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Weight Management of Diabetic Patients: Can Text Messaging Help?

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ABSTRACT

The prevalence of obesity and diabetes have steadily increased over the past three decades with projections calling for 83% of men and 72% of women becoming overweight or obese by 2020; similarly, the incidence of women with diabetes is projected to increase from 37 % to 44% (Shute, N., 2011). These drastic increases have brought about a dramatic growth of innovative disease management tools that have proven to increase patient control over their disease as well as enhance patient-practitioner correspondence. The literature provided information involving the use of text messaging to prompt the patients to increase their adherence to the treatment regime to help control their BMI levels and overall obesity rates through out the study. The purpose of the study is to examine the extent to which a text messaging intervention can effectively reduce overweight/obesity in adult diabetic patients. More specifically, our research questions are: (1). Is a text messaging intervention efficacious at reducing overweight/obesity in adult diabetic patients? (2). Does a text messaging intervention have a differential effect on reducing overweight/obesity in adult diabetic patients based on their socio-demographic characteristics, and glucose level? The secondary analysis of 133 diabetic patients in Denver, Colorado concluded that despite the vast amounts of literature supporting the use of text messaging, the weight and BMI of these patients did not alter during the study, shifting from a mean BMI of 33.7 to 33.6. This study provided insight into the need for further examination between the factors linking diabetes and obesity as well as the use of technology to help enhance disease adherence. Recommendations for this study include using a larger population with a wider variety of age and socioeconomic status as well as using multiple tools to measure obesity such as abdominal circumference and skin folds tests.

INTRODUCTION

The alarming increase in the prevalence of diabetes and obesity constitutes a serious public health and financial burden in the United States. (Karmally, W. et al., 2012). According to most recent estimates of the Behavior Risk Factor Surveillance System (BRFSS, 2013), one out of ten people in the US suffers from diabetes, and more than six out of ten Americans are either overweight (36%) or obese (29%). Several health initiatives have been developed to address this national crisis, for example, two of Healthy People 2020's goals refer to overweight and obesity rates in the US. Goals NWS-8 and 9 specifically refer to increasing the proportion of adults who are at a healthy weight from 30.8% to 33.9%, and decreasing the proportion of the adult population who are obese, from 33.9% to 30.5% respectively. The latter was added to the Leading Health Indicators (LHI) subset of Healthy People, this category is reserved for objectives that are acknowledged as high-priority health issues (Healthy People 2020, 2014). Along with objectives for weight management, Healthy People also developed numerous goals to reduce the incidence of diabetes in the population from 8.0 new cases of diabetes per 1,000 population to 7.2 new cases in the population aged 18-84 years. They also have created a LHI objective that pertains to a reduction in the proportion of individuals with diabetes with an A1c value greater than 9% from 17.9% to 16.1% (Healthy People 2020, 2014). Both diabetes and obesity are serious epidemics in their own accord, but research has concluded that obesity alone is the best predictor of undiagnosed diabetes. A study by Klein Woolthius, E.P., et al., 2009, targeted a variety of low to high-risk patients who were seen during their primary care visits. After testing for numerous variables, the researchers concluded that during these visits targeting middle age to older adults with obesity could act as an opportunistic screening for type 2 diabetes (Klein Woolthius, E.P., et al., 2009).

There have been countless efforts made to decrease the prevalence of diabetes and obesity in the past couple years, and at the forefront is the state of Colorado, which has instigated health promotion initiatives to curb the diabetes and obesity epidemics. In May 2013, Colorado's governor, John Hickenlooper, announced the new health policy agenda. This report, *The State of Health: Colorado's Commitment to Become the Healthiest State,* discusses the states strengths, weaknesses and outlines 18 initiatives to help the state achieve its goals. The initiatives are based off of four focus areas including (1) promoting prevention and wellness, (2) expanding coverage, access, and capacity, (3) improving health system integration and quality, (4) enhancing value and strengthening sustainability. Each initiative is accompanied by specific metrics that enables their progress to be tracked (Office of the Govenor, 2013). Despite efforts like *The State of Health*, these health conditions continue to pose a societal conundrum as 260,336 adults in Colorado (6% of the population) have diabetes. Of these, 36% and 46% are considered overweight and obese, respectively (BRFSS, 2013). The conjunction of these two conditions is particularly problematic, as it increases risk of mortality. Moreover, obesity constitutes an additional impediment in the management of diabetes, particularly in certain racial/ethnic groups such as African Americans and Hispanics who are already facing socioeconomic hurdles, or live on the brink of poverty. *The State of Health* report states that tackling obesity is it's first initiative towards creating a healthier state and has created an Obesity Integration Project, which identifies, selects, and prioritizes evidence-based public health strategies that will be the most effective at reducing obesity and best use the state's resources (Office of the Govenor, 2013). Initiatives like this have brought Colorado to the forefront of the battle against obesity and have helped propel them to one of the healthiest states in the US.

A series of additional health care initiatives have been undertaken in Denver, Colorado. The Denver Health Organization created the Healthy Eating, Active Living (HEAL) program to help combat the obesity issue. The HEAL program includes many activities such as: facilitating the Metro Denver Partnership for Healthy Beverages, evaluation of the Mayor's Children's Cabinet goal to reduce obesity by 1% annually, implementation of Colorado's Healthy Hospital Compact to improve the food and beverage environment to make healthy options easy and routine, and the development of an Adult and Childhood BMI registry, along with many others (Denver Health, 2013). Colorado has also implemented a program: Diabetes Self-Management Education (DSME) to facilitate knowledge, skills and abilities that are necessary for diabetes self-care. This program has shown to be associated with higher patient adherence to preventive care practice leading to lowering average costs of patient care (Needs Assessment Examining Diabetes Self-Management in Colorado, 2009). The outcomes of this study shows that the prevalence of diabetes has doubled in the past 15 years, and is markedly escalated beginning at 55 years of age for all ethnicities. The evidence shows that individuals who have taken a self-management class are more likely to participate in preventative practices such as: daily self-monitoring blood glucose, annual A1C tests, annual foot and eye exams and an annual cholesterol check. These tests provided baseline data for the BRFSS to collect annual data to evaluate the use and effectiveness of programs like DSME (Needs Assessment Examining Diabetes Self-Management in Colorado, 2009). Although many forms of diabetes education has been tried and most have positive results, the rising prevalence of diabetes urges for new methods to be developed. Text messaging is a concept using cellphone technology to reach larges segments of the population, like those at risk for diabetes and providing them with

important health information (Center for Disease Control, 2014). For example, the use of text messaging as an efficacious weight management tool in diabetic adults has not been investigated.

LITERATURE REVIEW

Obesity

Despite the overwhelming number of initiatives and tools available to help patients lose weight, the incidence of overweight adults has steadily increased over the past three decades. In 2009-2010 more than 35 % of US men and women were obese and if these trends continue, it is projected that 86.3% of the adult population will be come overweight or obese (Hu, Y., Bhupathiraju, de Koning, Hu, F.B., 2014). Nearly one of every ten American deaths can be associated with obesity; similarly, obesity has been tied to costing our society $223 billion a year (Obesity in America, 2012). There are many theories as to why obesity has increased by over 50%. One theory focuses on obesity in the work place and how over the past 50 years jobs have shifted from requiring moderate physical activity to less than 20% demanding little to none. Americans are now burning approximately 142 fewer calories each day than the average man in 1960's; which surprisingly adds up, so much so that between the years 1960-1962 the average male weighed 169 lbs to an average of 202 lbs from 2003-2006. (Obesity in America, 2012). Obesity has proven to be a complex and controversial issue in America; it has become a clinical challenge for healthcare professionals to advocate healthy lifestyles to their patients who want to embrace their size and find anything less offensive (Obesity in America, 2012). Many argue that becoming obese isn't entirely their fault, and they blame the increasing prices of health foods compared to non-healthy foods as a main decision factor in their eating habits. In the US, baked chips, lean meats, and wholegrain pasta costs 20-60% more than fried chips, regular fat meats,

and white pasta. Similarly, studies have found that a 10% increase in the price of fruits and vegetables leads to a 3.2% reduction in consumption, which verifies that food prices have the potential to influence food consumption (Lee, Ralston, & Truby, 2011). The costs associated with eating healthy and leading healthier lifestyles can be contributed towards the increasing obesity rate, and decreasing health status of many low-income families.

While many people are concerned with the rising rates of obesity, there should also be an increased focus on and of the complications of obesity. Obesity has the potential to develop numerous serious health problems, including: high triglycerides and low HDL cholesterol, hypertension, heart disease, stroke, breathing disorders, osteoarthritis, and type 2 diabetes to name a few. Along with the physical side effects of obesity are the even more over-looked psychological effects and how it lowers an individual's quality of life. Weight related issues are commonly seen associated with: depression, sexual problems, shame and guilt, social isolation and lower work achievement. (Mayo Clinic, 2014). Countless studies have shown correlations between the degree of body weight as a risk factor for many chronic diseases, especially with regard to Type 2 Diabetes Mellitus and cardiovascular diseases (Hu, Y., Bhupathiraju, de Koing, Hu, F.B., 2014).

Body Mass Index

Body Mass Index (BMI) is commonly used to classify adult patients as underweight, normal range, overweight and obese. Other less commonly used methods to measure body fat include: skinfold thickness measurements using calipers, underwater weighing, bioelectrical impedance, dual-energy x-ray absorptiometry (DXA), and isotope dilution. But unlike BMI measurements these methods are not readily available, are typically more expensive and are

difficult to standardize (Centers for Disease Control, 2011; Kuczmarski, Ogden, Guo & al., 2000). BMI involves using a mathematical equation in which the weight in kilograms is divided by the square of the patients height in meters. The answer given is then correlated into different cut off points for the underweight, normal, overweight and obese categories. The World Health Organization (WHO) classifies underweight as under 18.50, normal range between 18.50- 24.99, overweight as equal to or over 25, and obese as equal to or over 30.00. As the numbers increase they further diagnoses obesity as obese class I (30.00-34.99), obese class II (35.00-39.99), and obese class III (equal to or over 40.00)(World Health Organization, 2014). BMI values are age-independent and the same for both sexes, ethnicities and body type, which could lead to possible discrepancies with the tool (World Health Organization, 2014). According to the Center for Disease Control (CDC), while the correlation between a given BMI number and body fatness is fairly strong, the correlation varies by sex, race, and age. For example, at the same BMI, women tend to have more body fat than men and highly trained athletes may have a high BMI because of increase muscularity rather than increased body fatness (Center for Disease Control, 2011). The CDC also states that according to the National Heart, Lung, and Blood Institute, BMI is only one factor related to risk for disease, it's also important to look at the individuals waist circumference and other disease conditions associated with obesity like high blood pressure (Center for Disease Control, 2011).

Diabetes Mellitus

The term diabetes has become a common in most everyday language. With 26 million Americans suffering from diabetes, it is easy to see why, but many don't fully understand what diabetes involves. Diabetes Mellitus (DM) is a disease that affects the way the body uses blood

sugar or glucose. Specifically, those who suffer from DM have too much glucose in the blood either from a lack of insulin development from the pancreas (Type 1), or have cells that are resistant to the insulin the pancreas creates (Type 2) ("Diabetes: Taking charge of your health", 2014). On a global basis the incidence of DM has increased dramatically over the past decade, affecting 6.4% of adults (285 million adults) in 2010 and is projected to affect 7.7% (439 million adults) by 2030 (Shaw, Sicree, Zimmet, 2010). DM has also become a leading cause of morbidity and substantial life altering complications such as cardiovascular diseases, retinopathy leading to blindness, lower limb amputations and possible renal failure (Wong et al., 2013). In 2008, there were 1.8 million premature deaths caused by type 1 and type 2 diabetes, with over 80% of those deaths occurring in low and middle-income countries (Free, 2013). This dramatic increase in the number of affected individuals along with the high number of deaths related to diabetes is concerning which helps bring new innovative ways to combat chronic diseases such as DM.

Management of DM requires multiple education requirements specifically towards: glucose monitoring, weight, exercise, diet, complications, and medication administration. Along with the education, successful control of DM requires continuous communication between patient and healthcare provider (Hussein, Hasan, Jaradat, 2011). Lately, there has been an increased prevalence with diabetes and costs of managing the disease having a significant negative impact on health outcomes. These issues call for the need of diabetes management that is innovative and cost-effective for high-risk, low income patients (Burner, Menchine, Kubicek, Robles, Arora, 2014).

Obesity related to Diabetes

El-Hazmi and Warsy, state that obesity and diabetes can be classified as the odd couple; meaning that you often see diabetic patients who are obese, but also frequently see obese patients developing diabetes (2000). Excessive body fat has also been linked to insulin resistance through adipose tissue releasing increased amounts of non-esterified fatty acids, glycerol, hormones, pro-inflammatory cytokines and other factors that are involved in the development of insulin resistance. This becomes an issue when these increased amounts are accompanied with dysfunction of pancreatic islet β-cells, which release insulin, creating further failure to control blood glucose levels (Kahn, Hull, Utzchneider, 2006). But most obese individuals retain normal functioning islet β-cells that can compensate for the decreased insulin sensitivity. Insulin sensitivity is not solely reserved to obese individuals; lean subjects that have peripherally distributed fat are more insulin sensitive than those who have centrally distributed fat.

Throughout the literature there have been very few definitive answers linking obesity and diabetes, but there are many proposed connections. One of these connections includes the way insulin acts on the hypothalamus to regulate body weight. For example, a β-cell dysfunction would lead to a reduction in insulin which would be expected to cause a reduction in the action at the hypothalamus, creating weight gain and increased insulin resistance (Kahn, Hull, Utzchneider, 2006). Decreased insulin production can also affect the liver by no longer causing inhibition of hepatic glucose production which in turn causes an increased plasma glucose level. The increase in plasma glucose level is further increased with decreased insulin production because of the decreased efficiency of glucose uptake from the muscles which adversely affects the β-cell health leading to further weight gain (Kahn, Hull, Utzschneider, 2006). This example

provides a connection between the principal sign of impaired islet β-cells which is commonly seen with diabetes and how their decreased functioning can cause obesity. The systematic complications endured by the DM disease process leaves most with outrageous medical bills that many are unable to cover, or causes uninsured patients to be denied services leading to even greater manifestations of the disease.

Obesity, Diabetes and Insurance Coverage Disparities

With the new healthcare initiatives there is an expectation for more US citizens to become insured but even with these improvements, studies have found disparities in quality for certain racial/ethnic and socioeconomically disadvantaged groups (Hu, R., Shi, L., Rane, S., Zhu, J., & Chen, C., 2014). Hu, Shi, Rane, Zhu, and Chen's study used the Diabetes Care Survey of 2010 Medical Expenditure Panel Survey to examine the link between quality of diabetes care and type of insurance coverage, race/ethnicity and socioeconomic status (SES). This study found that those patients with private insurance or Medicare/Medicaid were more likely to receive quality diabetes care than the uninsured, but only few significant disparities based on race/ethnicity or SES. Suggesting that insurance coverage makes the greatest impact in ensuring quality diabetes care, regardless or race or SES (Hu, R., Shi, L., Rane, S., Zhu, J., & Chen, C., 2014). While their study didn't find a direct impact on diabetes care based on race, there are numerous studies that highlight the inequalities related to race and the acquisition of insurance coverage. Kail, B.L., & Taylor, M.G., (2014) completed a study of racial disparities in health focusing on disparities and limitations among Medicare age-eligible Americans. Their study found that African Americans have limited access to private insurance, which may be an important aspect of SES inequality

stimulating the difference between Caucasian and African Americans (Kail, B.L., & Taylor, M.G., 2014).

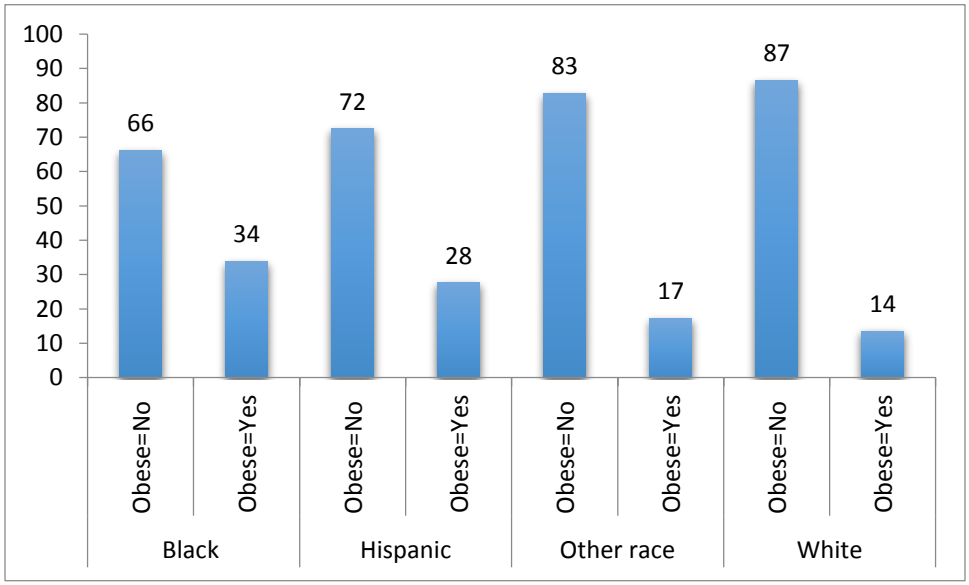
In disabled older adults, ethnic disparities have been linked to mortality, depression, loss of earnings, increased medical expenditures, and the ability to actively participate in society (Kail, B.L., & Taylor, M.G., 2014). Kail and Taylor found the relationship between racial groups and disability was facilitated by differences in access to care, Medicare/ Medicaid coverage and supplemental insurance coverage (Kail, B.L., & Taylor, M.G., 2014). While there are many different factors integrated into the relationship between racial disparities, insurance coverage, and overall health of individuals, what can be certain is that insurance coverage has a positive impact on the health of individuals.

The State of Diabetes and Obesity in Colorado

In the past year, the rate of diabetes in Colorado has decreased by from 7.4% to 6.5% of adults, which denotes Colorado as having the lowest rate of diabetes the US. Not only has the prevalence of diabetes decreased over the past couple years; the state also has the lowest prevalence of obesity at only 21.3% and physical inactivity at 16.2% (America's Heath Rankings, 2014). The America's Health Rankings organization has been around for 25 years and helps provide a holistic view of the nation's health. They observe each state and evaluate its health outcomes by comparing the behaviors, clinical care, community and environment, and policies of each state (America's Health Rankings, 2014). Through these evaluations they found some significant differences when observing obesity by race. While the state has a low obesity rate of 21.3%, African Americans (29.5%), Hispanics (30.5%), and American Indians (23%) together comprised an astonishing 90%. But, Caucasians didn't fall too far behind with 18.7%,

and Asian Americans comprised the least amount at 9.8% (America's Health Rankings, 2014). There is not only discrepancies between race, when looking at diabetes prevalence, males have continuously had higher rates of diabetes than females with a difference of 8.2% of males and 6.3% of females in 2012 (National Diabetes Surveillance System, 2012). These differences, while small, share an insight as to where the state needs to focus its preventative health care. Another factor that could be effecting the obesity rates is that 14.4% of the population doesn't have health insurance. Factors like this could negatively affect the health outcomes of Colorado. In fact, even though Colorado has the lowest diabetes, obesity, and physical inactivity prevalence, it is only ranked 8th in overall health compared to other states (America's Health Rankings, 2014).

Graph 1- Percent of Obese Adults in Colorado based on BMI (%)



Source: Colorado Behavioral Risk Factor Surveillance System, 2011-2012

An important aspect is to contrast Colorado to the Nation as far as obesity and diabetes go please see http://www.americashealthrankings.org/

Information Technology

The World Health Organization (WHO) recommends that providers use innovative care techniques for chronic conditions, pointing out that patients should receive care in many forms, not exclusively face-to-face visits (Zolfaghari, Mousavifar, Pedram, Haghani, 2011). To compliment this objective, the amount of technology available for use by healthcare workers has significantly increased over the years. A recent systematic review examined the use of texting and mobile reminders for chronic disease management and other health care services. They found that 77% of the studies showed improved outcomes for patients that used SMS reminders, indicating its beneficial use in health care settings (Kannisto, Koivunen, & Valimaki, 2014). Nine out of ten US adults use a mobile phone regularly, with the fastest growing markets being African Americans and Hispanic users and low-income families. The universal availability of cell phones allows for instant connection to data collection and intervention apparatuses to further help in the treatment of patients. Cell phone use has also been associated with an increase of health knowledge (Fischer, H.H., et al., 2012). With this instant connection there is evidence that patients are more inclined to stick to their treatment regime than with other forms of medication reminders (Kaplan & Stone, 2012). For example, previous literature has shown that cell phone based text messaging was associated with improved glycemic control when used in treatment plans for diabetic adults (Fischer, H. H. et al, 2012). The use of text messaging has also become easier for providers to use, many programs use web-based SMS messaging services that allows a large number of text messages to be sent at one time to different mobile numbers which

decreases the cost and time of implementing the service (Wong et al., 2013). The use of technology in the medical field has limitless possibilities, and we will continue to see technological advances in the coming years to further increase patient satisfaction and treatment.

Researchers in Denver, Colorado conducted a quasi-experimental pilot study to assess the use of text messaging to provide support and reminder notifications to help patients more successfully control their diabetes. The Westside Family Health Center, where the study took place, caters to a predominantly Latino population (81%) that is either uninsured (41%) or on Medicaid or Medicare (56%), but all participants were confirmed to have access to a cell phone (Fischer, H. H. et al, 2012). The researches created a software program, Patient Relationship Manager (PRM), to help send text messages and process the patients' responses. Over the three month period, messages were sent requiring a fasting blood sugar readings at 0715 on every Monday, Wednesday, and Friday, appointment reminders were also sent out to each patient three times before the schedule appointment during the study period (Fischer, H. H. et al, 2012). Based off of this pilot study the following research questions were constructed.

PURPOSE OF THE STUDY AND RESEARCH QUESTIONS

The purpose of the study is to examine the extent to which a text messaging intervention can effectively reduce overweight/obesity in adult diabetic patients. More specifically, our research questions are:

1. Is a text messaging intervention efficacious at reducing overweight/obesity in adult diabetic patients?

2. Does a text messaging intervention program have a differential effect on reducing overweight/obesity in adult diabetic patients based on their socio-demographic characteristics, and glucose level?

HYPOTHESES

Hypothesis 1: Text messaging intervention reduces overweight/obesity in adult diabetic patients.

Hypothesis 2: There are statistically significant differences in overweight/obese adult diabetic patients who receive the intervention with regards to their race/ethnicity, gender, age group, type of insurance, and glucose level.

METHODOLOGY

Data Source and Sample

This research study is based on secondary data from a feasibility study conducted for a period of 6 months in Denver Colorado (2011-2012)*. The study was conducted among 133 adult patients in possession of cell phones who receive regular treatment at federally qualified community health centers which serve an urban population that is predominantly either uninsured (41%) or on Medicaid or Medicare (56%). Patients were predominantly Latino (65.5%), 8.5% were Black, and 25% were Caucasian. The majority of patients were over age 50 (70%), with more women (65%) than men (35%). This data was accessed via the Research electronic data capture (REDCap) (Harris Pa, Taylor R, Thielke R, et al., 2009).

mHealth Infrastructure: A software platform- the Patient Relationship Manager- was created to send and receive text messages allowing patients to report blood sugars and blood pressures up to 5 days per week, and automated outreach to patients late for medication refills. Review of text message data gauged the accuracy of home measurement prompts and automated outreach based on laboratory and pharmacy clinical datasets.

Statistical Analysis Plan

The outcome measure: Body Mass Index

Independent variables: gender, age groups (21-39, 40-59, 60 and older), race (Caucasian, African-American, Hispanic), type of insurance (uninsured, Medicaid, Medicare), blood glucose level.

Univariate analysis: To describe the characteristics of the patients, frequencies will be conducted for categorical variables, and measures of central tendency and dispersion will be presented for continuous variables.

Bivariate Analysis: Fisher exact test was conducted to examine whether there was an association between weight status and age, as well as weight status and gender. A level of $\alpha = 0.05$ was set to determine statistical significance.

RESULTS

I- Socio-Demographic Characteristics of the Diabetic Patients: A Univariate Analysis

The BMI of 127 diabetic patients of the 133 participants were collected before the intervention took place. During the study, 115 patients had their BMI measured. The socio-demographic characteristics presented below are based on the participants at baseline.

As Chart 1 depicts, at baseline over half (66%) of patients were females and a third (34%) were males. The mean age was 54 years old (standard deviation of 12 years) with the youngest person aged 21 years, and the oldest aged 87 years. As Chart 2 reveals, the majority of diabetic adults were between the ages of 40 to 59. Close to three out of ten (28%) were 60 years and older, and less than one out of ten (9%) were between the ages of 21 to 39.

Even though patients were predominantly Latino (66%) (9% African American and 25% Caucasian), a higher proportion (73%) reported that their primary language was English, and 36% reported that their primary language was Spanish (Chart 3).

Chart 1. Gender distribution of Diabetic Adults

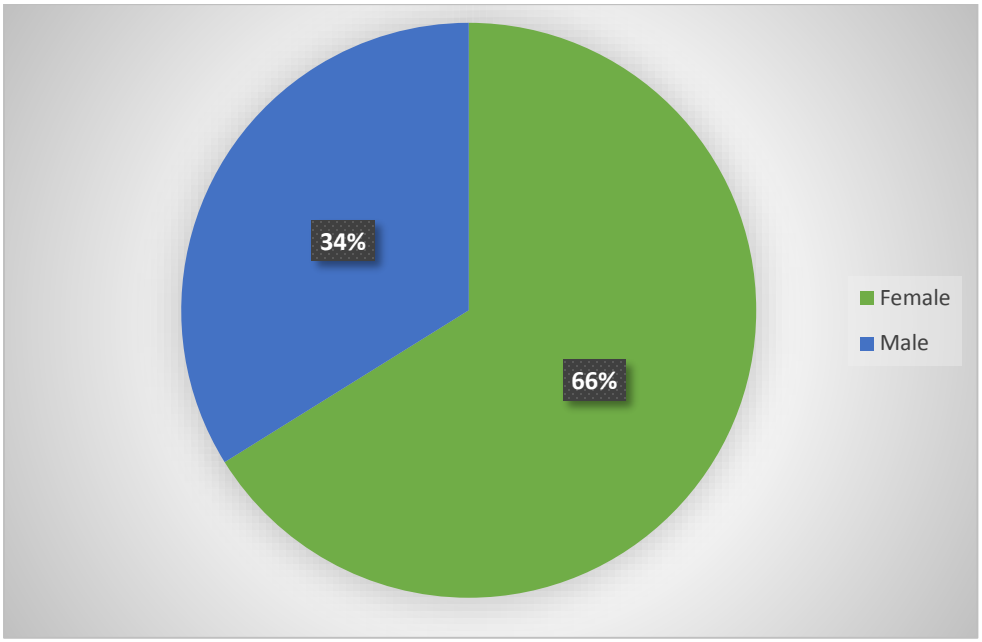


Chart 2. Age distribution of Diabetic Adults

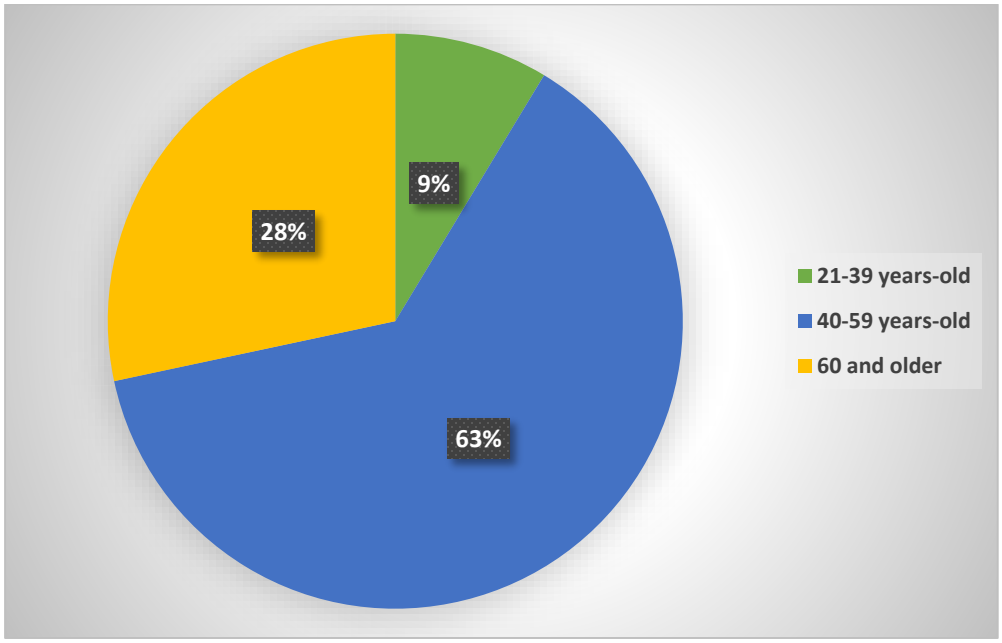
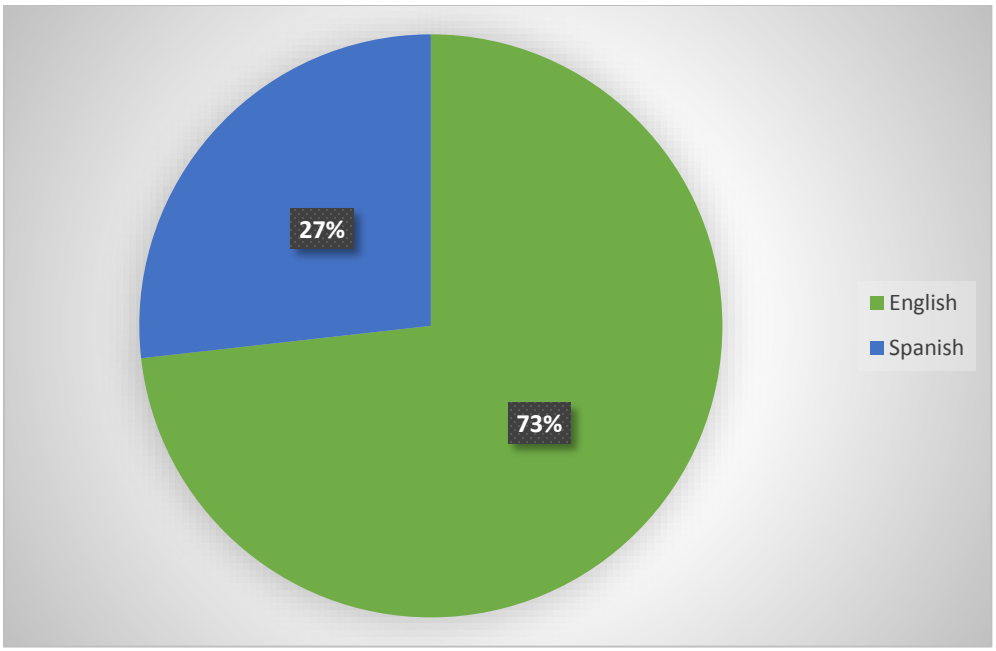


Chart 3. Primary language spoken by Diabetic Adults



HEALTH INSURANCE COVERAGE

In 2013, 83% of Colorado residents had some type of insurance coverage (BRFSS, 2013). As Table 1 depicts, insurance coverage was quite heterogeneous among patients. At baseline, most participants were covered either by Medicare (32%) or Medicaid (31%). Only one participant had private insurance. Almost three out of ten adults participated in the Colorado Indigent Care Program (CICP), a state program that helps Colorado residents who are not eligible for Medicaid (Colorado Department of Health Care Policy & Financing, 2015). Eight adults were part of the Denver Health Medical Plan (DHMP), an entity of the Denver Health and Hospital Authority that covers employees of the Denver Health Authority and the Career Service Authority (Denver Health Medical Plan, INC., 2015).

Table 1. Insurance coverage

BLUECROSS/BLUESHIELD	Count	1
	%	1%

CICP	Count	28
	%	27%
CICP EMERG DENTAL	Count	1
	%	1%
DHMP OPTION A	Count	8
	%	7.6%
MEDICARE ANTHEM FQHC	Count	1
	%	1%
MEDICARE CHOICE/SELECT-OP	Count	5
	%	5%
MEDICARE HUMANA FQHC	Count	1
	%	1%
MEDICARE SEC HRZN FQHC	Count	1
	%	1%
MEDICARE SELECT OP	Count	13
	%	12%
MEDICARE FQHC OP	Count	11
	%	10%
MEDICARE HMO NON DH	Count	2
	%	2%
MEDICAID CO IP/OP	Count	3
	%	3%
MEDICAID FQHC	Count	4
	%	4%
DH MEDICAID CHOICE	Count	21
	%	20%
MEDICAID OAP FQHC	Count	2
	%	2%
MEDICAID PENDING-DISABILITY	Count	2
	%	2%
OHS AUTH OTHER SVCS	Count	1
	%	1%

WEIGHT STATUS

Colorado is one of the healthiest states in the nation. Recent data from the Behavioral Risk Factor Surveillance System (BRFSS, 2012) unveil that four in ten adults in Colorado have a normal weight (based on BMI status) as compared to a third of all Americans (Chart 4).

Concomitantly, the proportion of obese people is lower in the state than it is in the nation (21% vs. 28%) (BRFSS, 2012).

Although Colorado is number one in the nation for physical activity, and is among the states with the lowest prevalence of diabetes in the nation (Colorado Department of Health), obesity still strikes Colorado diabetic population disproportionately. Indeed, when we look at the population of diabetic adults in the state, we can notice that close to half (48%) adults with diabetes were considered obese, and only 16% of adults with diabetes who were considered as having a normal weight (Colorado Department of Health and Environment, 2009).

Between 2011 and 2012, patients' BMI were assessed once, but at different dates before and during the study. Charts 5 and 6 reveal that the proportion of obese diabetic adults was higher in the sample than it was among the population of diabetic adults in the state.

Before the intervention took place, close to seven (67%) out of ten diabetic adults were obese. During the study, there was a decrease of 7 percentage points in the proportion of obese diabetics (Charts 5 and 6). However, on average, BMI before the study and during the study remained unchanged: from a mean of 33.7 (standard deviation=0.8) to a mean of 33.6 (standard deviation =0.8).

The box plots shown in charts 7 and 8 give a better sense of the data structure. The median BMI values are very similar (33 before and 32 during the intervention), and the distribution of BMI values in the sample remained quite similar, before and during the study.

Chart 4. Weight Status in the US and Colorado

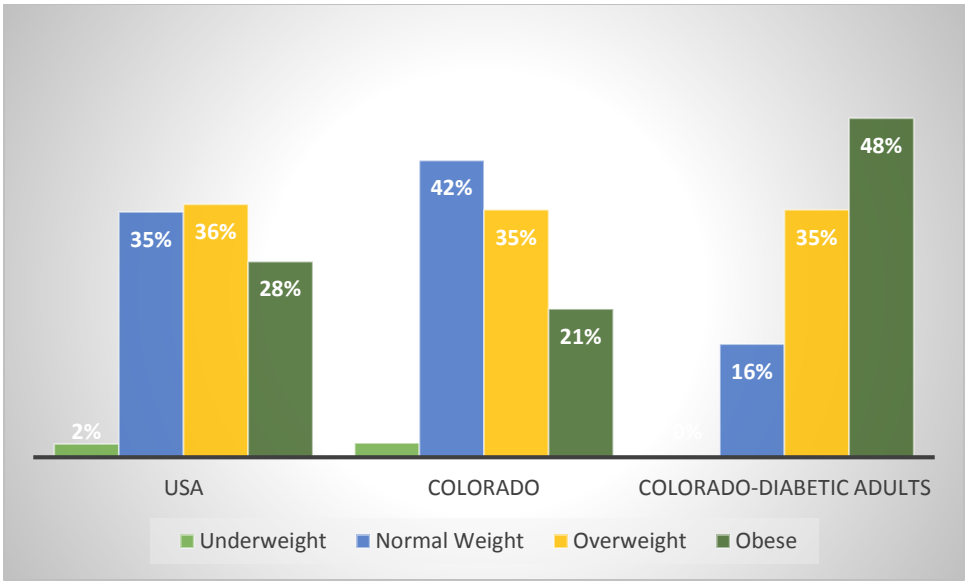


Chart 5. Baseline Weight Status of Participants

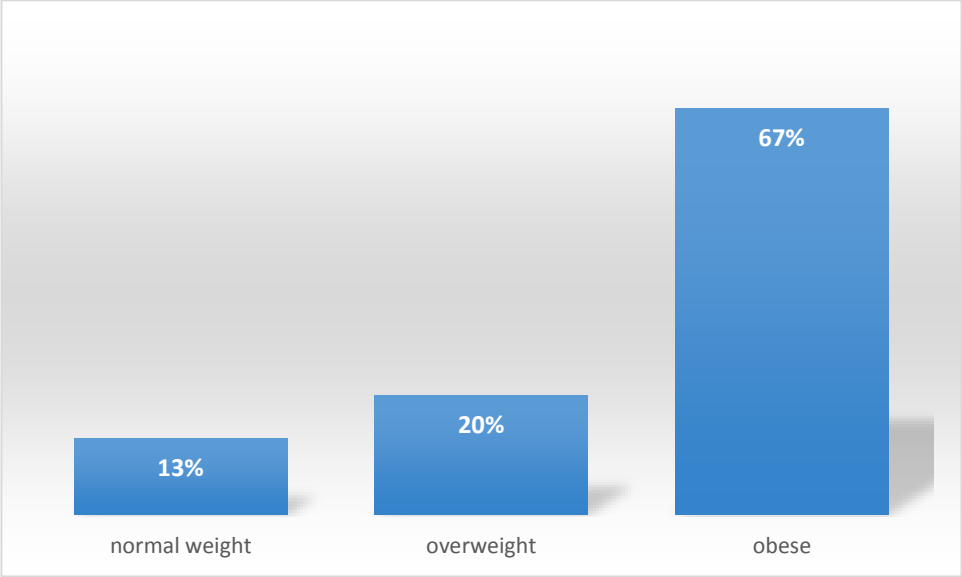


Chart 6. Weight Status of Participants during the intervention.

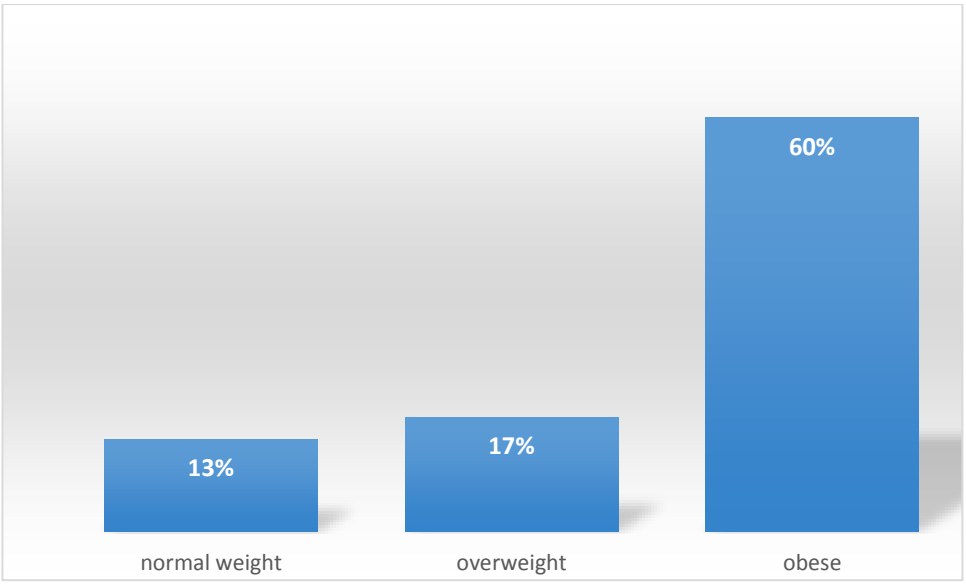


Chart 7. Box Plot of BMI scores of patients before the study

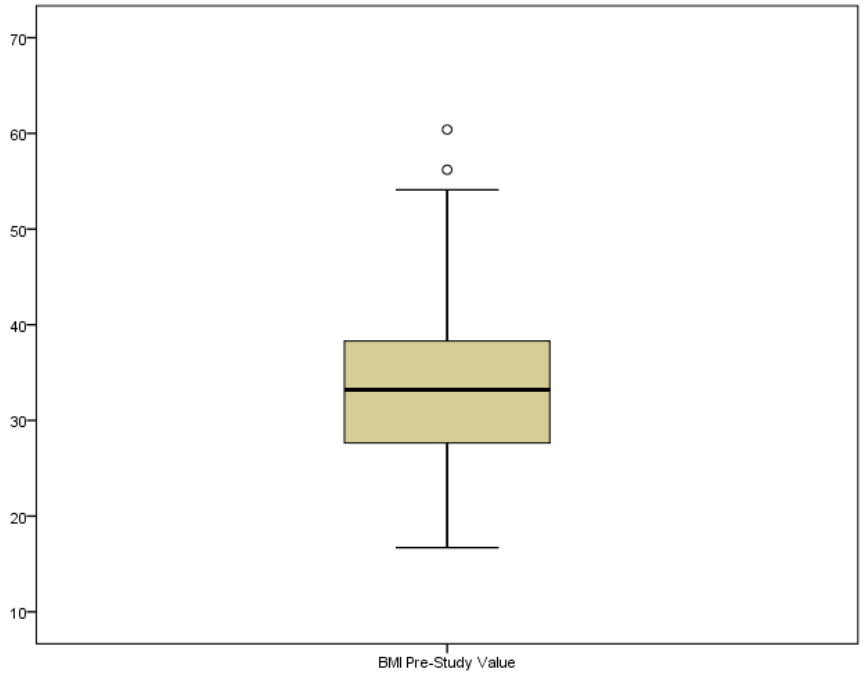
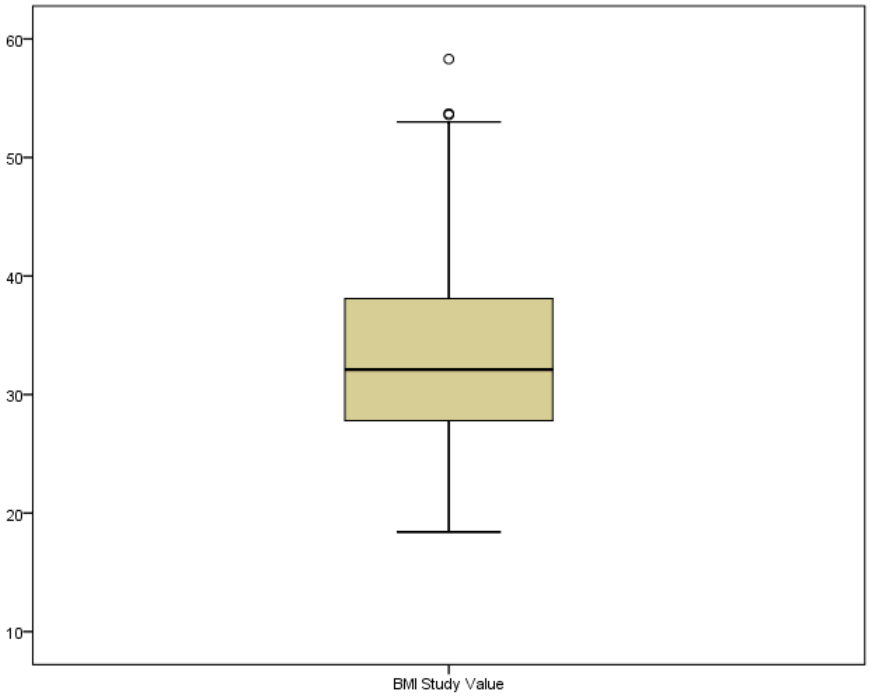


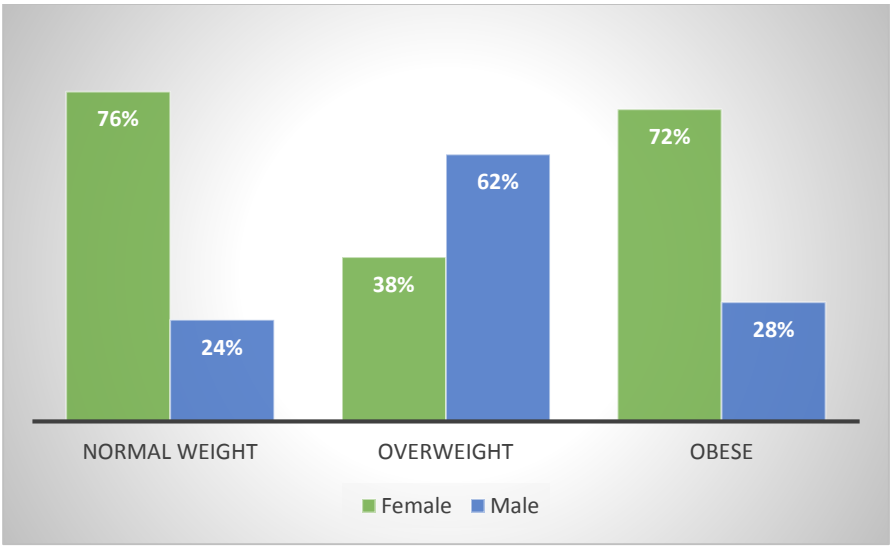
Chart 8. Box Plot of BMI scores of patients during the study



II- Socio-Demographic Characteristics of the Diabetic Patients: A Bivariate Analysis

Chart 8 describes the gender distribution across weight categories. A higher proportion of females were found in the normal weight and obese categories (76% and 72%, respectively). However, in the overweight diabetic group, a little over six out of ten were males and close to four out of ten were females. A Fisher exact test was conducted and revealed a statistically bivariate association between gender and weight.

Chart 8. Baseline Weight Status by Gender



Overall, the age distribution among the different weight categories did not change much before and during the study. A shift in the age distribution is noted among the overweight people, however, a Fisher exact test revealed a lack of significant association between age and weight status.

Chart 9. Weight status by age before the intervention

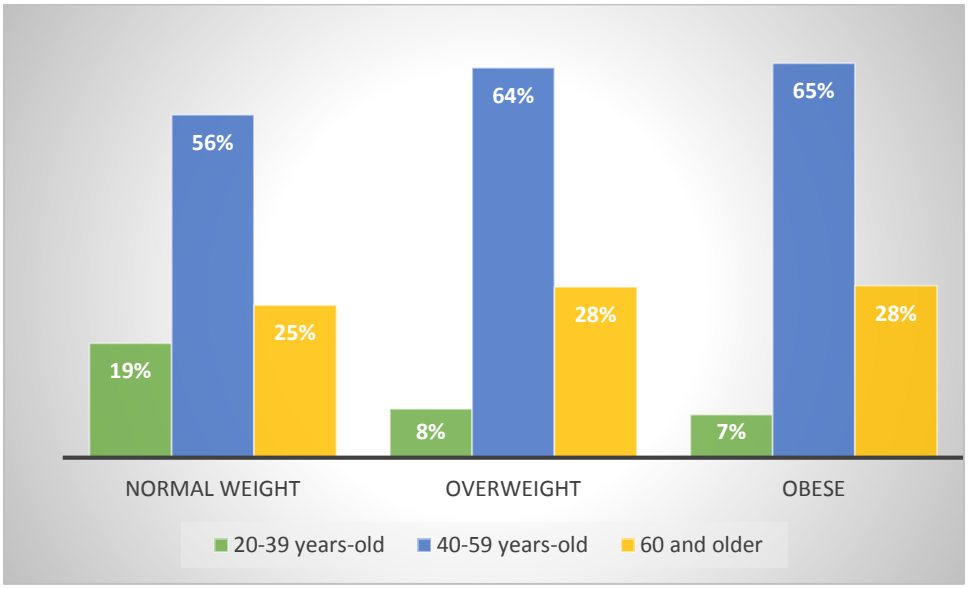
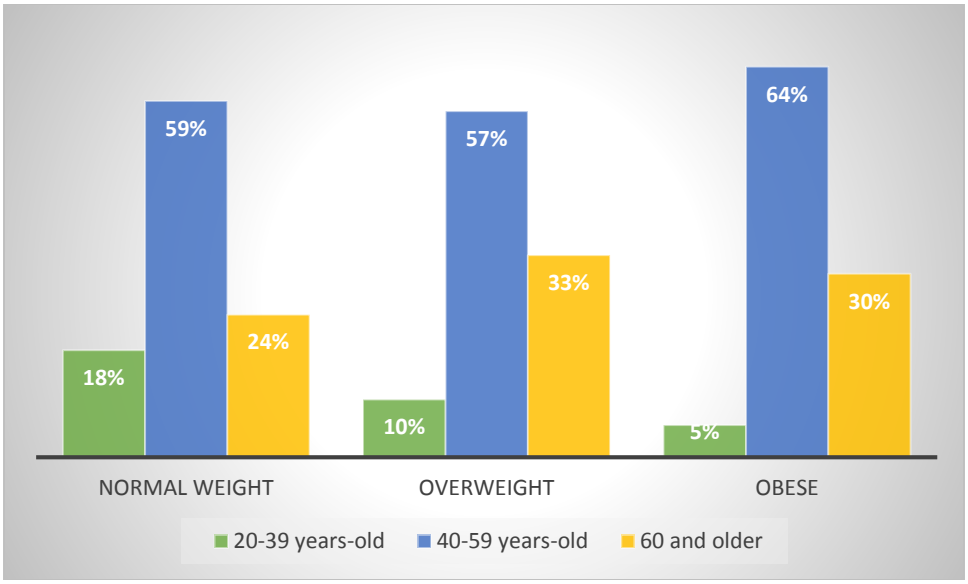


Chart 10. Weight status by age during the intervention



A1C LEVELS OF DIABETIC ADULTS

During the study, A1c levels were not assessed for all the 115 diabetic patients. A1c levels among nine normal weight adults with diabetes ranged between 7% and 12% with an average of 9. A1c levels were assessed among 11 overweight patients, and the levels varied between 6% and 11%, with an average of 8. The A1c levels ranged between 5% and 12% among 41 obese diabetic patients, with an average similar to that of the overweight group.

Table 3 displays the estimated average blood and corresponding A1c levels (source: Mayo Clinic).

Table 2. Average A1c Levels by Weight Status

	Normal weight (n=9/17)	Overweight (n=11/21)	Obese (n=41/76)
Mean	9	8	8
Std. Deviation	2	2	2

Minimum	7	6	5
Maximum	12	11	12

Table 3. Average blood sugar levels and corresponding A1c

A1C level	Estimated average blood sugar level
5%	97 mg/dL (5.4 mmol/L)
6%	126 mg/dL (7 mmol/L)
7%	154 mg/dL (8.5 mmol/L)
8%	183 mg/dL (10.2 mmol/L)
9%	212 mg/dL (11.8 mmol/L)
10%	240 mg/dL (13.3 mmol/L)
11%	269 mg/dL (14.9 mmol/L)

12%	298 mg/dL (16.5 mmol/L)
13%	326 mg/dL (18.1 mmol/L)
14%	355 mg/dL (19.7 mmol/L)

LDL CHOLESTEROL LEVELS OF DIABETIC ADULTS

LDL cholesterol was measured in a small number of patients that participated in the study (37 out of 115 adults). The average LDL cholesterol was highest in the overweight group, and lowest in the normal weight group.

Table 4. Average LDL Levels by Weight Status

	Normal weight (n=7)	*Overweight (n=6)*	*Obese (n=24)*
Mean	87	105	94
Std. Deviation	23	48	26
Minimum	62	60	52
Maximum	117	185	158

DISCUSSION

According to the most recent Behavior Risk Factor Surveillance System (BRFSS, 2013), one out of ten people in the US suffers from diabetes, and more than six out of ten Americans are either overweight (36%) or obese (29%). These numbers have caused a massive increase in initiatives and studies produced trying to identify the best ways to combat this national crisis. The state of Colorado with 6% of its adult population being diabetic and of those, 36% are considered overweight and 46% obese, has made large steps forward with initiatives like *The State of Health: Colorado's Commitment to Become the Healthiest State* (BRFSS, 2013). This new policy agenda has sparked further interest and concern for the growing numbers of overweight, diabetic patients in the state. One of these programs, the Diabetes Self-Management Education (DMSE), used to facilitate knowledge and skills, has been associated with higher

adherence to care practices that has lead to lower average costs of patient care (Needs Assessment Examining Diabetes Self-Management in Colorado, 2009). Positive results from these programs sparked interest as to what other interventions could be used to enhance diabetic patients adherence.

The study by Dr. Henry H. Fischer, MD and associates, *Care by Cell Phone: Text Messaging for Chronic Disease Management*, looked at the use of text messaging as a source for increased disease management for patients with chronic diseases such as diabetes mellitus. For our secondary analysis, we chose to look at the effect of this new technology on the weight management of diabetic patients. While this study lacked significant data to prove that use of text messaging aids in the weight management of Diabetic patients, with the BMI before and after the study averaging 33.7 to 33.6 respectively, there was a 7 percentage point drop in the amount of obese diabetics. The small population involved in the study may have lead to this lack of statistical significance, but even with this limitation, there was a great deal of beneficial information found. Besides measuring BMI from the patients, a hemoglobin A1c levels were obtained from 61 of the 115 diabetic patients. A1c is an important test for diabetic patients as it measures how well their glucose is controlled during a 3 month time span and can be an indication of a worsening disease state that can lead to end organ disease (American Diabetes Association, 2014). For this study, there was not a significant difference between normal weight, overweight and obese patients' A1c levels with the averages of 9 for normal weight and 8 for overweight and obese participants. There was not enough data to run other statistical analysis on possible hemoglobinopathies that could possibly interfere with the participants A1c values.

LIMITATIONS

This study provided many limitations; the most significant includes the small sample size of patients that were additionally isolated to the Denver, Colorado community. The small magnitude of the study along with the isolation of a single city fails to provide a generalized sample that would be indicative of the entire United States population. It has been found that appropriate sample sizes are determined by the power of an a-test. This test shows that a study that is sufficiently powered has a statistical chance at rejecting or accepting the studies hypothesis (Suresh, K. P., & Chandrashekara, S., 2012). Also, research has found that inadequately sized studies tend to result in results that favor the researcher's assumptions about the effectiveness of the study rather than true data (Suresh, K. P., & Chandrashekara, S., 2012). Finally, research has found that by having appropriate sample sizes along with quality data collection could lead to more reliable, generalized results as well as saving resources (Suresh, K. P., & Chandrashekara, S., 2012). However, this population is appropriate for our intervention in that it is geared to populations that are more at risk. Within this small population there were more females (66%) than males (34%), which could affect the end results of BMI interpretations. Another limitation includes the lack of variety in ethnicities, 66% of the participants in the study were Latino, which fails to depict the general US population.

The term adherence is defined in Oxford English Dictionary as "persistence in a practice or tenet; steady observance or maintenance" (Aronson, J. K., 2007). Other common words used in the place of adherence are compliance and concordance, all of which generally mean an understanding and acting in accordance with a request (Aronson, J. K., 2007). Good adherence is beneficial to the patient and the researchers, but unfortunately they do not always get total adherence from the patients. Some barriers that deny patients adherence include: the complexity

of the regimen, failure of the patients to understand the importance of adherence and the patient's perception to the need to make lifestyle changes (Aronson, J. K., 2007). In this study, like many others, adherence was an issue. Out of 133 participants, BMI from only 127 patients were collected initially, and a mere 115 BMI's were collected during the study. The loss of patients during the study negatively alters the data collected, and doesn't provide access for a thorough analysis. The measuring of participants BMI was also an issue, as the patients had them calculated before the study and then at different intervals that were not uniform for everyone, which could lead to fluctuations in the findings.

The use of BMI as a measurement of obesity could also be a limitation. As mentioned before, the WHO states that there has been increasing evidence between BMI, percentage of body fat, and body fat distributions across different populations (World Health Organization, 2014). Furthermore, other variables, such as waist circumference, waist-hip ratio, waist-height ratio and visceral adiposity index that were underscored in the literature have not been captured in this study. Despite these limitations, this study has the potential to unveil how text messaging can decrease the BMI in obese diabetic adult patients.

While measuring the A1c levels of participants, the study did not draw A1c levels on everyone. There was also no additional info on hemoglobinopathies that could possibly interfere with the A1c levels produced during the study. Since the "A1c test is based on normal hemoglobin, hemoglobinopathies can affect the reliability in three ways: 1) altering the normal process of glycation of HbA to A1c, 2) causing an abnormal peak on chromatography, making estimation of A1c unreliable, and 3) by making the red blood cell more prone to hemolysis, decreasing the time for clycosylation to occur and producing a falsely low A1c result" (Smaldone, A., 2008). Since such variation in A1c level is possible with hemoglobinopathies, it

would be important to have known this information. When measuring for LDL, there was such small sample, 37 out of 115 participants; it was difficult to infer anything statistically significant which is disappointing due to the importance of lipid levels and cholesterol control in diabetic patients. Lipid and cholesterol levels are indicative of the amount of fat in the blood and are associated with cardiovascular disease and strokes which are commonly linked as the leading cause of deaths for diabetics (Diabetes and Cholesterol, 2015).

Another limitation addresses the number of study participants in the original study compared to the secondary analysis. For this project a statistical analysis was examined on the 115 participants with BMI measurement versus the entire 133 participants. Another key element to address using secondary analysis, is that the original study can omit and change anything in their study before publishing, which could alter any secondary data analysis completed. Ideally, the study should have included a control group, which would have included a group of patients that did not receive the text messages, but weight and BMI were measured in the same period as the experimental group.

CONCLUSION

The use of technology in medicine is increasing as our society becomes more dependent on the use of technology in everyday life. In recent studies, 77% have shown improved outcomes for patients that used text messaging as a source of disease management (Kannisto, Koivunen, & Valimaki, 2014). With these findings, it would be seem absolute that the use of text messages would aid in weight management for overweight and obese diabetic patients. Even though this study found the decrease in BMI from 33.7 to 33.6 as not statistically significant, if this study was completed on a larger scale with increased adherence to the study there may be different

results. The use of technology did lower the rate of overweight and obese diabetic participants by 7 percentage points, after completing the study, leaving hope to the benefits of using technology as an effective intervention.

Future Recommendations

As our technology expands, studies need to look into ways to best use the new devices and systems to better receive and input data to quickly and efficiently use the information to better the health outcomes of patients. Continuous glucose monitoring (CGM) systems are a new technology being developed by multiple companies and approved by the U.S. Food and Drug Administration (FDA). A CGM system uses a tiny sensor inserted under the skin to check glucose levels in tissue fluid; and unlike other blood glucose monitors, the sensors stay in place for several days and then must be replaced (National Diabetes Information Clearinghouse, 2013). At this point, CGM devices are not as effective as standard blood glucose meters, but they have potential to greatly increase disease management for diabetic patients as it is a constant monitor instead of remembering to check blood glucose levels at prescribed times. (National Diabetes Information Clearinghouse, 2013). With this new technology continuously evolving, there is hope that a continuous glucose monitoring system could also pull other information from bodily tissues and be automatically sent to a software system in order to easily and clearly organize data.

I also think this study would have improved results if they were completed in states that have a higher prevalence of diabetes. States like Alabama, West Virginia, and Mississippi would be appropriate for a similar study, as they are the states with the highest rates of diabetes, at 13.8%, 13%, and 12.9% respectively (State of Obesity.org, 2013). Using these states would

drastically increase the number of patients with DM, therefore allowing for more statistically significant and diverse population data.

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