

# Diabetes Management in the Digital Age; Text Messaging in Rural North Carolina

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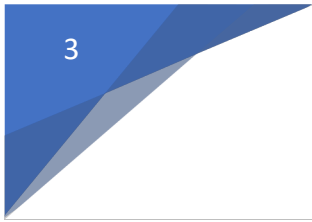
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Public Health Importance

Diabetes and its associated symptoms have been prevalent since 1500 B.C.E.

Longstanding evidence shows diabetes as a continually increasing public health problem around the world, including the United States (US), and even locally here in the state of North Carolina.<sup>1</sup> Diabetes is plainly not going away, and projections as to its burden on healthcare are significantly increasing.

According to a recently published article, the cost of global health care related to diabetes is in the trillions of dollars and projected to almost double by 2030.<sup>2</sup> The World Health Organization (WHO) also stated in its 2016 report on diabetes that approximately 8.5% of the adult population globally are living with diabetes.<sup>3</sup> That works out to roughly 422 million adults in the world living with this debilitating disease.

Diabetes is not just a public health concern on a global level. The Center for Disease Control (CDC) estimated in its 2017 statistical report, that approximately 9.4% of the US adult population is living with diabetes.<sup>4</sup> That equates to roughly 30 million adults. Also raising significant concern, is that, according to the CDC, nearly 33% of US adults are living with prediabetes.<sup>4</sup> Unfortunately, these statistics only pertain to individuals older than 18 years of age, with the prevalence of diabetes within younger children in America being on the rise as well.

Pathophysiology of Diabetes

There are multiple types of diabetes, but we often only hear and focus on two specific types. For the purposes of this paper, we will focus on two types and refer to them under the umbrella term of “diabetes.”

Two of the most often referred to types are type I diabetes mellitus and type II diabetes mellitus. type I diabetes mellitus is an autoimmune disease that destroys the  $\beta$ -cells of the pancreas. These cells are responsible for the production and secretion of insulin, the hormone responsible for moving glucose out of the bloodstream and into cells for use. This disease is often diagnosed in the young population, which is why it was once called, “juvenile diabetes.” These patients require lifelong insulin pharmacological therapy.

Type II diabetes mellitus is not an autoimmune disease, but a chronic, slowly progressing disease over time. The progression of type II diabetes is due to a pancreatic insulin secretory defect and insulin resistance. These effects are directly correlated to obesity, which is one of the biggest risk factors for becoming a type II diabetic. In fact, according to the CDC, 87.5 % of people living with diabetes are overweight or obese.<sup>5</sup> As our country continues to grow in body size, new diagnoses of type II diabetes also continue to rise. Type II diabetes encompasses approximately 90 % of adults living with diabetes.

### Epidemiology

The prevalence of type I and type II diabetes mellitus has risen between the years of 2001 to 2009.<sup>6</sup> There are also experts that believe these numbers will continue to climb as evidence shows this to be the trend. In a 2012 article, type I and type II diabetes among US youth was expected to increase by 23 % and 49 %, respectively, by 2050.<sup>7</sup> Considering the prevalence of diabetes is on the rise, the monetary cost to Americans is proving to be

significant. It is estimated that Americans spent a half of a trillion dollars on diabetes health care in 2015 alone.<sup>2</sup> The cost of healthcare will only continue to rise in the future, making this disease more monetarily, physically, and emotionally costly, which is a daunting prospect.

While diabetes is a rising health concern throughout the US, some states are markedly more affected by this disease than others. The “diabetes belt” has been identified as the southeastern region of the US, including a high percentage of counties in the states of Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, Texas, Virginia, and West Virginia, as well as the entire state of Mississippi.<sup>8</sup> Populations in the diabetes belt are 3.2 % more likely to be diagnosed with diabetes, particularly type II diabetes, than other populations in the US, resulting in an increased health concern for states within this region.

In North Carolina, the prevalence of diabetes is very similar to that of the national average. In 2015, the CDC estimated that 9.6 % of North Carolina’s adult population were living with diabetes, compared to the national average of 9.4 %.<sup>9</sup> Diabetes is the seventh leading cause of death in North Carolina and can decrease the life expectancy of a person by 15 years.<sup>10</sup> In 2011 it was estimated that state spending related to diabetes, was approximately \$5.3 billion. One can reasonably speculate that North Carolina spends even more on diabetes-related health care today, in 2018. Additionally, there was an estimated 2.7 million adults in North Carolina who were living with prediabetes, a condition that markedly increases the risk of developing diabetes.<sup>11</sup> As has been shown, the problem of diabetes hits close to home for many people, especially those living here in North Carolina.

#### Mortality and Complications of Diabetes

Why is good glycemic control important? Diabetes is associated with greater mortality

and countless complications. When clinicians counsel their patients on diabetes and its associated comorbidities, they acquire a hemoglobin A1C, which is a measure of the patients' blood glucose over the past three-month period. The American Diabetes Association (ADA) recommends that patients diagnosed with diabetes maintain a hemoglobin A1C between 7 – 8 %, in order to minimize health complications associated with diabetes.<sup>12</sup>

There is a lower life expectancy in individuals diagnosed with diabetes when compared to non-diabetic individuals. One study found that on average, if an individual was diagnosed with diabetes at age 40, males would lose approximately 11.6 years of life and females would lose approximately 14.3 years of life.<sup>13</sup> In 2012, the WHO estimated that 1.5 million deaths were related to diabetes worldwide.<sup>3</sup> Therefore, diabetes plays a big role in one's quality of life and life expectancy.

Diabetes is a disease that also has vast physiological effects on the body. A chronic hyperglycemic state can lead to multiple long-term complications. Some complications include (1) myocardial infarction (MI), (2) cerebrovascular accident (CVA), (3) retinopathy and blindness, (4) extremity amputations, (5) poor wound healing, (6) neuropathy, and (7) chronic kidney disease, making diabetes one of the leading causes of hospitalizations in the US. The CDC estimated approximately 7.2 million hospital admissions in 2014 were related to diabetes.<sup>4</sup> With adequate glycemic control through lifestyle modifications and pharmacotherapy, these hospitalizations and complications can be minimized.

MIs, CVAs, and retinopathy are complications largely due to blood vessel atherosclerosis. Hyperglycemia causes slower blood flow and an inflammatory process that

increases in blood vessels. Both factors accelerate the process of atherosclerosis. These complications can cause further medical problems such as MI, CVA, and retinopathy depending on where in the body they are occurring.

The cascade starting with atherosclerosis also causes poor circulation. An individual with poor circulation is also at risk for other complications of diabetes, such as limb amputations and poor wound healing. Hyperglycemia causing slow blood flow in vessels that are already plagued with plaque increases the incidence of these complications. The vessels are not efficient enough for adequate perfusion that is needed in the wound healing process. Poor wound healing can lead to complications such as gangrene, which ultimately drives the need for limb amputation.

The toxic effects of hyperglycemia are also associated with neuropathy. The pathophysiology of this process is not fully understood. Many theories exist and it is hypothesized that damage to blood vessels that supply peripheral nerves are behind this problem (in a similar process as discussed above).<sup>14</sup> Neuropathy to peripheral nerves causes pain and loss of sensation for many diabetics. The loss of sensation is the major reason many diabetics do not notice wounds on their feet. This is another driving force behind the plethora of problems leading to limb amputations. Routine diabetic foot exams are therefore important and are a standard of care for all diabetic patients.

Another major complication of diabetes is progressive kidney disease. People who have chronic kidney disease, along with diabetes, can potentially progress to end-stage renal disease (ESRD) and need to be placed on dialysis. This typically includes going three days a week to a specialized medical facility for dialysis treatments. While this presents a huge financial burden

on health care costs, the eventual impact on someone's life undergoing dialysis is immeasurable. According to a November 2017 Morbidity and Mortality Weekly Report (MMWR) presented by the CDC, it was estimated that approximately 44 % of new dialysis patients have diabetes listed as their primary cause of ESRD.<sup>15</sup> However, in the same report, it was shown that there is an actual overall decrease in ESRD related to diabetes. North Carolina had a 42 % decrease in ESRD related to diabetes between the years of 2000 to 2014.<sup>15</sup> Clearly, this is a positive change when it comes to battling diabetes. But ESRD is just one aspect of the myriad diseases associated with diabetes, whereas it has nevertheless been shown that the prevalence of diabetes is still on the rise.

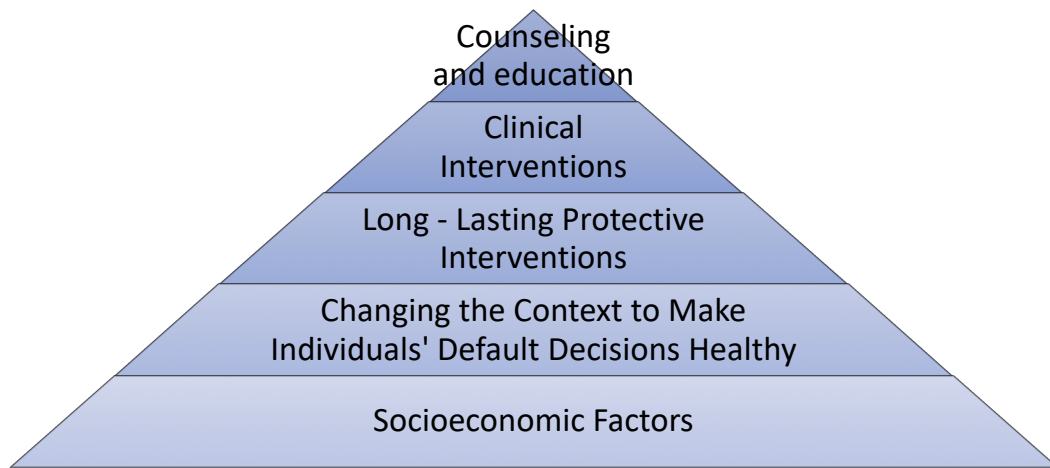
#### Public Health Research

So, now the question is how do we continue to make a positive change?

Today, there are many researchers studying the most effective way to attack public health obstacles. In 2010, Frieden et al. proposed a "health impact pyramid" to explore the effectiveness of interventions to control diabetes (Figure 1).<sup>16</sup> One section of their five-part pyramid is counseling and education. The authors felt this aspect was the foundation of public health, but that it was also the least effective.<sup>16</sup> This should not, however, deter anyone from endeavoring to improve public health through education. The authors also reported that health education could have a "considerable impact...when applied consistently and repeatedly."<sup>16</sup> Interestingly, the aspects at the top of the pyramid may be the least impactful, but they are the ones that health care providers have the most control over. Health care providers need to find ways to make education about specific diagnosis effective while reaching as many people as possible. The use of technology to increase the impact of education is a hot

topic in today's research. Patients have better health once they feel better about their care.

Public health researchers have studied this subject for many years.



**Figure 1: Modified Health Impact Pyramid<sup>16</sup>**

One psychological model, the health belief model, attempts to predict and explain health behaviors. This model has been used by public health services to explore different short and long-term health behaviors. The health belief model proposes that a person will take health-related action if they can avoid negative health outcomes, have a positive expected outcome by taking the recommended action, and can successfully take that recommended health action.<sup>17</sup> The model attempts to describe public health behaviors by using six concepts.

The following table helps to describe each concept further.

Concept	Definition
1. Perceived Susceptibility	Someone's belief of the chances of getting a condition
2. Perceived Severity	Someone's belief of how serious a condition and its consequences are
3. Perceived Benefits	Someone's belief of the efficacy of an advised action to reduce risk and seriousness of the impact

4. Perceived Barriers	Someone's belief in the costs of the advised behavior
5. Cues to Action	Strategies to start action
6. Self-efficacy	Someone's confidence in their ability to act

***Table 1: Health Belief Model Adopted from Glanz et. Al.<sup>17</sup>***

According to these concepts and applying them to diabetes, people need to have some baseline knowledge of the disease. Society must also have the motivation and understanding of how to help prevent the disease (perceived susceptibility). The basis of our research is for patients who already have diabetes and, therefore, not all concepts could be applied. By design, we would have the most impact on targeting patients' understanding of their diagnosis of diabetes and their self-efficacy. If we can provide the tools necessary to help the patient take more health-related actions, then they are more likely to be more active in their own health. This model is a good basis for the design of our research. We believe by providing patients with education and motivation, they are more likely to take a larger role in their own health care.

### Technology and Medicine

There are numerous factors that have previously been and are currently studied as to why diabetes is so prevalent. Some of the major factors include limited access to health care, lower socioeconomic status, and lower education level. These factors are all correlated with poor health. People living in America often face these same factors when it affects their health care in general. With technology advancing daily in today's world, there has been increasing research to see how technology could help reach people who have limited access to health care. Lepard *et. al.* found that up to an 80 % retention rate of self-managed diabetes

interventions was seen with the use of telemedicine and face to face meetings.<sup>18</sup> This article lends to the positive outcome of the use of some constant reminders through technology for diabetes care.

The Health Resources and Services Administration (HRSA) of the U.S. Department of Health and Human Services defines telehealth as the use of electronic information and telecommunications technologies to support and promote long-distance clinical health care, patient and professional health-related education, public health and health administration.<sup>19</sup> A 2014 meta-analysis also found a correlation between the use of telemedicine and a decrease in hemoglobin A1C levels, a measure of diabetes control.<sup>20</sup> To be more specific, Hall et al. found that, “the majority of published text-messaging interventions were effective when addressing diabetes self-management.”<sup>21</sup> Therefore, research has shown that the use of telemedicine, including text-messaging, can and does have an impact on managing diabetes.

The use of technology in educating patients is the background and focus of our program plan through the use of text messages. Taking the known, positive correlation between telemedicine and diabetes control, we hope to successfully impact the diabetic population of North Carolina. The goal of our program plan is to help educate and motivate those living with diabetes in a rural population of North Carolina with the use of text messages and possibly other forms of communication, ultimately leading to a potential decrease in the health impact of diabetes and its associated health problems in the state of North Carolina.

### **Needs Assessment**

Although diabetes is a worldwide health concern, change that affects the care of patients living with diabetes has to occur on a much smaller level, an individual level. For this

reason, it was decided, for the purpose of this project that we would focus on a particular clinic in Chapel Hill, North Carolina. The clinic of focus was a Chapel Hill Family Medicine Center (FMC). The FMC is a full – service primary care practice that provides quality health care to over 15,000 North Carolinians, with many of those patients being uninsured and living in rural communities in the state. Some of the services provided by the FMC include, but are not limited to: (1) nutrition counseling, (2) weight management, (3) family-centered medical care, (4) behavioral health care, (5) preventative health care, (6) substance abuse counseling, (7) prenatal care, and (8) sports medicine.<sup>22</sup> With the FMC offering such comprehensive services to a diverse patient population in many communities throughout North Carolina, the assumption was made that the FMC adequately represented our target population, of North Carolinians living with diabetes.

As part of the FMC's health care initiative to provide their patients with quality centered health care, a metric based preventative approach was implemented in their clinic. In total, the clinic measured 15 different metrics that have been shown to decrease mortality and morbidity. Metrics included but were not limited to: (1) falls risk screening, (2) Atherosclerotic Cardiovascular Disease (ASCVD) indication for a Statin, (3) cervical cancer screening, (4) colorectal cancer screening (5) Hypertension (HTN) Blood Pressure (BP) control, (6) diabetes eye exam, (7) Hemoglobin A1C less than 9 %, (8) depression screening, (9) influenza vaccine completion, and (10) moderate to severe depression currently in treatment.<sup>22</sup>

Due to the plethora of people suffering from diabetes and its known health complications worldwide, we decided for this project to focus on the FMC health metric of a Hemoglobin A1C less than 9 %, with even more focus placed on rural North Carolinian patients

diagnosed with diabetes. Although diabetes and the health metric related to the Hemoglobin A1C was of importance to us, we needed to make sure that our interests lined up with the FMC health interests. To assess whether FMC and our health interests were aligned, a needs assessment was conducted.

The goal of the needs assessment was to: (1) identify and analyze the patient population and community, (2) identify stakeholders, (3) assess strengths, assets, and resources within the community of interest, and (4) prioritize and design a plan to address the identified issue.

(1) Identify and analyze the patient population and community:

In order to identify and analyze the patient population, interviews with six staff members at FMC were conducted. The interviews consisted of different specialties within the clinic, to include: (1) Clinical Social Worker, (2) Director of Clinical Business Operations, (3) Care Assistant/Health Coach, (4) Associate Medical Director, (5) Family Medicine Physician, and (6) Patient Service Manager II. Each staff member was interviewed using a standardized questionnaire from the University of Dartmouth-Hitchcock (Appendix A).<sup>23</sup> Each staff member interviewed, identified diabetes medical management as a challenge for the patient, the clinic, and their providers to manage effectively and efficiently (Table 1). Another unifying theme throughout the interview process was the lack of resources available and the increased barriers for both patients in rural communities and patients from a lower socioeconomic status. Although FMC provides care to a variety of different patient populations, the organization members interviewed expressed a huge concern for patients and their health from resource-poor communities (Table 1).

Interviewee's Title	What are some of the biggest challenges you see with patients in this clinic?	What are some of the barriers you commonly see in your patient population?
<b>Clinical Social Worker</b>	"Health literacy and nutrition literacy"	<ul style="list-style-type: none"> <li>• "Financial issues predominantly, patients with low or no income, unable to afford insurance, copays, doctor visits, and medicine."</li> <li>• "Transportation is also an issue, not so much in CH, but rural patients."</li> </ul>
<b>Associate Medical Director</b>	<ul style="list-style-type: none"> <li>• "Of our 15 metrics, cancer screening, vaccinations, and diabetes care is the biggest bulk"</li> <li>• "Hemoglobin A1C control is the hardest metric and blood pressure are two hardest metrics – it is extremely hard to change behavior"</li> </ul>	<p>"We take care of a lot of patients that don't have economic resources or live very far away.</p> <p>It can be very challenging for them to come to appointments... or they have trouble affording medicines, following what we recommend mainly due to monetary issues.</p> <p>That's a big challenge in this clinic."</p>

<b>Family Medicine Physician</b>	“Diabetes, depression, and blood pressure management.”	<ul style="list-style-type: none"> <li>• “barrier to the patient actually changing their behavior”</li> <li>• “We don’t have a great sense of what the actual needs are at the population level (one-on-one needs assessments are happening with the social workers), but we don’t have a great idea of who the people actually are: average income, reading level, education level, access to foods/resources”</li> </ul>
<b>Director of Clinical Business Operations</b>	“A1C>9 is the metric we’ve all been looking at and saying, that’s too hard – it’s going to be a tough nut to crack”	“I do not have direct contact with patients, so it is hard for me to answer this question.”
<b>Care Assistant/Health Coach</b>	“The biggest issue is literacy and health literacy. Patients not being able to understand their condition, for example, our patient with diabetes, don’t know or understand what	<ul style="list-style-type: none"> <li>• “Transportation, just getting to the clinic for appointments is challenging for most of our patients.”</li> </ul>

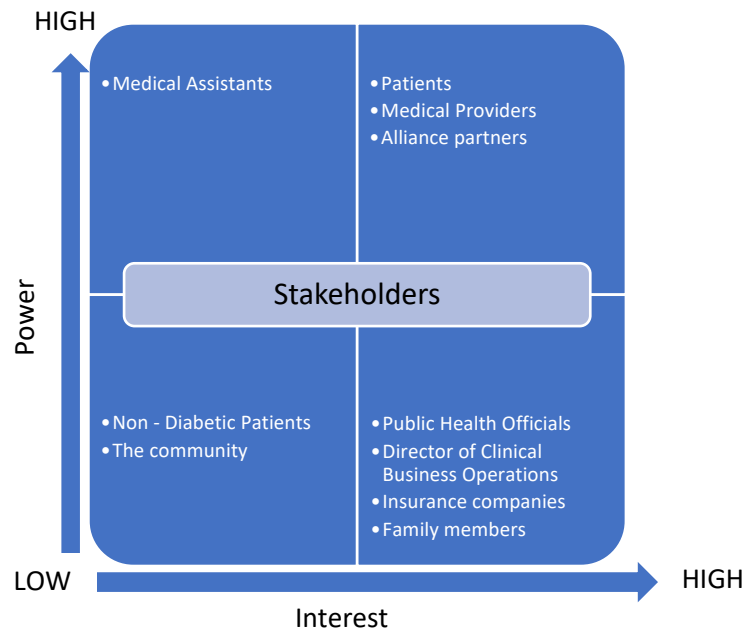
	diabetes is, why they need to take insulin; they just don't understand their condition."	<ul style="list-style-type: none"> <li>• "Remembering their appointments."</li> <li>• "Insurance not covering medication or machines"</li> </ul>
<b>Patient Service Manager II</b>	<ul style="list-style-type: none"> <li>• "Coordination of all the care between services. Can be overwhelming for providers and the patient as well."</li> <li>• "Education! I think it would be beneficial for our diabetic patients to have a packet of education for newly diabetic patients."</li> </ul>	<ul style="list-style-type: none"> <li>• "Health literacy is a huge issue and barrier for many patients"</li> <li>• "Time spent with the provider. With the provider seeing so many patients in a day it is hard for them to spend the time necessary with the patients educating them about their disease and making sure they comprehend what is being said."</li> </ul>

*Table 2: FMC interviewee key points*

(2) Identify stakeholders

A stakeholder analysis was performed in order to gather and analyze qualitative data to determine whose interests needed to be considered when developing and implementing our quality improvement project. We grouped the vested individuals and organizations into four different categories, in order to better understand their role and involvement in our quality improvement project.<sup>24</sup> The four categories were: (1) high interest and high power, (2) high interest and low power, (3) low interest and high

power, and (4) low interest and low power (Figure 2). Vested individuals were determined by what individuals would be affected and to what degree they would be affected by the metric of interest. With this information identified, we hoped to address all the key parties involved, and the degree of their involvement in order to maximize support and guidance from FMC.



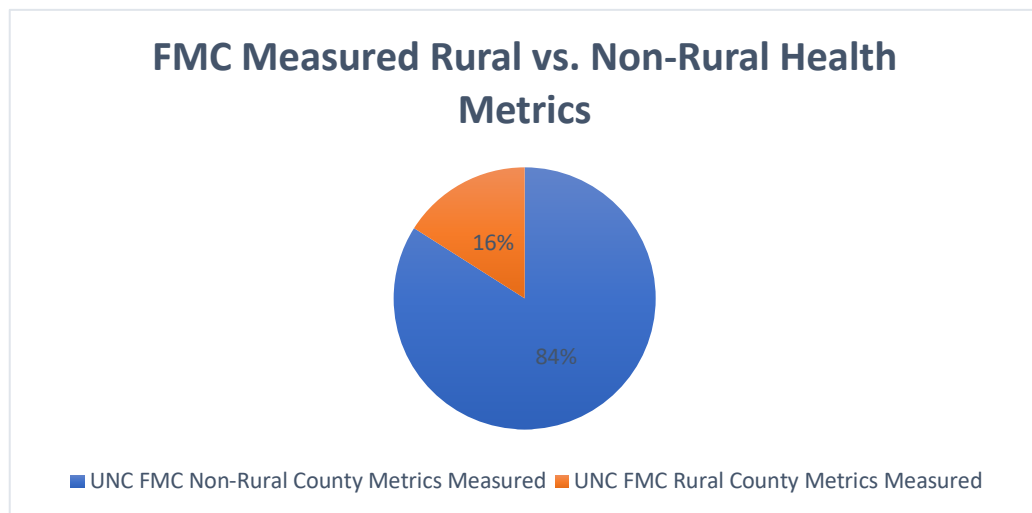
**Figure 2: Stakeholders FMC**

### (3) Assess strengths, assets, and resources within the community of interest

From the interviews conducted at the FMC, one unifying and identifying theme related to diabetic patients was the increased health barriers for both rural and socioeconomically poor patients. With rural Americans making up at least 20 % of the United States population, we are hard-pressed to address this patient population and the issues that are associated with the inequalities of health care provided, that lead to inferior patient care and increased mortality and morbidity.<sup>25</sup> Metric data was obtained from the FMC for the 15 metrics that the clinic monitors in order to help improve their

patients' health and aid in the increase of preventive health care their patients receive.

Analysis of this data showed that from all the metrics measured by the FMC, about 16 % of those metrics were from patients that lived in rural counties in North Carolina (Figure 3). Of the 16 % of rural county metrics measured, which encompasses 56 different rural counties in North Carolina, 49 % were from the rural county of Chatham while the other 51 % were from the other 55 rural counties in North Carolina. With Chatham county patients having the largest metrics measured by the FMC, we decided to use the rural county of Chatham as the targeted patient population for our quality improvement project, with our main focus on the diabetic patients of Chatham County.



***Figure 3: FMC Measured Rural vs. Non-Rural Health Metrics***

There are some resources already available to the citizens of Chatham County. One resource we were introduced to is the Chatham County Health Alliance. This is a collaborative group of professionals and residents that are working collectively to improve health in the county. Their interactive website lists several resources available

to residents including, but not limited to, food sources, health care, and recreation.

Their group was established during the 2014 Chatham County Health Assessment. Their mission includes getting people healthier and more active in the community.

Considering the recent establishment of the health alliance, there are newer resources available that many residents may not know about.

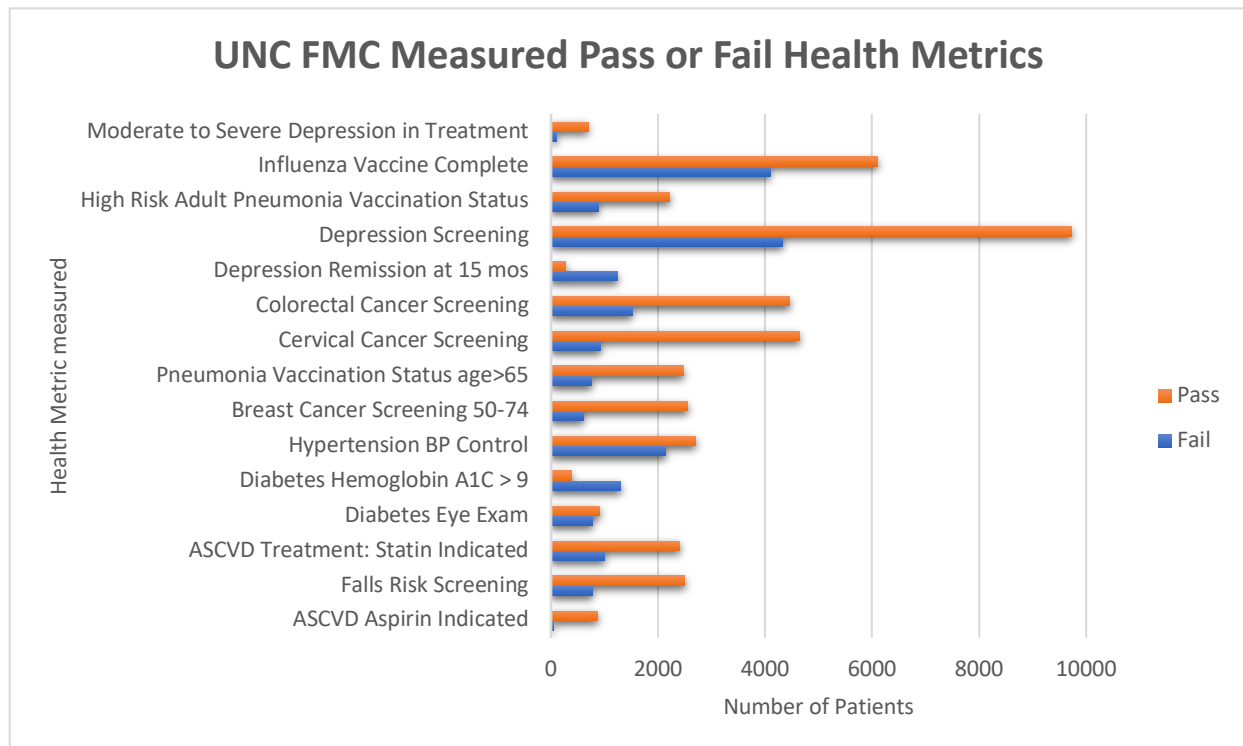
Other diabetic-specific resources available to citizens include the Chatham Health Department and the Chatham Hospital Diabetes Management Program. Both groups provide education about diabetes, especially to those newly diagnosed. The local county council on aging even has a diabetes support group. Chatham County diabetics have resources available to them, but the barrier to overcome, in our opinion, was getting the information about the resources to the diabetic population. These residents also needed the information necessary to effectively use these resources.

#### (4) Prioritize and design a plan to address the identified issue

##### Data extraction and Inclusion criteria

Data for our proposed quality improvement project was obtained from the health metrics that were measured by the FMC for their patient population up until January 1, 2018. The FMC health metric data included: (1) the patient county, (2) postal zip code, (3) a pseudo ID to represent the patient, (4) the health metric that was being measured, (5) whether the metric was passed or failed by the patient, (6) insurance company, (7) patient date of birth, (8) and the patient's age. We decided to organize the data obtained from the FMC by the total number of health metrics failed vs. passed among all patients, in order to identify what health metric had the largest percent failed

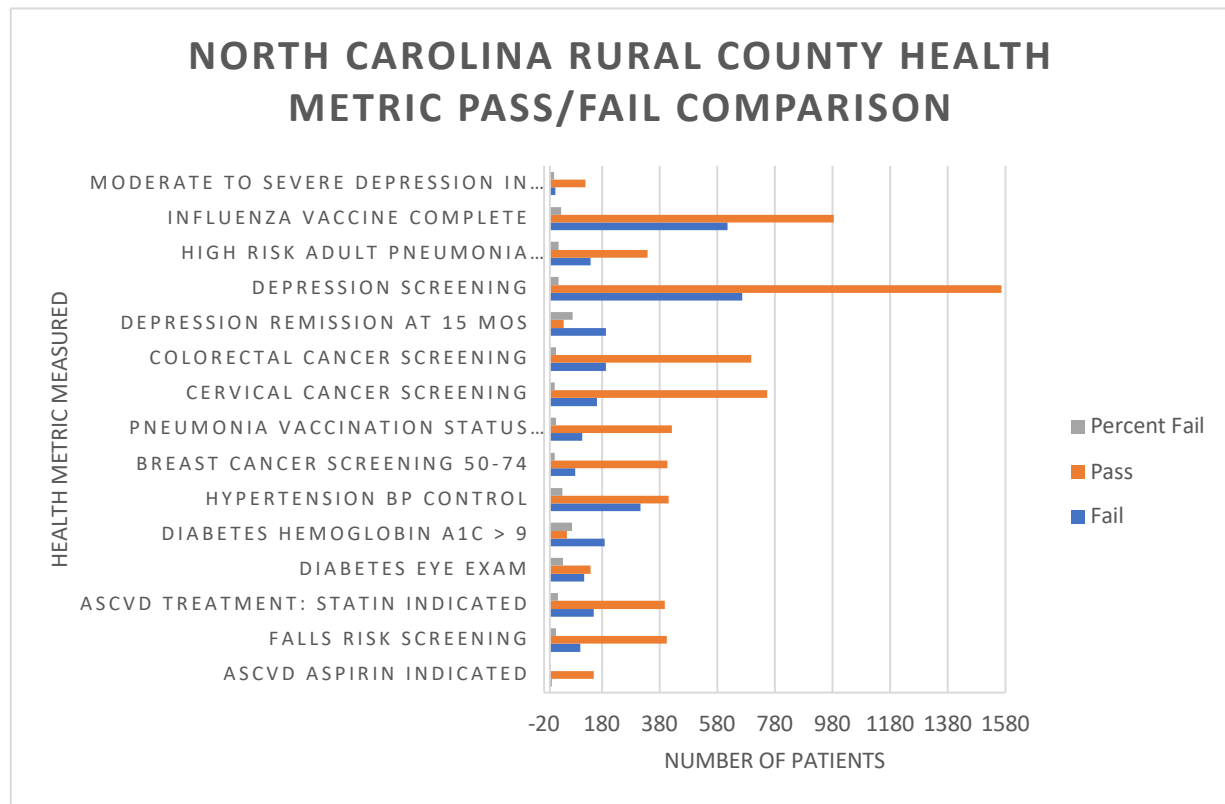
(Figure 4). Through this analysis of the data, the FMC had two major metrics that patients failed to meet, Diabetes Hemoglobin A1C less than 9 % with 77 % failed and depression remission at 15 months with 82 % failed. Though depression remission at 15 months had a higher percent failed, our group decided to focus on the diabetes hemoglobin A1C greater than 9 % health metrics.



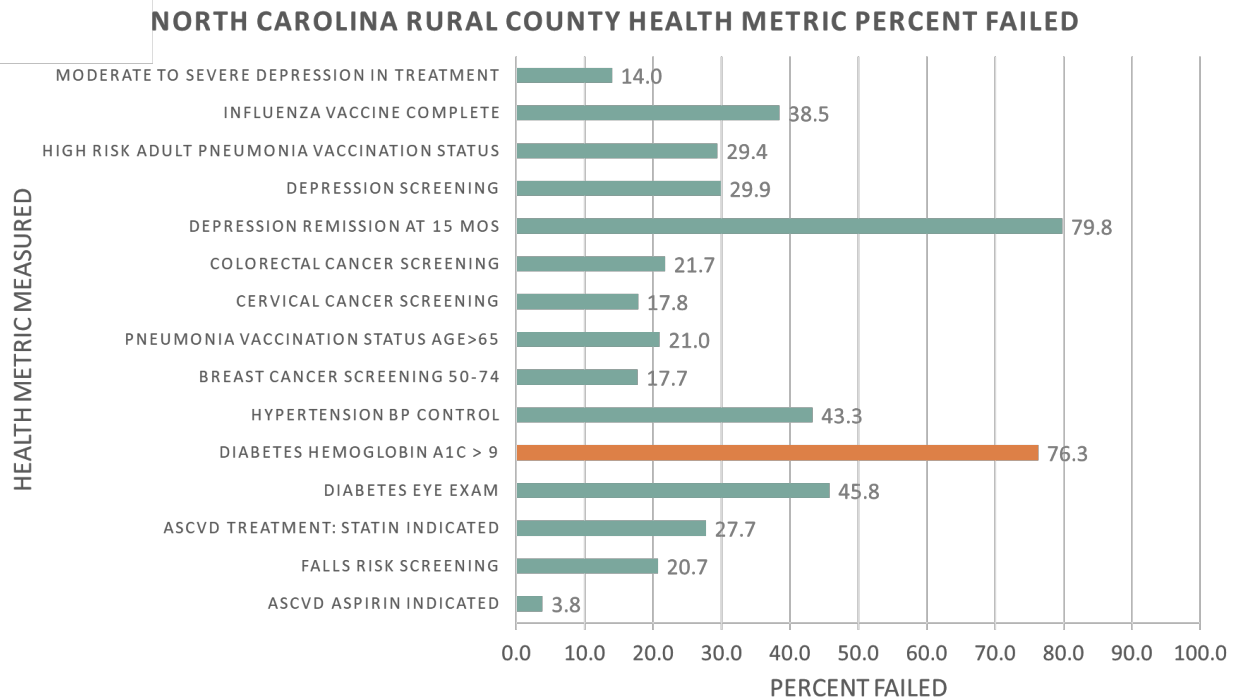
**Figure 4: FMC Measured Pass/Fail Metrics**

The data was then further organized to include only rural counties in North Carolina. With this data modification the two most failed metrics were still Diabetes Hemoglobin A1C less than 9 mmol/mol with 76 % failed and depression remission at 15 months with 80 % failed (Figure 5). With the Diabetes Hemoglobin A1C of less than 9 % health metric having the second highest failure rate for both rural patients and total patients cared for at FMC, and the

qualitative data obtained from the interviews of the FMC staff highlighting diabetes care as a major issue for the clinic, we concluded that addressing diabetic care in rural populations in North Carolina was justified, and would benefit both parties.



**Figure 5: North Carolina Rural County Health Metric Pass/Fail Comparison**



**Figure 6: North Carolina Rural County Health Metric Percent failed.**

Our patient inclusion criteria were: (1) diagnosis of diabetes mellitus (either type I or type II), (2) established patient at the FMC, (3) between the ages of 18 – 70 years old, (4) Chatham County residency, (5) valid cell phone number with text capability, and (6) English language fluency.

## **Methods**

### **Recruitment**

All patients at the FMC that met the inclusion criteria were contacted about their optional participation. Patients were recruited via phone calls to assess whether they would be interested in participating in our quality improvement project. Our goal was to recruit at least 50 - 100 individuals for the purpose of this quality improvement project. All patient information was kept confidential, and patients were only identified via their pseudo ID.

To help educate and motivate diabetics in Chatham County we decided to use technology as a tool, specifically using SMS text messaging. We used a mass text message sending website, *Textedly.com*. This website allowed us to create text messages to send out at scheduled times. Messages could be pre-loaded at one time. To be mindful of literacy, the text messages were written at a 5<sup>th</sup>-grade level. We enlisted the help of the UNC Health Science Library writing center and their health literacy department for evaluation of our message choices.

We designed our text messages based on four categories (1) general diabetic information, (2) nutrition, (3) exercise, and (4) medication management. In total, 31 text messages were designed. These four categories were chosen because we felt they would have the most impact on a patient's disease self – management. Exercise, nutrition, and medication management are all important aspects of a diabetic's life. They all can have a chain reaction on disease control, for better or worse. The general category gave people information about diabetes such as signs and symptoms of hypo/hyperglycemia. The nutrition category was designed to give people better recipes for healthy diabetic meals. The exercise category sent information about local trails for exercise and even some local walking groups and their meeting times. The final category of medication management was designed to give patients information about their medications and storage of insulin, etc.

The participants could opt in or out of the four categories of messages. Once the participants were recruited, they were sent general messages about how to opt into each individual category of messages. The ability to opt into each category was based on a reply

from the participant utilizing a certain keyword. This keyword reply would place them into the groups within the website and subsequently, a list of participants was created for each category. This allowed the website to send targeted messages to patients based on which categories they selected. Each participant would get two messages per category each week. Therefore, each participant could only receive a total of eight messages per week, if they opted into all four categories.

### Outcome Measures

Healthcare metrics are typically scored using a pass or fail system. There is no measure related to an individual and their care. Therefore, self-efficacy was chosen as a measurable outcome to give the participant more individualization of their care.

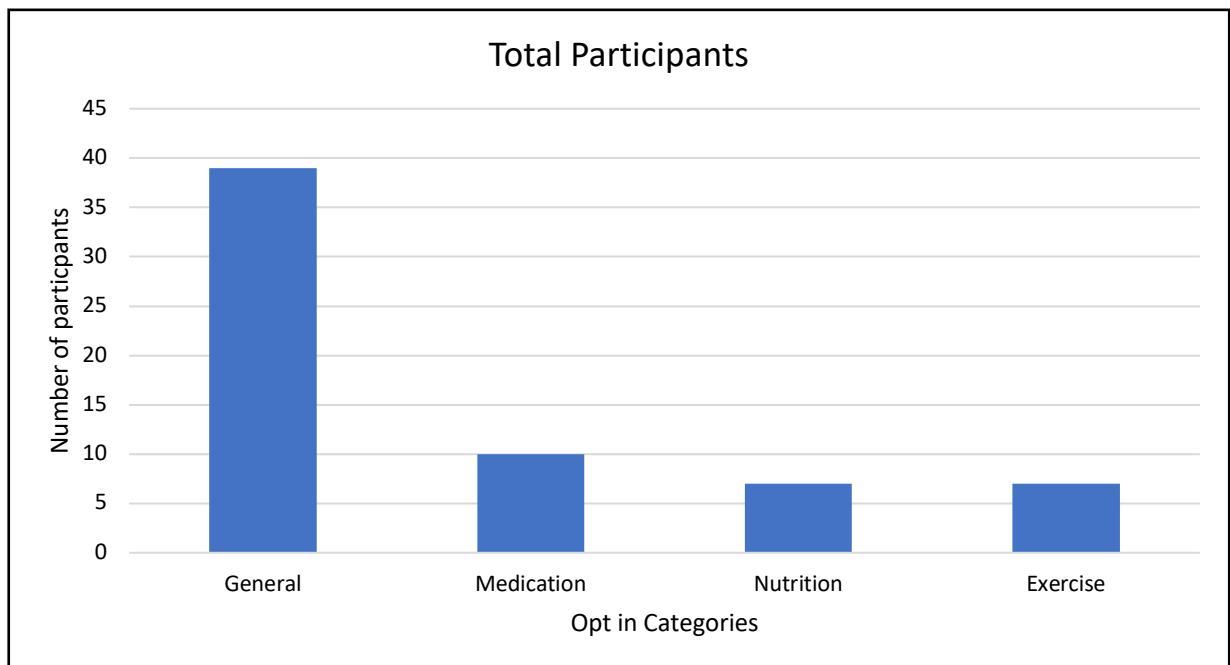
A diabetic self-efficacy survey was used to measure the impact of the SMS messages (Appendix B).<sup>26</sup> This questionnaire was designed by the Self-Management Resource Center. It is an 8-question survey that rates each answer on a scale of 1 – 10. This survey was used pre and post text messages to see if the participants felt an improvement in self-efficacy in their own diabetes care. A link to a pre-self-efficacy survey was sent out prior to the group messages to evaluate people's confidence in their diabetes care. Once the messages ended, a link to a post-survey was then sent to each participant. We expected an increase in the self-efficacy of each participant. This was the only outcome available to measure due to time constraints of the project.

### Results

There were 126 participants who met our inclusion criteria and were contacted either via a phone call or a "MyChart" message. Of those 126 individuals, 44 participants agreed to

enroll in the project. Due to the logistical circumstances of the website, all 44 participants were enrolled under a “general” group. Under the general group, participants were then allowed to opt into between one and all four focused categories via a keyword specific to the given category. Participants were also provided with a “stop” message with each text message, to have the option to opt out of the focus group at any point in time.

After the initial enrollment messages were sent out to the 44 participants, 39 participants opted into the general group. From in the general group, 10 participants opted into the medication only group, and 7 participants opted into both the nutrition and exercise groups, but not the medication group (Figure 6).

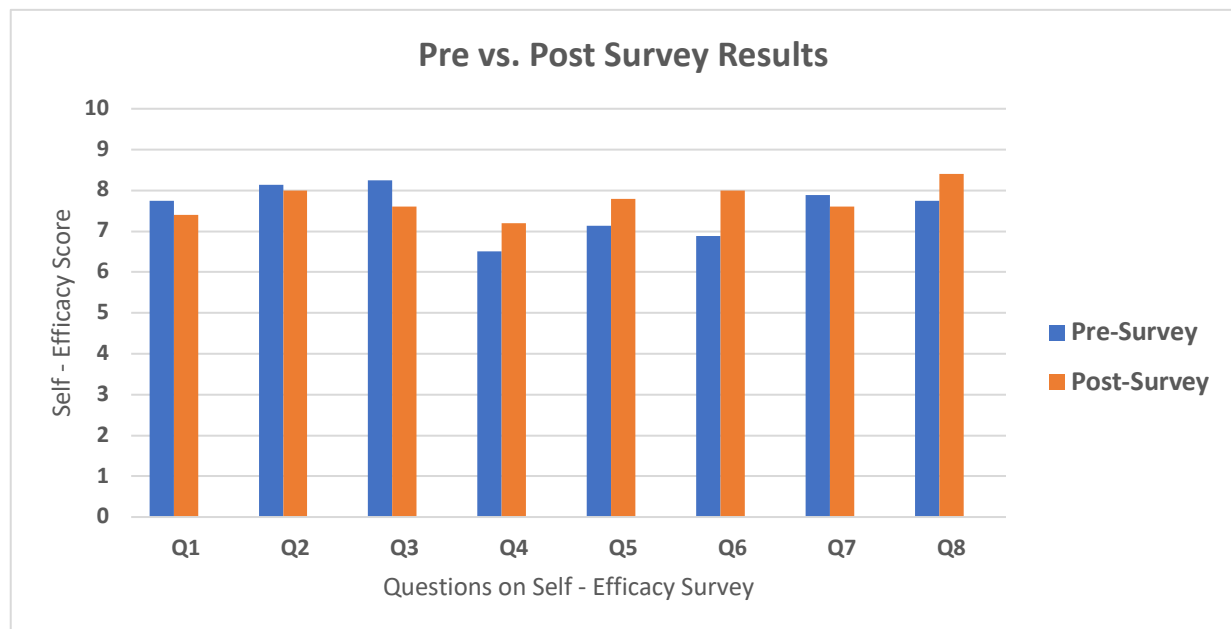


**Figure 7 - Total Participants**

Each group participant was sent two text messages randomly during the week. Therefore, a total of eight messages were sent per week. The trial lasted three weeks due to time constraints outside of our control. Nonetheless, 24 text messages were sent in total.

Prior to the initial keyword group messages, a pre-participation diabetes self-efficacy survey was sent out to all participants. A total of 44 pre-surveys were sent out. A Qualtrics survey was set up by the researchers to send each participant a link via text message. The survey included all the questions and answer scale of the validated survey. The use of Qualtrics also allowed for statistical analysis. In total eight participants filled out the survey, demonstrating a completion rate of 18 %.

At the end of the trial, a post-self-efficacy survey was sent out to each participant. The post-survey was set up like the pre-survey. In total six participants filled out the post-survey. The results, using mean values of each response, from each survey are shown in Figure 7.



**Figure 8 - Pre vs. Post Survey Results**

## **Discussion**

Most everyone today can be seen with a mobile phone in hand. Our technologically advanced society is always making changes to make life more efficient. There is an abundance

of text messaging use with the increased use of mobile phones. This alone has sparked new research in many healthcare fields as to how this technology can be utilized to improve health outcomes.

The focus of our program plan was to impact diabetic patients with the use of technology. Our intentions were to set up a program that would send patients SMS text messages pertaining to their diabetes. Based on the health belief model, we hypothesized that if we educated and motivated the participants, then we would see a positive change. Despite previous research showing a positive change in diabetics with the use of text messages, our results are inconclusive as to whether there was a positive change.<sup>20,21</sup> As Figure 7 shows the pre and post survey results are inconsistent. About half of the self-efficacy questions demonstrated a positive change and the other half showed a negative change. We believe that there is not enough data to extrapolate strong conclusions. Based on the results above, we had an 18 % response to pre-message surveys and 15 % response to post-message surveys.

There are many reasons as to why our results are not consistent with past research. For one, our program design may have been too extensive for everyone in our target population. Instead of just sending general messages to participants, we gave our users the option to opt into further categories. In retrospect, we may have used a style of SMS messaging that people may not be accustomed to using. We may have overestimated our target population's understanding of the website's workflow. The use of a "keyword" required participants to reply to a number that is not in the form of a normal telephone number. We speculated that this may have led to some confusion, especially with our older population. There were many

messages that were replied to incorrectly and the website alerted the researchers of this issue via email. A simpler design may be warranted moving forward with similar research.

Another limitation of our study is that the results were not statistically analyzed in more detail. The cross analysis of which phone numbers signed up for multiple groups would have been interesting. There could have been trends to help guide further research. It would be worthwhile to examine from which particular categories individuals opted into receiving messages. Also, identifying the ages of the participants who signed up would have been beneficial. Targeting particular age groups or a narrower demographic of individuals could help in providing more focused interventions in future studies. One can assume that most younger people are more technologically inclined. Knowing the ages of participants that stayed active in the study would help to clarify this assumption. The self-efficacy surveys were kept anonymous and we wonder had we been able to identify the participants by phone number if we could see which, if any, participants filled out both the pre and post surveys. Further analysis could have been beneficial in directing further studies and interventions.

This study was conducted in the time frame of a typical college semester (four months). Therefore, one major limitation is time. If this study could have been conducted over a greater length of time, better planning and implementation could have taken place. Also sending participants messages for greater lengths of time would have been helpful. Other metrics could have been studied such as trending hemoglobin A1C measures. This measure is what often guides diabetics and their treatments, as it provides information regarding a patient's level of glycemic control from the preceding three months. Therefore, a longer length of study would have possibly allowed us to analyze such a metric.

Despite the limitations of the study, there was valuable information extrapolated. One

of the strengths of the study is that the recruitment rate showed that patients do want help outside the clinic. We made roughly 126 phone calls to eligible participants and were able to get 44 people who wanted to be a part of the study, demonstrating a 35 % recruitment rate. This rate shows the potential that there are patients who would be willing to seek further treatment and aid outside of the clinic. This is exciting for future studies, as this demonstrates people may be interested and willing to participate.

Another strength of the study was the ability to maintain focus on the initially targeted patient population. We set out with precise inclusion criterion and were able to find many patients who fit within the parameters. Furthermore, we were able to focus on a rural county in North Carolina where diabetes has a high prevalence.

### **Conclusion**

From our research, it is fair to say that diabetes continues to be a huge medical concern that affects millions worldwide. With diabetes becoming a societal norm, a solution is needed now more than ever to aid in the billions of dollars diabetics spend on their medical care related to their diabetes and diabetes-associated comorbidities. Due to our world becoming more technologically driven and advanced, telemedicine is shaping to be a viable option to reach more patients worldwide, especially those in rural populations with limited access to healthcare. With the use of technology, healthcare providers can better educate, motivate, and hold patients accountable for their actions that impact their health beyond the clinic walls.

Further research is needed to determine how telemedicine would best serve each patient population. The health belief model outlines the need for individualized patient

healthcare to make the most profound impact on patients' disease processes. With cellular devices becoming a cultural expectation, it only seems natural to gravitate towards cellular devices to interact with and stay connected to patients, making downloadable medical applications a practical solution to this ever-growing health concern. Our project was able to support that the patient receptivity for this modality of providing and promoting care is there, and we need to continue to explore this in order to optimize the delivery of care to improve health outcomes for the ever-pressing diabetes epidemic.

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## E1. Personal Interview Questions for Key Informants

### PRACTITIONER VERSION<sup>23</sup>

Good morning/afternoon/evening. My name is \_\_\_\_\_ of \_\_\_\_\_ [institution] and I am involved with \_\_\_\_\_ [person] in conducting interviews with practitioner and consumer groups to learn more about the decision making needs people when they are making decisions about \_\_\_\_\_ [problem X].

During the interview, we will be asking you some questions about the health decisions people might make in your area of practice, for example [decisions/a decision about \_\_\_\_\_]

[insert decisions appropriate to clinical area]

This information will contribute to a better understanding of the decision making needs of patients to improve planning of decision support.

All of the information we collect in this interview will be kept confidential. We'd like your help, It won't take more than \_\_\_\_\_[insert] minutes.

#### DECISION

1. What decisions do patients with \_\_\_\_\_ [problem X] have to make in your practice?

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2. Lets focus on one particular decision . . . [NOTE TO QUESTIONNAIRE DEVELOPER YOU NEED TO ADAPT BASED ON WHETHER YOU ARE FOCUSING ON ONE DECISION OR LEAVING IT TO RESPONDENT TO PICK THE MOST IMPORTANT DECISION] insert either" 'the decision about whether .....' or 'one that is important and difficult for patients to make (e.g. patients need a lot of help, or practitioner spends a lot of time)'. Which one would you choose?

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3. Lets talk about the difficulty people have making this decision about [ ].

How do patients feel when making this decision?

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*[Probe behavioral manifestations of decisional conflict]*

**Do patients feel:**

- ☐ unsure about what to do?
- ☐ worried what could go wrong
- ☐ distressed or upset
- ☐ constantly thinking about the decision
- ☐ wavering between choices or changing their mind
- ☐ delaying the decision

5. What do you see as the main options patients have?

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6. What do you see as the main advantages/benefits and disadvantages/risks of the options?  
[INSERT BELOW USE BACK OF PAGE FOR MORE COMMENTS]

7. What is your usual role in making this decision?	<p><i>[Probe role:]</i></p> <p><b>Do you usually:</b></p>
---	---

<hr/> <hr/> <hr/> <hr/> <hr/>	<input type="checkbox"/> Make the decision for the patients <input type="checkbox"/> Share the decision with the patients <input type="checkbox"/> Provide support or advice for patients to make the decision on their own
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8. What factors make it difficult for you to support your patients' decision making?

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9. What factors make it easier for you to support your patients' decision making?

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<p>10. Who else besides yourself and the patient is usually involved in making this decision?</p> <hr/> <hr/> <hr/> <hr/> <hr/>	<p><b>[Probe:]</b></p> <input type="checkbox"/> spouse <input type="checkbox"/> family <input type="checkbox"/> friend <input type="checkbox"/> health care provider <input type="checkbox"/> other, specify _____
---	--

<p>11. What is their usual role in making this decision (i.e. the person mentioned above)?</p> <hr/> <hr/> <hr/> <hr/> <hr/>	<p><b>[Probe role:]</b></p> <p><b>Do you they usually:</b></p> <input type="checkbox"/> Make the decision for the patients <input type="checkbox"/> Share the decision with the patients <input type="checkbox"/> Provide support or advice for patients to make the decision on their own <input type="checkbox"/> Don't know <input type="checkbox"/> Other, specify _____
--	--

<p>12. How do patients usually go about making such a decision?</p> <hr/> <hr/> <hr/> <hr/> <hr/>	<p><b>[Probe decision making behavior:]</b></p> <p><b>Do they:</b></p> <input type="checkbox"/> Get information on options <input type="checkbox"/> Get information on the chances of benefits and risks <input type="checkbox"/> Consider the personal importance of the benefits and risks
---	--

- |  |   |
|--|---|
|  | <input type="checkbox"/> Get information on how others go about deciding<br><input type="checkbox"/> Get support from others<br><input type="checkbox"/> Find ways to handle pressure |
|--|---|

13. What would help patients to make this decision?

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14. What will hinder patients (get in the way of) making this decision?

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15. Is there anything else that would help overcome barriers to decision making?

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16. I will list possible ways to help some people with a decision, which ones do you think might be useful to your patients?

<input type="checkbox"/> Counseling from a health Practitioner →	IF YES, specify what types
<input type="checkbox"/> Discussion groups of people facing the same decision →	IF YES, specify what type of organization or group
<input type="checkbox"/> Information materials	IF YES, specify content <input type="checkbox"/> Health condition <input type="checkbox"/> Options <input type="checkbox"/> Benefits <input type="checkbox"/> Risks <input type="checkbox"/> Probabilities of benefits/risks <input type="checkbox"/> Help considering the personal importance of benefits versus risks <input type="checkbox"/> Guidance in the steps of deliberation and communication <input type="checkbox"/> Other, specify _____ IF YES, specify format <input type="checkbox"/> Booklet, pamphlets <input type="checkbox"/> Internet

	<input type="checkbox"/> Videos/DVDs <input type="checkbox"/> Other, specify _____ IF YES, who do you think should prepare information about the decision <input type="checkbox"/> Pharmacies <input type="checkbox"/> Expert medical and health practitioners <input type="checkbox"/> Health societies for specific condition (e.g.Cancer, Heart and Stroke) <input type="checkbox"/> Government <input type="checkbox"/> Insurance companies <input type="checkbox"/> Companies that produce and sell drugs and health products <input type="checkbox"/> Consumer associations <input type="checkbox"/> Not for profit companies that produce health information [e.g. Healthwise] <input type="checkbox"/> For profit companies that produce health information [e.g. WEB MD; BMJ Best Treatments.ORG]
--	---

17. Is there anything else that would help you to do a better job supporting your patients' decision making?

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## CHARACTERISTICS OF PRACTITIONER

### 18. Age Category (guestimate)

- ☐ Twenties
- ☐ Thirties
- ☐ Forties
- ☐ Fifties
- ☐ Sixties or more

### 19. Sex (observe)

1. Male
2. Female

20. Practice Discipline specify \_\_\_\_\_

21. Practice Specialty

22. Practice Location specify \_\_\_\_\_

[THANK RESPONDENT]

Appendix B<sup>26</sup>

## Self-Efficacy for Diabetes

We would like to know how confident you are in doing certain activities. For each of the following questions, please choose the number that corresponds to your confidence that you can do the tasks regularly at the present time.

1. How confident do you feel that you can eat your meals every 4 to 5 hours every day, including breakfast every day?
 

not at all		totally
confident	<div style="display: flex; justify-content: space-between; padding: 0 10px;"> <span>1</span><span>2</span><span>3</span><span>4</span><span>5</span><span>6</span><span>7</span><span>8</span><span>9</span><span>10</span> </div>	confident
  
2. How confident do you feel that you can follow your diet when you have to prepare or share food with other people who do not have diabetes?
 

not at all		totally
confident	<div style="display: flex; justify-content: space-between; padding: 0 10px;"> <span>1</span><span>2</span><span>3</span><span>4</span><span>5</span><span>6</span><span>7</span><span>8</span><span>9</span><span>10</span> </div>	confident
  
3. How confident do you feel that you can choose the appropriate foods to eat when you are hungry (for example, snacks)?
 

not at all		totally
confident	<div style="display: flex; justify-content: space-between; padding: 0 10px;"> <span>1</span><span>2</span><span>3</span><span>4</span><span>5</span><span>6</span><span>7</span><span>8</span><span>9</span><span>10</span> </div>	confident
  
4. How confident do you feel that you can exercise 15 to 30 minutes, 4 to 5 times a week?
 

not at all		totally
confident	<div style="display: flex; justify-content: space-between; padding: 0 10px;"> <span>1</span><span>2</span><span>3</span><span>4</span><span>5</span><span>6</span><span>7</span><span>8</span><span>9</span><span>10</span> </div>	confident
  
5. How confident do you feel that you can do something to prevent your blood sugar level from dropping when you exercise?
 

not at all		totally
confident	<div style="display: flex; justify-content: space-between; padding: 0 10px;"> <span>1</span><span>2</span><span>3</span><span>4</span><span>5</span><span>6</span><span>7</span><span>8</span><span>9</span><span>10</span> </div>	confident
  
6. How confident do you feel that you know what to do when your blood sugar level goes higher or lower than it should be?
 

not at all		totally
confident	<div style="display: flex; justify-content: space-between; padding: 0 10px;"> <span>1</span><span>2</span><span>3</span><span>4</span><span>5</span><span>6</span><span>7</span><span>8</span><span>9</span><span>10</span> </div>	confident
  
7. How confident do you feel that you can judge when the changes in your illness mean you should visit the doctor?
 

not at all		totally
confident	<div style="display: flex; justify-content: space-between; padding: 0 10px;"> <span>1</span><span>2</span><span>3</span><span>4</span><span>5</span><span>6</span><span>7</span><span>8</span><span>9</span><span>10</span> </div>	confident
  
8. How confident do you feel that you can control your diabetes so that it does not interfere with the things you want to do?
 

not at all		totally
confident	<div style="display: flex; justify-content: space-between; padding: 0 10px;"> <span>1</span><span>2</span><span>3</span><span>4</span><span>5</span><span>6</span><span>7</span><span>8</span><span>9</span><span>10</span> </div>	confident

## Scoring

The score for each item is the number circled. If two consecutive numbers are circled, code the lower number (less self-efficacy). If the numbers are not consecutive, do not score the item. The score for the scale is the mean of the six items. If more than two items are missing, do not score the scale. Higher number indicates higher self-efficacy.

## Characteristics

Tested on 186 subjects with diabetes.

No. of items	Observed Range	Mean	Standard Deviation	Internal Consistency Reliability	Test-Retest Reliability
8	1-10	6.87	1.76	.828	NA

## Source of Psychometric Data

Stanford English Diabetes Self-Management study. Study reported in Lorig K, Ritter PL, Villa FJ, Armas J. Community-Based Peer-Led Diabetes Self-Management: A Randomized Trial. The Diabetes Educator 2009; Jul-Aug;35(4):641-51.

## Comments

This 8-item scale was originally developed and tested in Spanish for the Diabetes Self-Management study. For internet studies, we add radio buttons below each number. There is another way that we use to format these items, which takes up less space on a questionnaire, shown also in the PDF document. This scale is available in Spanish.

## References

Unpublished.

*This scale is free to use without permission*

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