was held in classrooms in the Applied Health Sciences building of UIC campus. It was conducted in two small groups of two experts each.

Phase 1: One-on-one interviews testing the prototype were also held in the Applied Health Sciences building classrooms.

Phase 2: Patients were introduced to the application at the Cardiac Rehab Center, a location with which they were familiar, to ensure their comfort level. This location was also the most accessible to the patient testers.

2. Sample or population sampling methods

The expert panel consisted of a group of nutrition and physical therapy experts within UIC and the Cardiac Rehabilitation Center. They were chosen specifically for their knowledge and familiarity with the patient population.

The obesity-diagnosed patients assessed in Phase 2, were recruited through the Cardiac Rehabilitation Center, and by recommendation of Phase 1 experts.

a. Selection criteria

The selection criteria for the focus group was a panel of experts at the University of Illinois at Chicago selected for their specific backgrounds and expertise. These experts were physical therapists and dieticians that regularly treated and interacted with an overweight and obese patient population.

The selection criteria for the patient population were that they were age 21 or older, that they had been diagnosed with obesity, and that they were seeking treatment at the Cardiac

Rehabilitation Center. The age restriction was implemented to avoid the likely variations in maturity levels in subjects under the age of 21. All subjects were required to have access to a smartphone and all were required to be fluent in English, since the app features were in English.

b. Selection strategy

The expert population was selected with the help of committee members based on experience at UIC. The patient population was selected with the help of the healthcare providers in the Cardiac Rehab Center and Bariatric Surgery Center.

c. Size

The pre-phase of the study involved a discussion with four experts. Phase 1 involved individual interviews with five experts. Phase 2 of the study collected data and feedback from two patients.

d. Data collection

PHASE 1

Qualitative data for Phase 1 was collected. Subjects were given certain tasks to complete while interacting with the prototype. They were recorded and encouraged to talk out loud as they navigate through the tasks to explain certain decisions they made or any confusion they had. Data collected was in the form of a table of summarized answers to specific questions, as well as a table of summarized comments while performing assigned tasks on the prototype.

PHASE 2

Qualitative data for Phase 2 was collected. Participants were given a pre-test before they used the app as well as a post-test after a week of app use. These tests evaluated them on their comfort level and knowledge base of nutrition and lifestyle management. Testing was done on paper in the Cardiac Rehabilitation Center to ensure that no data was stored on patients' phones.

e. Method of analysis

Focus group feedback data from Phase 1 was summarized and then used to inform decisions in Phase 2.

Data from Phase 2 was not interpreted statistically. Since there were only two participants, and not a large difference between the pre- and post-test results, interpreting the data would have been difficult. Rather, the data collected in this phase were analyzed for qualitative value.

V. RESULTS

PRE-PHASE

In the pre-phase, information was gathered about the patient population, the healthcare provider population, the condition, and necessary concerns, and most effective ways to deliver information surrounding this topic. There were two focus groups held, each with two expert professionals. The format of each focus groups was that of an informal discussion more than a question and answer session. The highlights of each of each focus groups are discussed below.

1. Focus Group 1

The two experts consulted for Focus Group 1 were both main healthcare providers in the Cardiac Rehabilitation Center, and therefore have a rich understanding of its patient population. They each described a typical day in a typical visit with the patient, the various types of patients they see, and frequency with which they see them. They also talked about features of the proposed app they would find beneficial. One feature they suggested was an in-app pedometer. They also suggested the app features change color depending on what mood they are in to facilitate user engagement. They suggested this would give users the satisfaction of customizability, as well as giving the app the ability to complement the mood users were in. Using different color palettes could either help users remain motivated if they were feeling positive, or calm them down if they were feeling a more negative mood.

Another important part of the discussion was about the information these experts give their patients and the sources of information that would be appropriate for the app. They suggested the *Physical Activity and Vital Signs* questionnaire from the American College of Sports Medicine would be a resource for measures of physical activity and that the American Heart Association would be a good source of information for nutrition and exercise facts.

2. Focus Group 2

The second focus group was held with a dietician, and a health care provider from the Bariatric Surgery Center at the University of Illinois at Chicago. The health care provider talked about his patients that were preparing to go through or in recovery from gastric bypass surgery, and the fact that many patients had BMIs of well over 50. It was noted that this affected the patients psychologically and made relating to others difficult. He also discussed that many of these patients were obese due to past childhood trauma and/or abuse.

Both experts expressed the need for patients to connect with their providers and for some way providers could monitor their patients' progress through the app. They also suggested that reminders from the app via the patient's phone (also known as push notifications) would also be extremely helpful in keeping patients on track with their goals.

Information from these discussions was compiled and organized, then used to make informed decisions on the content and layout of the app. Not all suggestions could be incorporated due to limited scope and resources, but these discussions provided a great deal of insight into what should be considered for future app improvement.

PHASE 1

In this phase, usability testing was conducted to obtain valuable input from healthcare providers about usability of the app. Five healthcare provider subjects assesses the app and offered input about ways to improve it. Table 2 summarizes the results for general questioning of healthcare providers, and Table 3 summarizes the responses users gave after being given tasks to perform.

Question	Summarized responses from providers
What is a day to day experience like with this patient population?	• They are optimistic about their treatment • They come in and have 45-minute appointments with the health professionals at

	the Cardiac Rehabilitation Center • Even though they might not be physically impaired, they are often more frail • They are on lots of medication
What kinds of questions does this patient population have and what are their most pressing concerns?	• They are concerned whether they will be able to perform tasks outlined for them • They are worried that their insurance will find out about new conditions they might have and the prices will increase and they will not be able to afford it
What kind of nutritional knowledge do they have and what materials are already provided to them?	• Generally, they know that they should eat fruits and vegetables and not hamburgers and french fries • They would like information presented to them in the form of fun facts rather than a suggestion of what they should be doing
How comfortable is this patient population in talking with their physicians?	• Some patients are very comfortable talking to their health professionals they see regularly

How much does this patient population know about their condition?	• They are relatively familiar with their condition since they have already taken this step to seek further treatment
	• There are three types of patients:
	  o Those who research their condition thoroughly after being diagnosed and keep an open communication with their doctor
	  o Those who self-diagnose by putting their symptoms in online and come to their doctor with their diagnosis
	  o Those who only come to the doctor because they have to and say what they have to

What kinds of content should appear on the screen when patients first open the app?	• Something catchy, to draw them in • Not too many things that it's confusing where to click • An exciting image of the pet
What content is a priority that the patients should know?	• When their next appointment is • What they decided to work on in their last appointment
Should patients see their weight right when they open the app or should they have to press more buttons to find it?	• No • If it isn't a weight loss app, then they do not need to see their weight • It is important that they check their weight, so having a reminder for them to do so would be

	appropriate
How detailed should the nutrition information and scientific facts be?	• Variety of patients are Cardiac Rehabilitation Center; some are even dieticians. But there are also patients that do know only basic nutrition • Information that appeals to both people that know about nutrition and those that do not
How personalized should/can the nutrition and exercise information be?	• The information should be personalized, since each patient has different abilities and other conditions.

Table 2. Phase 1 Healthcare Provider General Questionnaire

Task	**Summarized responses from providers**
Where would you go to look at nutrition information?	• 4/5 participants able to complete task with no problems • 1 participant said the fact sheet icon was not as clear
-Where would you go to input your exercise goals for the day?	• 3/5 participants were able to complete task with no problems. • 2/5 were confused because they associated exercise with the image for MyCondition since it has a heart with an ECG through it. But they we able to eventually find the place to input goals
-Where would you go to learn about obesity facts?	• 3/5 participants had already seen this screen before when they pressed it in earlier tasks • 1 participant was able to complete this task with no problems • 1/5 participants went back to the MyFacts page
-Where would you go to check on your workout pet and customize it?	• 5/5 participants said that the icon for this page was confusing • 1 participant said the icon resembled a pig, which would be inappropriate for this audience

Table 3. Phase 1 Task and Response Chart

Picking color theme according to mood buttons

In the original wireframes, the opening screen for the app when opened for the first time on a given day would prompt the user to indicate their mood and would display varying app

colors accordingly. The colors were chosen based on color psychology research about the types of colors most suitable for encouraging positive emotions, and soothing negative emotions. The mood the user chose would automatically set the app's color palette for the day, and there was no way to customize it to a different color palette. Additionally, data collected from each day's mood choice would be saved and displayed in a mood tracker in the MyMood section of the app.

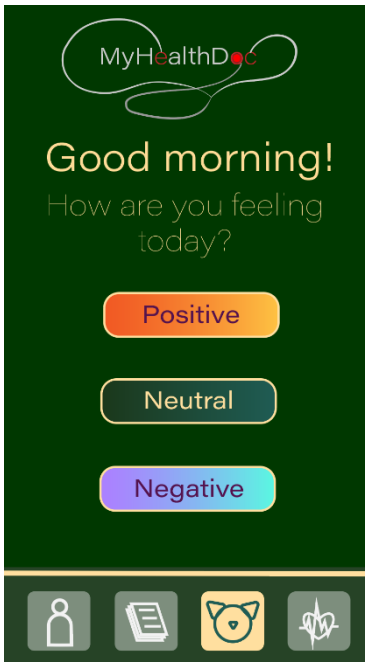

Figure 14. Opening screen Phase 1 Prototype. Figure shows the three color palettes corresponding to different moods.

During usability testing, the subjects brought up important points about this component of the app and its possible disadvantages. While the colors generically match up with a typical perspective of mood, some users might have different color preferences than those offered with the mood choices (Figure 14). For example, someone could prefer the color blue over orange, but be in a positive mood, and then be forced to make the decision as to whether they want to stay true to their mood or customize the app palette to their preference. In this case, either choice would pose at least one disadvantage to the user. As mentioned in Octalysis gamification principles, customization is an important part of any "game" (Chou, 2017). It draws the user in

and allows them to become more attached. Tying the color and mood together hinders customization.

Another complication to this method is that the person's perception of their own mood could be affected by the colors associated with the mood. It's possible a user may begin to feel more positive upon viewing the word *positive* in a fiery orange, and it is also possible it could have the opposite effect. While this could play a role in affecting patient comfort, altering mood through color and examining the changes is not within the scope of this study. Furthermore, subjects also mentioned their personal preferences towards certain colors. Most subjects really preferred the blue theme, with the orange theme as a second preference. However, one subject mentioned that the orange theme actually made them feel more anxious. The blue theme was most popular and it is perceived as soothing (Morton, 1997).

To solve this issue, the app was altered to separate mood and color palette. In the final version of the app, the user may still go into the *MyMood* settings (under the *MyBody* tab), input their mood for the day, and track their mood history. There is, however, another button in the *MyBody* called *MySettings*, where users may customize the color palette and make other changes in app appearance, such as text size. With these alterations, users have full ability to customize the app do not have to make any conflicting decisions.

Organization of information

In the original wireframes, information was organized as shown in Figure 3. After user testing, different solutions to organizational problems were suggested. The topic of most discussion was that the obesity facts were not displayed with the nutrition and exercise facts. While most participants understood the difference in the functionality of the facts, they did not understand why they were shown under separate tabs. Reorganization and recategorization of the

information was needed.

Icon design

In the original wireframe, the icons were as shown in Figure 15. Icons for MyBody and MyFacts were intuitive for most users. The MyBody icon was very intuitive because it is the universally used icon for personal profile, or where one might customize their account. No changes were necessary to this icon.

The MyPet icon was also easily recognizable by most subjects once they knew there was a pet involved, but not before. One subject raised a concern that the icon looked like a pig at first, which could have highly negative connotations, especially in this population. It could be changed to resemble a specific animal, instead of an ambiguous animal.

The icon for *MyCondition* was the most problematic, since different users thought it could represent various categories, but none actually recognized it as the symbol for *MyCondition*. Instead, users thought it could represent their personal health data, the physical activity tracker, or heart health.

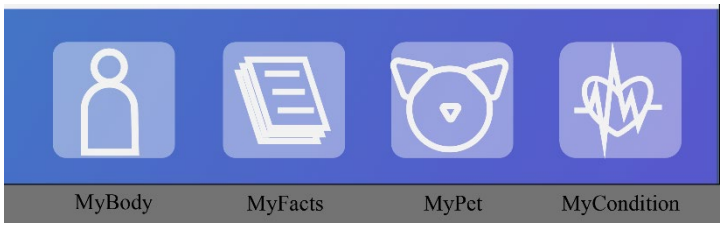

Figure 15. First draft Icons. From left to right: MyBody (MyGoals and MyMood), My Facts (nutrition and exercise facts), MyPet, and MyCondition (obesity facts).

The solution to this problem involved rearranging the organization of information as well as shifting the meanings of the icons to better fit with their content. Figure 16 shows the finalized icons included in the app. The first major change was the addition of a home button. During Phase 1 testing, most users said they look for a home screen button when using an app. Even though the home screen in this app has no unique functionality, users wanted the comfort and reorientation of returning to the first screen they opened when starting the app.

An organizational change was also made in which the *MyFacts* button now included nutrition, exercise, and obesity facts. Users from Phase 1 testing said they were confused by the separation of types of facts into different areas of the app. To remedy this, they are all located under the same icon and each one has a different tab.

Finally, the MyPet icon was upgraded to look more like a specific pet than an ambiguous animal. It now resembles a cat complete with the eyes and mouth.

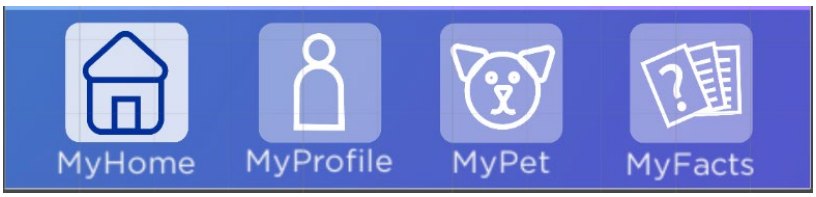

Figure 16. Revised Final Icons. From left to right: Home Screen, MyBody (MyGoals and MyMood), MyPet, and My Facts (nutrition, exercise, and obesity facts).

Privacy and data protection

One of the panel experts brought up a specific concern that many patients have considering taking part in a scientific study: having their privacy breeched through the collection and publication of sensitive data. This sentiment echoed that of many health app users (Krebs, 2015) who were weary of apps that asked them to input personal information such as weight, food intake, and exercise history. Keeping these two considerations in mind, this app is designed to focus less on data input and analysis and more on information transfer and retention, goal management, and accountability.

PHASE 2, PART A: App Creation

Results from Phase 1 testing that informed Phase 2 app creation were organizational changes, icon changes, and some design choices. Following these changes, the version of the app that was used for Phase 2 testing was created.

MyHome

This page is the first page the user sees when they open up the screen (Figure 17). Every time users open up the app on a new day, they are awarded one point. The first button is to go directly to *MyGoals*, as it is more likely users will set goals if reaching that page is relatively easy. The second button is the *MyPet* button, which prompts the user to feed their pet, and the third button is the *MyFacts* button, which prompts the user to read the facts. While the *MyPet* and *MyFacts* are both accessible from the icons at the bottom of the page, having them visible on the home screen is another prompt for users.

Figure 17. Phase 2 MyHome: Home screen of the app featuring the three main functionalities

MyProfile

The *MyProfile* tab houses *MyGoals, MyMood,* and *MySettings* (Figure 18). *MyGoals* allows the user to set three goals at a time, and check the boxes when they have achieved their goal. Each time they achieve a goal, they are awarded one point. Each day, the check boxes for the goals reset, so they are expected to complete that goal again. They can edit these goals by hitting the edit button. Figures 19 and 20 show the screens for *MyGoals.* The *MyMood* section of the app allows users to input their mood every day, and be able to see their mood history since they began using the app. Lastly, the *MySettings* tab allows users to customize their color palette and text size for the app.

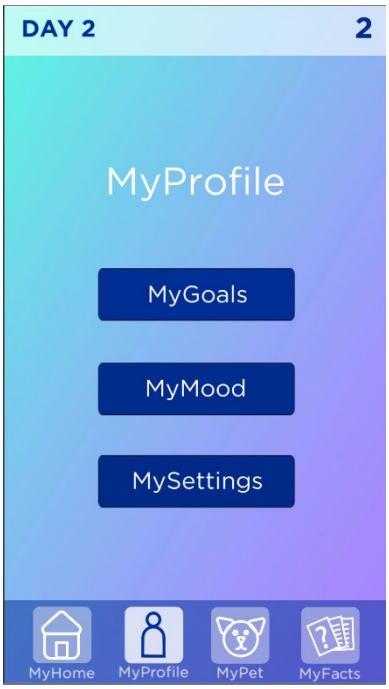

Figure 18. Phase 2 MyProfile: Landing page of MyProfile tab featuring its three functions

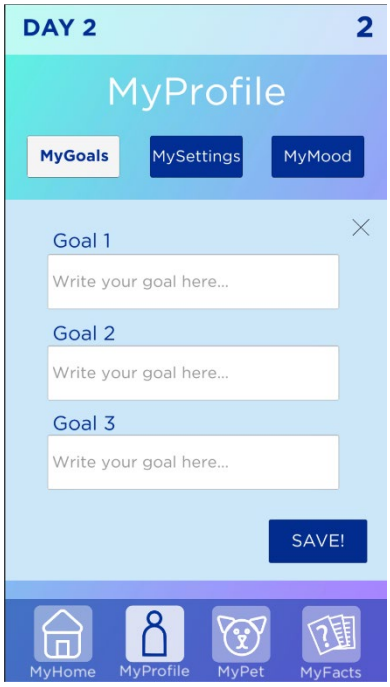

Figure 19. Phase 2 MyGoals Entry: The first time a user opens the MyGoals section and is prompted to input their goals

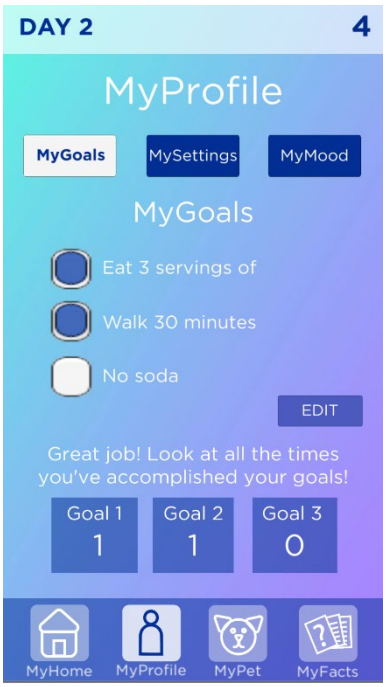

Figure 20. Phase 2 MyGoals Completion: After the user has inputted and achieved some of their goals

MyPet

This section of the app is where users can feed, exercise, and accessorize their pet (Figure 21). Checking on the pet's health was a proposed idea, but due to time limitations, it had to be taken out of the app. In the Food section of *MyPet,* users have four options of what they can feed their pet. According to whether the food is "healthy" or "unhealthy" the pet reacts in positive or negative ways. Next, there is the Exercise tab. This tab has four options of activities as well. If the activity gives the pet exercise, then the pet reacts positively. If it does not exercise the pet,

the pet responds negatively. The next section is the Extras sections (Figure 22). Under this section, users can put various accessories on their pet. They start off with two options of accessories. More accessories are “unlocked” as more points are earned. In this case, after earning five points, two more accessories would be unlocked for a total of four. There are six accessories in total.

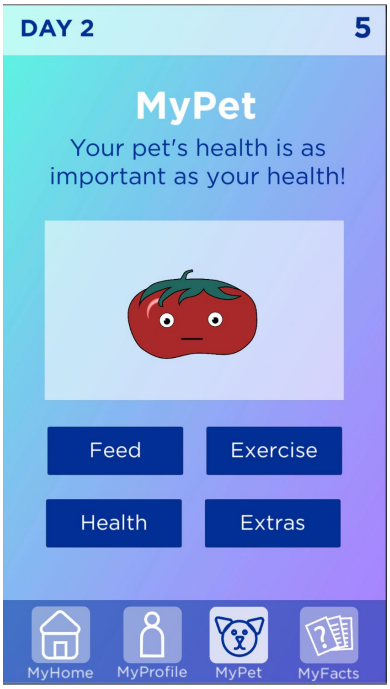

Figure 21. Phase 2 MyPet Home: Landing page of the MyPet tab that allows the user to go to any of the four options

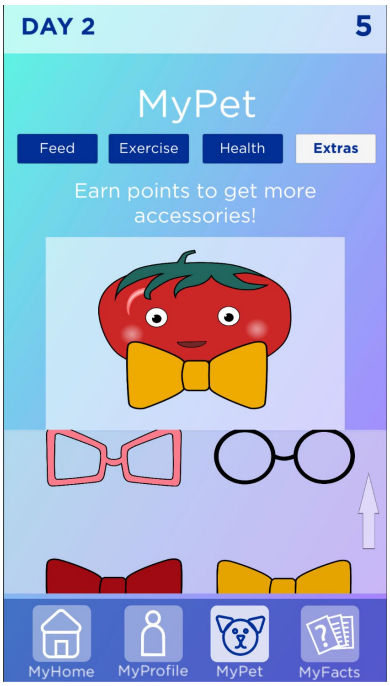

Figure 22. Phase 2 MyPet Extras: This is Extras section of the MyPet tab. Here, users can accessorize their pets. Since the user has five points, they were able to unlock for accessories.

MyFacts

MyFacts, the section where all facts in the app are contained, has three separate tabs: Nutrition, Exercise, and Obesity. When the *MyFacts* tab is first opened (Figure 23), the nutrition and exercise facts that the user has unlocked appear. Every day the user opens the app, two new facts (one nutrition and one exercise) are unlocked and appear in this section. Clicking the nutrition or exercise buttons at the top of the screen makes only those respective facts visible. The third tab, the obesity tab, leads the users into to the obesity facts section of the app (Figure 24). These facts do not change like the ones in the nutrition and exercise tabs.

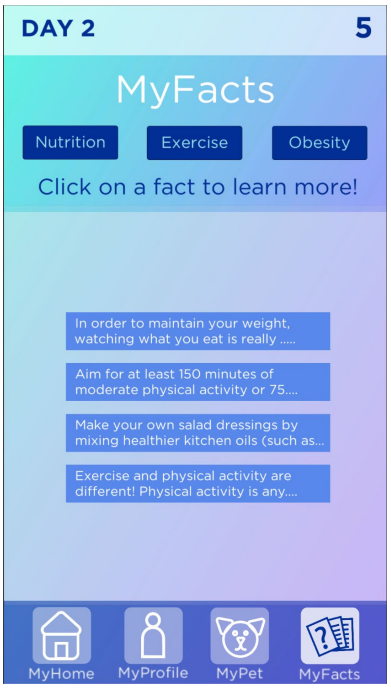

Figure 23. Phase 2 MyFacts Home: Since this is Day 2, four total facts are visible (two nutrition and two exercise). Clicking each fact will display the full text of the fact.

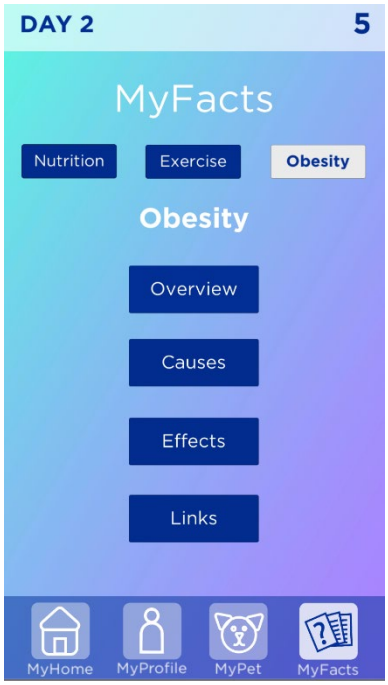

Figure 24. Phase 2 MyFacts Obesity. Obesity section of MyFacts

PHASE 2, PART B: Patient Testing

After using this app, the goal was that patients would be better informed and more comfortable with their obesity diagnosis. They would also be better informed about nutrition and lifestyle management and be able to make better choices to encourage weight loss.

The results from the study showed that:

a. There was not a large difference between the responses on the pre- and post- tests.

b. There was not a large difference between patients that received the treatment and the control group.

Among all the questions, there were seven responses that changed between the pre- and post-tests for the treatment group. They are outline in the table below:

Question Number	Control Group	Treatment Group
Were the physician's instructions clear?	-	9 → 8
Did the physician answer questions you might have had?	-	8 → 9
Did you feel comfortable asking the physician questions?	-	9 → 10
How easy is it for you to compose a balanced meal at home?	7 → 8	-
How easy is it for you to evaluate if a specific food is relevant for a healthy diet?	7 → 9	7 → 9
How many servings of vegetables should I be eating in a day?	-	2 → 2-3
To take care of my heart, I should be eating food with __% saturated fat.	0 → 5	-

Table 4. Phase 2 list of results of interest. In the columns with a "-" the results between the pre-test and post-test did not change. Questions in blue are comfort-related, and questions in green are nutrition and lifestyle education-related.

Analysis of Comfort

The results of the Phase 2 assessment showed that the interventions (both the app and the

printed handout) made a difference in the comfort level of the patients. Regarding the comfort level with their decision-making about nutritious food, both patients felt more confident that they could evaluate the relevance of a food for a healthy diet, than they did before receiving the interventions. The patient that received the printout felt more comfortable composing a balanced meal at home than before receiving the handout. This was not the case for the patient that used the app.

Regarding the comfort level with their physician, the patient that used the app felt more comfortable asking questions and getting responses from their physicians, while the patient in the control group stayed the same. It should be noted that the patient in the control group had high scores (9s for questions 1-6) on the pre- and post- tests for all questions regarding comfort level with the physician.

Analysis of Nutrition and Lifestyle Knowledge

There were only two questions that had different responses on the pre- and post- tests. The patient in the treatment group wrote that they should be eating two servings of vegetables per day on the pre-test, and changed that response to 2-3 servings on the post-test. While not a significant change, it is positive.

The other question that had different results on the pre- and post- test for the control group patient was about saturated fat content. On the pre- test, the patient wrote that they should be eating foods with 0% saturated fat, whereas on the post- test they wrote 5%. While this increase in percentage of saturated fat is not a positive result, it does show that the patient read the handout. It states to "reduce saturated fat intake to no more than 5 to 6 percent of total calories" (Appendix D, p. 79). This question could have been rephrased to better match the content by reading "To take care of my heart, I should be eating food with at most __% saturated

fat."

Overall, both patients scored very high on the pre- and post- tests for nutrition and lifestyle knowledge. Because of the high pre-test scores, there was not tremendous room for improvement from the intervention. There was only one question both patients consistently answered incorrectly on both the pre- and post- tests: "How many calories are in 1g of fat, protein, and carbohydrate respectively?" (Appendix B, p. 73). Both patients answered incorrectly, with answers ranging from 10 to 400, even though both the handout and the app had a fact that read "Remember: Protein and carbohydrates each have 4 calories per gram, while fat has 9 calories per gram." (Appendix D, p. 79)

Analysis of App by Section

Overall, the patient thought the app was not very effective for a number of reasons.

MyFacts

When asked what the patient liked about the app, the patient said they enjoyed learning new facts. However, they said that because the facts did not change over the course of time, they lost interest and did not click on them. The app was programmed so that every day the app was opened, two new facts would appear in addition to the previous facts shown. All facts had a similar appearance except for the words used in them. Hence, at first glance, new facts might not have always been recognized as new, since they tended to look like the same ones shown earlier. This may have been exacerbated by the fact that the user is required to open the facts up to read them, meaning at first, they will not see that they are different lengths. Future versions of this app could have the new facts show up in a different color. That would signal to the user at a first glance that they are different.

MyPet

The user indicated that the pet was an acceptable addition to the app and that they put on the glasses on the pet. They did not elaborate further on the use of the pet. In this case, the app was programmed so that the user would get one additional point for each new day the app was opened. Since the user only opened the app for three days, they only had three points. For the pet, the user could get new accessories for the pet once they reached five points. However, the user never had the chance to see that happen.

The point system was designed so that if the user opened the app and used the goals for one or two days, they would have enough points to unlock the new accessories on the next day. However, future versions of this app could have new accessories unlock at an even lower threshold of points. Alternatively, the app could prompt users to use certain features that earn them points, letting them know that they will unlock new accessories after they receive the right amount of points.

MyGoals

The user said they did not have a chance to use *MyGoals*, but they did see that screen and knew they had the option to use them. Since the user did not use *MyGoals*, they could not check the box for completion of goals, and therefore did not receive any points for completing goals. This contributed to their low point count, leading to a lack of accessories loading in the pet section. Future versions of the app could prompt the user to input their goals, and even have prompts for examples of goals.

Ideally, the user would input their goals with guidance from their HCP and then follow them for the next couple days. However, that was not feasible with this user. Because testing was administered at the end of the user's session at the CRC, they were very tired and did not want to input goals or go through the app.

Overall Comments

Overall, the user said that they did not use the app very much since they had a very busy week. However, they did report that they looked through all the pages. When asked what features might be useful to include in the app, they indicated it would be best to ensure full functionality and content creation before testing. The user also said that they were "not a big fan of using apps" and they would not use one for health purposes. However, they did mention that having some information about meal preparation and healthy carbohydrates would be helpful. Although, there are some facts included in the app that touch upon meal preparation and outline healthy carbohydrates, the user was unable to get to them without a certain amount of progress. One way this problem could be solved is to gamify the user's eagerness to receive some facts. Notifications could appear on the user's phone alerting them that in *n* number of days of app use, they will receive facts about meal preparation. Knowing that they will soon be receiving information they want to read will prompt users to keep using the app.

The user also said they uninstalled the from their phone as soon as the study was over. Since this user was not fond of apps in general, results from this user might not reflect those of someone who regularly would use a health app. In future studies that have access to more patients and a larger time frame, one selection criteria for patients could be that they are open and willing to use an app regularly.

Summary of Phase 2 Results

As a whole, no conclusions can be drawn from the pre- and post- test results as presented, since no statistical analysis was performed. There were more favorable responses for nutrition and lifestyle knowledge, and for comfort with their HCP in both the control and treatment groups. There can be no conclusions drawn about the differences between the control and

treatment groups. However, the qualitative information gathered in both phases has interesting and insightful implication for future development work in this area.

VI. DISCUSSION

SUMMARY

This research study aimed to develop an application to help patients become more comfortable with their obesity diagnosis and more informed about lifestyle and nutritional choices that can help manage their obesity. The study was conducted in three steps. In the pre-phase, informal discussions were held with a group of healthcare providers that regularly interacted with the target patient population, about the content, aesthetics, and feasibility of the app. In Phase 1, a prototype was tested for content, functionality, and UI/UX design. Important considerations about all three elements in the app were documented, and decisions about finalizing development were based on these considerations.

Next, the app was created incorporating feedback received from testing in Phase 1. In Phase 2, the app was tested on two individual patients at the UIC Cardiac Rehab Center, examining any changes in comfort level with their diagnoses as well as any increase in nutrition and lifestyle knowledge. Results from the study were inconclusive in determining whether an app, compared to a handout, increased nutrition and lifestyle knowledge. In the patient who used the app, some changes in comfort level with their diagnosis were observed. There were, however, no significant changes observed in the patient's nutrition knowledge. There were also increases in comfort level for the patient in the control group, but less than that of the patient in the treatment group. There were no significant changes in nutrition and lifestyle knowledge of either group.

IMPACT

This study provided impactful information for the fields of biomedical visualization, nutrition, and patient care by documenting the creation of an app that was designed to make

obesity patients more comfortable with their diagnosis while simultaneously educating them about ways to manage it. Although the testing groups were limited in size and some features of the app did not have the effect for which they were designed, these limitations and outcomes can help inform further development of similar apps. Further development of this kind of app has the potential to help bridge the gap between medicine and nutrition and enhance patient-physician interactions in regard to this particular diagnosis.

LIMITATIONS

Small Sample Size

Limitations for this study included small sample size, time limitations, and development limitation. The sample size of Phase 1 was only five healthcare providers. While valuable information was gained from this testing, to few subjects were tested to obtain a thorough perspective on all the ways the app could be more useful and efficient. In particular, having more data from patients and more patient participation would have been ideal. However, because of limited time, this was not possible.

Only two patients were tested in Phase 2. This low number of subjects was due to the limited time frame and limited available population. There was only a week and a half in which the investigator could recruit patients, and unfortunately, both the Cardiac Rehabilitation Center and Bariatric Surgery do not see a large number of patients. The Cardiac Rehabilitation Center only has 5 to 6 people going through the program at one time. Another limiting factor was that the app could only be built out for Android with the current time frame. Thus, only subjects with Androids could participate in the study.

Limited Time

There are several ways additional research time could have improved the outcome of this

study. First, it could have allowed for a more fruitful iterative design process. This app only went through one round of paper prototyping and usability testing, while app design often requires many more rounds. As such, a few more rounds of testing could have improved usability multi-fold. Furthermore, there was not enough time to monitor long-term effects of app use on actual patient lifestyle. While the assessments given in the one-week time frame measured impact on immediate decision-making and retention of information, it was not a long enough time to assess any habits that may have been formed to impact lifestyle, nor was it a long enough time frame to measure subjects' long-term retention of information. A future study would ideally observe subjects over longer periods of time and measure how app use affects their implementation of learned lifestyle modifications. Finally, time constraints limited the degree to which certain features of the app could be developed. *MyPet* would ideally be more interactive, customizable, and animated; these features may cause patients to become more engaged with and attached to their pet. However, since creating the pet was not the main point of this research, its development had to be narrowed to keep within the scope.

Additionally, due to time, the app could only be developed for Android and not both Android and iOS. Excluding iPhone users narrowed the population size when there was not a large enough population size from the beginning.

Scope of Development

The scope of development had to be kept smaller than ideal because of limitations in time and resources. Certain useful features could not be added to the app because of security concerns regarding push notifications and customizable health data. For example, push notifications would have functioned as valuable reminders for patients to meet their goals, and they would have allowed providers access to their patients' apps in order to input data or keep track of their

progress. Both of these would have also been valuable for the lifestyle modification process.

Additionally, certain features had to be simplified because of time constraints during the development process. For example, *MyGoals* was originally planned to be much more customizable and informative, but it had to be simplified to a system that tracked only the number of times goals were completed instead of completion of specific goals. Another feature that was simplified was the customizability of the settings. Originally, the app was going to have customizable themes (colors), and customizable text sizes for accessibility purposes. Unfortunately, the finished app only included one theme. Most Phase 1 participants said they enjoyed having access to the different themes, and, of the two, the orange theme incited a slightly negative emotional response from some participants. Due to this, blue seemed to be the safest theme to choose if there could only be one.

Sample Population

One of the limitations of this study was the sample population's status in their rehabilitation programs. The Cardiac Rehabilitation Center patient population, from which the sample population came, is unique in that they receive more nutrition and exercise knowledge than the average patient that is obese or overweight. These patients were tested on nutrition and lifestyle information, as well as comfort level with their HCP and healthy food decisions. In addition, this population specifically was in a more advanced stage in the program. These factors made it difficult to determine whether their high scores on the pre- test were because of prior knowledge or knowledge from their physician, or because of their involvement in the Cardiac Rehabilitation program. Because of this, it was difficult to determine how these results would compare to results of a patient not in the Cardiac Rehabilitation program. Furthermore, these patients receive more one-on-one counseling with their HCPs than the average patient. This

counseling could lead to a closer relationship with their HCPs than their counterparts who are not receiving this kind of one-on-one interactions, leading to higher physician ratings on the survey.

Ideally, the tested patients could have been chosen from a population that had not gone through the program before using the app. In fact, patients that were diagnosed with obesity by physicians would have been a better sample population because they are representative of a more typical situation. Unfortunately, due to the timing of the research schedule, less advanced patients in the Cardiac Rehab program were not available when testing needed to be conducted. Furthermore, timing did not allow for the sample population to be opened to general patients with obesity outside of the center.

IMPLICATIONS

This study could help inform more thorough future research involving a more developed app, a longer time frame of study, and/or a larger testing population. Design logistics from development of this app could be used in the future to make apps that are more tailored to other types of patients. With fewer time constraints, researchers could obtain clearance to deliver notifications to the user's phone and allow healthcare providers access the users' accounts in the app. The app, upon further research and development, could not only be better designed, but could also expand to various versions to address conditions other than obesity.

That being said, this study has a number of interesting qualitative points to contribute to the fields of biomedical visualization, nutrition, and patient care. Considering the feedback from both phases of patient testing, results indicate that iterative design in general has an important role in the development of these kinds of applications. Though the patient using the final developed app indicated a dislike for health apps in general, points about specificity in content, frequency of updates, and methods of communication are notable for future development

projects and could hold enormous value in future studies.

APPENDIX A

PHASE 1 FOCUS GROUP QUESTIONNAIRE

-What is a day to day experience like with this patient population?

-What kinds of questions does this patient population have and what are their most pressing concerns?

-What kind of nutritional knowledge do they have and what materials are already provided to them?

-How comfortable is this patient population in talking with their physicians?

-How much does this patient population know about their condition?

-What kinds of content should appear on the screen when patients first open the app?

-What content is a priority that the patients should know?

-Should patients see their weight right when they open the app or should they have to press more buttons to find it?

-How detailed should the nutrition information and scientific facts be?

-How personalized should/can the nutrition and exercise information be?

-Is the interface of this app inviting to a user?

-Is the home screen of the app intuitive and gives just the right amount of information?

-Can you easily get to any given location in the app within five clicks?

-Are the colors pleasing to your eye?

-Is the text large enough to read easily but not so large that it is overwhelming?

-What kinds of food do you currently eat, and do you have an idea of what might make them healthier?

-What is the number one reason you think you do not consume healthy foods?

Tasks they will be asked to complete:

-Where would you go to talk to your healthcare provider?

-Where would you go to look at past nutrition information?

-Where would you go to input your exercise prescription and exercise goals for the day?

-Where would you go to learn about obesity facts?

-Where would you go to change the number of notifications the app gives you?

-Where would you go to check on your workout buddy and customize it?

-Where would you go to look at how many points you have?

APPENDIX B

PATIENT TESTING QUESTIONNAIRES

a. Comfort testing

Would you recommend this physician to other friends that might be suffering from the same problem as you?

1 2 3 4 5 6 7 8 9 10

Were the physician's instructions clear?

1 2 3 4 5 6 7 8 9 10

Did the physician answer the questions you might have had?

1 2 3 4 5 6 7 8 9 10

Did you feel comfortable asking the physician questions?

1 2 3 4 5 6 7 8 9 10

Did you feel like you were treated with respect during physician visits?

1 2 3 4 5 6 7 8 9 10

Is the physician approachable?

1 2 3 4 5 6 7 8 9 10

How easy is it for you to compose a balanced meal at home?

1 2 3 4 5 6 7 8 9 10

How well do you manage to choose accurate and relevant information from the vast variety available on the internet?

1 2 3 4 5 6 7 8 9 10

How easy is it for you to evaluate if a specific food is relevant for a healthy diet?

1 2 3 4 5 6 7 8 9 10

b. Knowledge testing

How many calories should I be eating in order to lose weight?

How many calories are in 1g of fat, protein, and carbohydrate respectively?

How much water should I be drinking a day?

Drinking water is not important in my weight loss and healthy lifestyle process.

Vitamins are a source of energy.

How many servings of vegetables should I be eating in a day?

I need to buy organic, expensive food in order to be healthy.

What is one thing I can change about my diet in order to make me healthier?

Food advertisements are a good source of nutritional information.

As a rule of thumb, I should eat food with ___% saturated fat.

Everyone should be eating 2.000 calories a day.

Juice and soft drinks are a good replacement for water.

Exercising is crucial to my weight loss process.

A healthy adult should have 150 minutes of moderate exercise a week.

Taking the stairs instead of using the elevator can have an impact on my health.

Walking instead of driving can have an impact on my health.

Which breakfast is the healthiest breakfast for you to eat?

Which of these foods are lowest in fat?

Sugar gives you energy, so you should eat a lot of it.

Drinking alcohol causes weight gain.

What types of food would you eat the most of if you were to eat a well balanced diet?

Replacing whole milk with skim milk will have an impact on my health.

If you can’t do thirty minutes of physical activity, it is best to not try at all.

Sitting for more than eight hours a day is harmful to my health.

Eating turkey and fish is healthier than eating beef and bacon.

I am tired of drinking water, and am craving something sweet. Which drink should I choose in order to be healthy?

APPENDIX C

Approval Notice
Initial Review (Response to Modifications)

December 18, 2018

Shariwa Oke, BA
Biomedical and Health Information Sciences
Phone: (480) 205-2189

RE: **Protocol # 2018-1449**
"Creating an Interactive Aid to Mediate Obesity Diagnoses and Management through Visualization"

Dear Dr. Oke:

Your Initial Review application (Response to Modifications) was reviewed and approved by the Expedited review process on December 18, 2018. You may now begin your research.

Please note the following information about your approved research protocol:

All approved and stamped recruitment/consent documents must be accessed via OPRSLive and are located in the investigator's specific protocol workspace under the "Approved Documents" tab.
Please note that approved and stamped recruitment documents no longer expire so need not be submitted for re-approval.

Protocol Approval Period: December 18, 2018 - December 17, 2021
Approved Subject Enrollment #: 45
Additional Determinations for Research Involving Minors: These determinations have not been made for this study since it has not been approved for enrollment of minors.
Performance Site: UIC
Sponsor: None
Research Protocols:

a) Creating an Interactive Aid to Mediate Obesity Diagnoses and Management through Visualization;11/27/2018
b) Creating an Interactive Aid to Mediate Obesity Diagnoses and Management through Visualization (no footer)

Recruitment Materials:

a) Recruitment Script; Version 1; 11/26/2018
b) Recruitment Script; Version 1; 11/26/2018
c) Eligibility Checklist (no footer)
d) Information Handouts (no footer)

Informed Consents:

a) Phase 1; Version 3; 12/13/2018
b) Phase 2; Version 3; 12/13/2018
c) A waiver of informed consent, under 45 CFR 46.116(d), and access to medical records preparatory to research has been granted only for initial identification and recruitment of potential subjects

HIPAA Authorization:

a) A waiver of informed consent, under 45 CFR 46.116(d), and access to medical records preparatory to research has been granted only for initial identification and recruitment of potential subjects

Your research meets the criteria for expedited review as defined in 45 CFR 46.110(b)(1) under the following specific categories:

(5) Research involving materials (data, documents, records, or specimens) that have been collected, or will be collected solely for non-research purposes (such as medical treatment or diagnosis),
(6) Collection of data from voice, video, digital, or image recordings made for research purposes., (7) Research on individual or group characteristics or behavior (including but not limited to research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

Please note the Review History of this submission:

Receipt Date	Submission Type	Review Process	Review Date	Review Action
11/13/2018	Initial Review	Expedited	11/18/2018	Modifications Required
11/28/2018	Response To Modifications	Expedited	12/05/2018	Modifications Required
12/13/2018	Response To Modifications	Expedited	12/18/2018	Approved

Please remember to:

→ Use your **research protocol number** (2018-1449) on any documents or correspondence with the IRB concerning your research protocol.

→ Review and comply with all requirements on the OPRS website under:
"UIC Investigator Responsibilities, Protection of Human Research Subjects"

Please note that the UIC IRB has the prerogative and authority to ask further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

Please be aware that if the scope of work in the grant/project changes, the protocol must be amended and approved by the UIC IRB before the initiation of the change.

We wish you the best as you conduct your research. If you have any questions or need further help, please contact OPRS at (312) 996-1711 or me at (312) 996-2014.

Sincerely,
Sandra Costello
Assistant Director, IRB # 2
Office for the Protection of Research Subjects

All approved and stamped recruitment/consent documents must be accessed via OPRSLive and are located in the investigator's specific protocol workspace under the "Approved Documents" tab.

1. **Informed Consent Documents:**
   a) Phase 2; Version 3; 12/13/2018
   b) Phase 1; Version 3; 12/13/2018
2. **Recruiting Materials:**
   a) Recruitment Script; Version 1; 11/26/2018
   b) Recruitment Script; Version 1; 11/26/2018
   c) Eligibility Checklist (no footer)
   d) Information Handouts (no footer)

cc: Anthony Faiola, Biomedical and Health Information Sciences, M/C 530
Samantha Bond,

APPENDIX D

TIPS ON HEALTHY LIVING

In order to maintain your weight, watching what you eat is really important. Eating 500 calories less daily will help you lose 1lb a week! Here are some tips and tricks to eating healthier every day!

Avoid these simple carbohydrates found in processed, refined or added sugars that do not contain any nutritional value:

- Candy
- Carbonated beverages, such as soda
- Syrups
- Table sugar
- Added sugar

Complex carbohydrates, often referred to as "starchy" foods, include:

- Legumes
- Starchy vegetables
- Whole-grain and fiber

Get more complex carbohydrates and healthy nutrients by eating more fruits and vegetables. Choose fiber-rich whole grains for most grain servings.

One-Dollar a Serving Food

Frozen Mixed Vegetables

- Great for: quick side dish, add to soups/stews
- What's a serving? ½ cup cooked
- Nutrition Info per serving: 59 calories; 4g fiber, 78% Daily Value for vitamin A, 5% Daily Value for vitamin C, 4% Daily Value for potassium

Lentils (cooked)

- Great for: Soups and stews, cold bean salads and casseroles
- What's a serving? ½ cup cooked
- Nutrition Info per serving: 115 calories, 9g protein, 8g fiber, 18% Daily Value for iron, 10% Daily Value for potassium

Oranges (fruit 2-7/8" diameter)

- Great for: Snacks, green salads and fruit salads
- What's a serving? 1 large or extra large orange
- Nutrition Info per serving: About 70 calories, 3g fiber, 138% Daily Value for vitamin C, 7% Daily Value for potassium

Pearled Barley (cooked)

- Great for: Soups and stews, cold salads and casseroles
- What's a serving? 1/2 cup (cooked)
- Nutrition Info per serving: 97 calories, 3g fiber, 6% Daily Value for iron

Homemade or Canned Beans (kidney, pinto, garbanzo or navy)

- Great for: Green salads, casseroles, stews, hummus and chili. Types of beans range from 50% less sodium kidney beans and black beans to white beans and garbanzo beans.
- What's a serving? Each can contains about 3.5 (1/2-cup) servings.
- Nutrition Info per serving (for canned kidney beans): About 105 calories, 7g protein, 7g fiber, 8% Daily Value for iron, 9% Daily Value for potassium

Spinach (raw)

- Great for: tossed salads, steamed as a side dish
- What's a serving? 1 cup raw or ½ cup cooked
- Nutrition Info per serving (1 cup raw): 7 calories, 0mg cholesterol, 1g fiber, 56% Daily Value of vitamin A, 14% Daily Value for vitamin C, 5% Daily Value of iron, 5% Daily Value for potassium

Baby Carrots (raw)

- Great for: Snacks, casseroles, stews, veggie platters and side dishes
- What's a serving? 8-10 baby carrots (3 oz)
- Nutrition Info per serving: 30 calories, 2.5g fiber, 234% Daily Value for vitamin A

Exercise Fact Sheet

Aim for at least 150 minutes of moderate physical activity or 75 minutes of vigorous physical activity (or an equal combination of both) each week.

Exercise and physical activity are different! Physical activity is any movement that you do with your arms and legs. Exercise is an intentional, repetitive movement done only for the reason of keeping you physically fit.

Don't get discouraged if you stop for a while. Get started again gradually and work up to your old pace.

Physical activity reduces depression and anxiety.

Physical activity decreases fat around the waist and total body fat, slowing the development of abdominal fat, which greatly contributes to obesity, and other diseases. Physical activity may not change the numbers on the scale, but you may be increasing or strengthening those muscles.

To stay at a healthy, most people will need an hour a day of physical activity. It is ideal to get 30 minutes of exercise a day but if you don't have time or the energy to do all 30 minutes don't sweat it! You can break this up by doing 10min of exercise three times a day. Anything that gets you moving like walking is exercise or taking the stairs, or lifting weights is exercise. Just keep moving!

Physical activity increases total energy expenditure, which is important to "break even" with how many calories you are eating.

Nutrition Fact Sheet

Make your own salad dressings by mixing healthier kitchen oils (such as olive oil) with vinegar and herbs. You can also make healthier version of your favorite creamy dressings by blending low-fat sour cream or cottage cheese and low-fat buttermilk and adding fresh herbs like dill, tarragon or chives.

Choose poultry and fish and limit red meat. Always look for leaner pieces and trim away skin and visible fat before cooking.

Use nonstick cooking spray instead of greasing bakeware with butter or shortening. And use it in skillets instead of butter for cooking. If you need to lower your blood cholesterol, reduce saturated fat to no more than 5 to 6 percent of total calories.

Not everyone needs 2,000 calories a day. You may need more or less depending on several factors including your level of physical activity and exercise, and whether you want to lose or maintain your weight.

Remember: Protein and carbohydrates each have 4 calories per gram, while fat has 9 calories per gram.

Choose fresh over canned to get the biggest bang for the buck in terms of vitamins and minerals, but if you must, choose canned fruits packed in juice rather than syrup. You can cut down on a lot of extra and unnecessary sugar that way! Refined simple sugars provide calories but they have very little nutrition.

Use frozen or canned fish and poultry for a quick and easy meal. Choose the options canned in water and watch sodium content.

APPENDIX E

OBESITY FACTS

What is obesity?

Obesity and overweight are defined as abnormal or excessive fat accumulation that could be harmful to health. Overweight is a BMI of equal to or over 25, and obesity is a BMI of equal to or over 30. BMI is a ratio of your height and weight.
Some effects of this harmful fat accumulation are diseases such as diabetes, heart disease, stroke, and certain types of cancers.

Why does it occur?

Fat accumulates as a result of more energy (calories) in than energy out. Anything you eat has energy in the form of calories. If this energy doesn't get used up fairly quickly, then it will eventually get stored as fat, which is your body's preference to store energy. Over time, this fat accumulates and you can start seeing the difference, on your body and on the scale.

What is happening in my body?

In our bodies, fat can be deposited in many places. Some of the most common places of fat deposition are in the lower body (hips and buttocks), and in the abdominal area. The fat in the lower body is called subcutaneous fat and leads to a pear shaped body. The fat in the abdominal area is called visceral fat and leads to an apple shaped body. Visceral fat is directly linked with higher total cholesterol and LDL (bad) cholesterol, lower HDL (good) cholesterol, and insulin resistance. Some more specific effects it can have on the body are:

Insulin resistance that leads to diabetes:

Insulin is what your body secretes in order to take care of sugar in your bloodstream. Insulin resistance is when there is so much insulin produced that your body stops responding to it. This is how Type II diabetes sets in.
There are a lot of reasons why increased fat could lead to insulin resistance. One possibility is that visceral fat (fat around your waist) could secrete certain other hormones that make it harder for tissues to respond to insulin.

Make your brain feel like it needs to eat all the time:

"Leptin" is a hormone that tells your body that it is full. Studies have shown that that the more fat you have, the less effective that leptin is in conveying that message to your body. This makes you eat more, resulting in more calories in, which leads to more fat accumulation!

Lead to infertility:

Fat is essential in regulating fertility and sexual development. If there isn't enough fat in teens, sexual maturation is often delayed. In adults, not enough fat can also lead to infertility. It is so important because of the hormones it releases, some of which are very beneficial.
When there is too much fat, it begins to decrease the release of beneficial hormones, like adiponectin, and increase the release of other hormones that are harmful in large quantities. One of these hormones is leptin (as we saw earlier). Leptin has a lot of effects on other hormones that lead to an inability to conceive a child and complications after conception.

Helpful links:

- http://www.obesitycampaign.org/obesity_facts.asp
- https://www.heart.org/en/healthy-living/healthy-lifestyle
- https://www.cdc.gov/healthyschools/obesity/facts.htm

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VITA

EDUCATION

August 2017- Present **University of Illinois at Chicago**
Masters of Science in Biomedical Visualization
Thesis: "Creating an Interactive Aid to Mediate Obesity Diagnoses and Management Through Visualization"

August 2013- May 2017 **University of Arizona**
Bachelors of Science in Health Sciences in Physiology with Honors
Bachelors of Science in Nutrition
Minors: Studio Art, Biochemistry, Spanish
Magna cum laude
Thesis: "EPIDEMIC: An Abstraction of the Physiological and Psychological Causes and Effects of Obesity"

PROFESSIONAL

May 2018- Present **Graphic Designer and Website Coordinator**
Masters Graduate Assistant
Department of Obstetrics and Gynecology
University of Illinois at Chicago

November 2018 **Research Assistant**
Microbiology Lab
University of Arizona

SCIENTIFIC AND PROFESSIONAL SOCIETIES

August 2017- Present Student Association of Medical Artists
Social Chair, August 2018-Present

January 2018 - Present Association of Medical Illustrators

PRESENTATIONS AND EXHIBITS

February 2019 Scientific Sketches and Subsurface Scattering: Capturing the Beauty Within
Student Exhibit, Chicago, Illinois

November 2018 Applied Health Sciences Research Day
Research Poster Presentation, Chicago, Illinois

March 2018 Tides of India
Co-Exhibitor, Phoenix, Arizona

March 2018 Art with Heart
Student Exhibit, Chicago, Illinois

May 2017 Honors Student Showcase
Thesis Presentation, Tucson, Arizona

November 2016 Symbiosis: An Exhibit of Biological Art
Student Exhibit, Tucson, Arizona

November 2015 Symbiosis: An Exhibit of Biological Art
Student Exhibit, Tucson, Arizona

PUBLICATIONS

Phillipis, SA., Ali, M., Modrich, C., **Oke, S.**, Bond, S. (2019). Advances in Health Technology and Implementation in the Era of Healthy Living: Implications for Precision Medicine. Forthcoming in: Progress in Cardiovascular Diseases.
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AWARDS AND HONORS

February 2019 Chancellor's Student Service and Leadership Award

May 2017 Academic Year Academic Distinction
Dean's List

May 2016 Academic Year Academic Distinction
Dean's List

May 2015 Academic Year Academic Distinction
Dean's List

May 2014 Academic Year Academic Distinction
Dean's List with Distinction

April 2014 Honors Student Council Travel Award

August 2013 Asian American Scholar

May 2013 National Merit Scholar