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Electronic Reminders to Improve Medication Adherence in Diabetes:

A Quality Improvement Project

Lisa E. Wilson

University of New Hampshire

Faculty Mentor: Pamela DiNapoli, PhD, RN, CNL

Practice Mentor: Christine Dube, APRN, FNP

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Abstract

BACKGROUND: Diabetes often contributes to many co-morbid conditions and their complications. Non-adherence to medications is common in patients with chronic disease. The project aimed to improve medication adherence through the implementation of electronic messaging. The project was set in a private medical practice within a critical access hospital. Participants were patients of the practice with diabetes.

METHODS: Baseline assessment included review and documentation of HgBA1cs, prescription requests, and past medical history. The development of an intervention to improve medication adherence utilizing electronic reminders was based on Bandura's (1989) Social Cognitive Theory and Ajzen's (1991) Theory of Planned Behavior.

INTERVENTION: The HgBA1cs of patients with diabetes were followed for the three months before the intervention and during the three-month intervention to trend improvements in HgBA1c. Monthly prescription monitoring for the three months before the intervention and during intervention also occurred as an additional measure of adherence. Read receipts of electronic messages were also tracked.

RESULTS: There was a sample of 21 patient-participants. The median aggregate HgBA1c pre-intervention was 8.5. The median aggregate HgBA1c post-intervention was 7.7 which was a significant median aggregate change. The patients reading the messages over the twelve weeks totaled 95% and prescription requests totaled 46 pre-intervention and 37 during the intervention.

CONCLUSION: The evidence suggests that using electronic reminders can be beneficial to help improve medication adherence in participants.

Keywords: medication adherence, electronic messaging, diabetes complications

Electronic Reminders to Improve Medication Adherence in Diabetes:

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Globally, type 2 diabetes impacted about 415 million patients in 2015 and that number is predicted to rise to over 642 million patients by 2040, the equivalent to around one in ten adults (Muralidharan, Ranjani, Anjana, Allender & Mohan, 2017). Despite the advances in the treatment of this disease, diabetes affects more than 29.1 million Americans and contributes to more than 200,000 deaths annually (Russell, Vess, Durham & Johnson, 2017). Diabetes currently accounts for 11% of worldwide healthcare spending with costs expected to increase to an estimated 600 million dollars per year by the year 2035 (Conway, Campbell, Forbes, Cunningham & Wake, 2016). Interventions such as electronic reminders have been shown to help patients in the self-management of their diabetes and have been shown to have a positive impact on clinical and behavioral outcomes for patients (Nutri, 2015).

Introduction

Problem Description

The disease burden of diabetes has significant implications for the health care delivery system (Nutri et al., 2015). There are financial implications, which are not limited to just costs for the patients but also impact the financial health of healthcare institutions. The costs for patients include frequent healthcare provider visits and hospitalizations as well as the inability to maintain employment hours. For patients, this often results in reduced income or loss of employment due to complications from their illness. Loss of employment may result in the loss

of health insurance and the ability to afford healthcare. Healthcare institutions often end up absorbing the costs of treatment for patients when their financial obligations cannot be met.

Diabetes is the underlying cause of many co-morbid conditions and their complications (Russell et al., 2017). Comorbid conditions and their complications increase the challenges faced by patients managing their diabetes, requiring collaboration and meaningful communication with healthcare providers. One major reason for uncontrolled symptoms and complications is non-adherence with medications. Non-adherence to medications is common in patients with chronic disease and reduces the effectiveness of prescribed medications (Usherwood, 2017). Medication adherence is critically important for patients to ensure optimum health outcomes. With an ever-increasing population of patients with diabetes, finding new ways to reach patients and create meaningful communication with their healthcare providers is imperative.

The enormity of the sheer number of patients affected by this illness requires that providers find new ways to help patients manage their diabetes more effectively to not only help improve patients quality of life and decrease the complications associated with this illness but also to help healthcare organizations better manage costs. Innovations in technology such as reminders and education for patients will become a critically important key in improving healthcare quality for this population. While patients have many reasons for not taking their medications, healthcare providers need to shift their focus from those reasons why and instead focus on providing more meaningful communication and education so that patients can make more informed choices around medication adherence.

Given the complexity and cost of diabetes management and the need for improved diabetes self-management education, technology has demonstrated that it meets the needs of patients (Russell et al., 2017). Using technology to improve communication with patients is

something that has been used effectively to help patients with other chronic illnesses, such as asthma, to be more adherent to their medications (Usherwood, 2017). For example, mobile health systems, such as automatic messaging to promote adherence has been shown be a cost-effective way to improve the self-management of chronic illnesses such as diabetes and enhance patient's adherence to their medication regimens (Fioravanti, Fico, Salvi, Betances & Arredodo, 2015). Healthcare organizations, especially small critical access hospital, despite limited resources and technology, must find ways to use the technology they do have to improve adherence with their medications so that patients can enjoy a higher quality of life.

Available Knowledge

The effectiveness of medications relies on the adherence to medication regimens and can be the single most effective intervention for improving health outcomes (Car, Tan, Huang, Sloat & Franklin, 2017). According to Car et al., (2017), up to half of the medicines prescribed for long term conditions are not taken as recommended. An estimated 375 billion dollars per year could be saved with improved medication adherence. Medication nonadherence is not unique to patients with diabetes and is not unique to patients with chronic illnesses treated within the United States. Globally healthcare systems face enormous challenges with medication adherence in the management of chronic disease (Fioravanti et al., 2015). These challenges are especially true for small hospitals which often have fewer resources and smaller budgets. Using mobile health systems that are focused on promoting adherence may be a cost-effective way of improving the self-management of chronic diseases such as diabetes, by enhancing adherence to medications and promoting patient empowerment (Fioravanti et al., 2015).

There is strong evidence that regular reminders are an effective strategy to improve medication adherence (Conway et al., 2016, Nuti et al., 2015, Usherwood, 2017). The results of

Usherwood's (2017) meta-analysis evaluating the use of text messaging in adults with chronic illness found regular reminders doubled the odds of adherence across 16 randomized controlled trials. Using electronic reminder systems to increase medication adherence was shown to be effective when used in the treatment of other chronic illnesses. For example, reminders to prompt patients with asthma to take their medications were shown to be effective when used in the treatment of patients with asthma. This is supported by Foster, Smith, Usherwood & Sawyer (2014) who wrote that in a six-month investigation, patients who received reminders took 73% of their prescribed doses as compared to only 46% in patients who did not get a reminder. Increases in adherence to medications, when prompted with a reminder, were also found in other studies (Bender et al., 2009, Huang et al., 2013)

In a quality improvement project by Russell et al., (2017), interactive text messaging sent through a secure messaging system to patients with diabetes, resulted in a reduction in participants mean finger stick blood glucose level over six months. Improved glycemic control was linked to frequent communication through text messages fostering the provider-patient relationship. (Russell et al., 2017). This same result was reported in other studies which evaluated the impact of mobile phone interventions on diabetes management and glycemic control. In a meta-analysis of 22 randomized trials it was reported that during a six month period when compared to control groups the patients that received electronic messages had a 0.5% reduction in HgBA1c levels. (Russell et al., 2017). These results are similar to those reported in other studies reporting similar reductions in HgBA1c levels. In a review of 61 studies, 81% (n=50) of those studies reported that SMS interventions positively impacted healthcare outcomes by enhancing diabetes self- management and improving glycemic control (Russell et al., 2017).

There is a correlation between patients who do not comply with a provider's treatment plan and worsening conditions resulting in increased healthcare costs (Peleg et al., 2018). It has been shown that nurse counseling has a major effect on self-management of glucose and HgBA1c in patients, particularly when paired with a proactive care management model and decision making support (Ginzburg, Hoffman & Azuri, 2017). Additionally, diabetes self-management education is critically important and is an evidence-based standard defined as an ongoing process to improve the skill, knowledge, and ability essential for diabetes self-management (Russell et al, 2017). Electronic reminders are tools that nurses can use to aid in the effective education of patients and encourage patients to become self-motivated to take their medications daily, thereby helping to increase medication adherence and potentially improve patient quality of life.

Utilizing electronic reminders to improve medication adherence can improve patient quality of life and decrease healthcare costs. Electronic reminders have shown promising results as an intervention for patients with chronic illness and have the ability to achieve high levels of engagement with broad population reach, while requiring minimal resources (Usherwood, 2017). Despite strong evidence that shows the negative impact of medication non-adherence on patients' health and the increased cost of care associated with it, a gap exists. A response that strengthens tertiary prevention and increases patient engagement through electronic reminders as an aid to patient counseling has the potential to improve patient medication adherence and quality of life.

Rationale

The development of an intervention to improve medication adherence utilizing electronic reminders was based on Bandura's (1989) Social Cognitive Theory and Ajzen's (1991) Theory

of Planned Behavior. Both of these theories were used to develop a theoretical understanding of the target behavior and guide the choice of interventions. Social cognitive theory proposes that people are neither driven by inner forces or automatically shaped and controlled by the environment, rather we can predict human behavior based on the reciprocal interaction of the behavior, personal factors and environmental factors (Bandura, 1989). The theory of planned behavior by Icek Ajzen (1991) is an extension of the theory of reasoned action. A central factor in the theory of planned behavior is the individual's intention to perform a given behavior and captures the motivational factors that influence behavior (Ajzen, 1991). The stronger the intention to engage in a behavior, the more likely it will be performed (Ajzen, 1991).

The theory of planned behavior has been used in a variety of studies to predict health behaviors and suggests that behavior is better predicted by the intention to perform that behavior which will be stronger, when there are more favorable attitudes toward the behavior, the perceived behavioral control and the subjective norms (Ferreira & Pereira, 2017). This is supported by Wong et al., (2018) and Cooper et al., (2016) who developed electronic reminders based on both social cognitive theory and the theory of planned behavior and grouped the electronic messages into four broad themes including lifestyle modification, diabetes and prediabetes, social influences on lifestyle change and self-efficacy.

Specific Aims

The specific aim of this quality improvement (QI) project was to determine if in adult patients with diabetes would electronic reminders be effective in increasing medication adherence as evidenced by decreased HgBA1c. The goal and the expected outcome of this quality improvement project were to improve disease self-management as evidenced by adherence to medication management resulting in a reduction in HgBA1c. An HgBA1c of under

7 is recommended by the American Diabetes Association to help slow the progression of their illness as well as reduce the risk of complications.

The primary clinical outcome of this project was a change in HgBA1c levels, measured by the difference between baseline and endpoint values and by the number of patients who experienced a reduction of at least 1% from baseline to endpoint. A secondary outcome of this study was a change in prescription requests as an additional measure of medication adherence. Finally, read receipts were recorded to show that the patients are reading the reminders. Participants were recruited from a private practice. Inclusion criteria included the following: Type 2 diabetes with HgBA1c equal to or greater than 7%, 18 years or older with access to the patient portal or email via personal computer or cell phone.

Methods

Context

Founded in the early nineteen hundreds, the hospital is a not for profit Critical Access Hospital serving 15 communities in central New Hampshire, providing both primary care and specialized services in a family and patient-centered environment. The hospital is affiliated with a larger hospital in the area. The primary care services at the hospital are offered Monday through Friday with 24 access to provider on-call. The primary care practice serves a large variety of patients for preventative, acute and chronic management of medical issues, including diabetes. The practice has 125 patients with diabetes who struggle to maintain HgBA1c at appropriate levels (below 7) and struggle with medication adherence. The hospital has a patient portal which is a safe and convenient online tool for patients to access personal health information and records and allows patients to communicate securely with their healthcare team.

However, this portal has not been utilized optimally for communication around medication adherence and patient education.

A cost-benefit analysis considering the cost of the current standard of care offset by costs associated with the project was completed (Appendix A). It is important to note that the initial costs are one-time costs. The initial costs included the time it took IT to build and launch the messages as well as the cost of having the patient portal manager sign up patients for the portal and help them with technical issues. The DNP student created 44 messages, however, IT had to spend time loading these messages into templates so that the DNP student could click the template and use it when sending each message out to patients in the project. Additionally, this work required a total of two hours of meeting with the IT department which included initial meeting and several other meetings for revisions based on provider feedback when the system was tested in the pilot run with the providers.

Time savings is a benefit that is hard to quantify in terms of dollars, however efficient use of provider time is critically important. Value-based incentives are based on the following quality measures: activities that contribute to positive health outcomes (IE: smoking cessation), measures of the effectiveness of care provided (IE: diabetes control) and patient satisfaction. These value-based incentive programs are closely related to the risk adjustment coding reimbursement methodology at the practice. Every time a provider sees a patient all chronic conditions that are considered while treating the patient should be documented in the current note as well as any medications the patient is taking. These must be mentioned in the HPI, exam, or MDM to be coded (not just pulled in by the EMR in a list). These diagnoses are assigned a risk score which increases the complexity of the patient. These scores are linked to increased reimbursement, but the additional diagnoses are also used by insurance companies to identify

patients with chronic illnesses for incentive programs. It takes additional time for providers to document this information, but ultimately it will increase reimbursement and improve patient care.

Value-based incentives in the ambulatory setting include Medicare Incentive Payment Program (MIPS), individual commercial insurance programs (including the Anthem and HPHC ACOs) and the Medicaid Managed Care Organizations (MCOs). For MIPS, one of the measures that NLH has reported on for the past two years is the quality measure of the percentage of patients with diabetes in poor control ($>9\%$ HgBA1c). This is only one of a total of six measures that we are required to report on for a calendar year that creates a portion of the score for our MIPS penalty or incentive payment. It is a complicated formula that includes improvement activities, quality measures performance, promoting interoperability measures and cost.

For 2018 the maximum penalty or incentive for MIPS was 5% of Medicare Part B payments and is applied against 2020 payments. The hospital will not get their final score for 2018 until late in 2019 so they do not know exactly what their incentive (or penalty) will be until then. There is no way to assign a dollar amount of incentive payments to one or two quality measures (in this case having an HgBA1c done and HgBA1c $>9\%$). Each of the commercial insurances and the MCOs has their own quality measures - the diabetes measures for each are not consistent from program to program. Each program also has its own financial incentive programs that include many quality measures. Ultimately this keeps our patients healthier and reduces complications, but the VP of Quality indicates the hospital currently has no way to track this improvement to a financial incentive.

The hospital could improve their numbers for value-based care in two specific categories through the use of this quality improvement program. This would include reducing HgBA1c

poor control (>9%) numbers and improving and increasing the percentage of patients who received an HgBA1c test during the measurement year.

The value of this initiative cannot be looked at purely from a monetary perspective. Helping patients better manage their illness and have more meaningful communication with their provider increases patient safety and provider morale which is critically important in providing the highest quality healthcare for patients. These aspects, though difficult to measure quantitatively, have innumerable benefits for patients, families and providers. Helping providers to have more time to be able to do the required paperwork with patients around value-based incentives can help improve the financial incentives that the practice gets and can reduce penalties, however, there is no way to quantify these numbers currently according to the VP Of Quality Improvement and Safety.

Intervention

Patients with diabetes at the private practice were the participants in this project. The participants were provided an intervention using electronic reminders over three months and the improvements in HgBA1cs were measured pre and post-intervention.

The electronic reminders aimed at improving patient medication adherence were developed through an iterative process based on the best evidence from the literature. The electronic messages consisted of three messages per week. The messages focused on medication, diet and lifestyle education. The messages were designed to encourage, inspire and provide more knowledge for patients, while encouraging meaningful communication and collaboration with their healthcare provider so they can make more informed choices regarding their care. These messages were designed to be sent at random times between 8 and 5 pm, with message themes

coinciding with relevant times for the day. The messages were sent through the patient portal system or email, based on patient preference.

The team involved in this work included the DNP student as the project leader, healthcare providers, as well as the IT department, the patient portal manager and the Quality Improvement Department. The DNP student was responsible for the creation and implementation of the electronic messages as well as the monitoring of read receipts, pharmacy requests, and the HgBA1c at the end of the intervention. The healthcare providers recommended patients for the project and tracked their progress, while the IT department helped with the electronic message templates. The patient portal manager helped patients sign up and navigate in the portal. Lastly, the quality improvement department helped with the participant letter creation and monitored the progress of the quality improvement project.

Study of the Intervention

The messages were tested with four healthcare providers at the practice who volunteered to be involved in this project and the testing occurred two weeks before the start of the project. They were invited to participate because they are important stakeholders in this project and for the project to be successful, stakeholder investment is essential. The one-week pilot study where one message was sent each day for five days was undertaken to determine message acceptability and ensure message content tone and structure were appropriate. Adjustments to the messages were made based on pilot participant feedback with approval and acceptance of the adjustments after one round of revisions.

During the pilot and preintervention, the existing processes of using the patient portal were mapped and analyzed. It was discovered that the portal was not easy for people to navigate

or join, especially for those who were not technologically savvy. To address this problem the portal manager contacted each patient enrolled in the project that requested assistance and she helped them access and register for the portal. However, some patients were still not comfortable utilizing the portal and requested that messages were sent directly to their email. Key interventions that were tested and implemented were inviting patients to join the patient portal and helping them sign up. Electronic reminders and education were created and entered into the messaging system in preparation for the start of the intervention. A pilot test of the portal system and electronic messages occurred with key stakeholders.

To assess the impact of the interventions three different sets of data were collected. Process measures were read receipts for each message sent and the number of prescriptions requested each month during the three months before the intervention and the three months of the intervention. The outcome measure was pre and post HgBA1c.

Measures

The primary clinical outcome of this project was the change in HgBA1c levels, measured by the difference between baseline and endpoint values. The outcome goal was a reduction of at least 1% from baseline to endpoint in the aggregate. A secondary outcome of this project was a change in prescription requests as an additional measure of medication adherence. Read receipts were recorded to show that the patients were reading the reminders. The outcome goal for read receipts was at least 50% of patients reading the messages. Table 1 outlines the timeline for the intervention including dates and descriptions of each phase of the project.

Table 1

Intervention Timeline

Stage	Dates	Description
Pilot Run	May 13 th to May 17 th	Sent daily messages to pilot participants and then revamped messages based on participant feedback
Preintervention	May 31 st	Retrieved HgBA1c of all patients (this result provided an average of blood sugar of the past three months (March, April, May) and got number of prescriptions requested during that time period as an additional measure of adherence.
Intervention	June 3 rd to August 23 rd	Began using electronic messages through secure patient portal for June, July, and August. Monitored read receipts of messages sent and monitored how many prescriptions were requested during the three-month intervention occurred. The plan was to revamp messages if limited uptick in people reading the messages occurred.
Post Intervention	August 4 th to October 5 th	Measured HgBA1c at end of twelve weeks which represented the average blood glucose of the patients during the intervention (June July and August). HgBA1c numbers were recorded as aggregate and standard deviation and range were also calculated. The prescription monitoring numbers from June, July and August were also recorded.

Analysis

A frequency count of the number of read receipt messages was done as measures of process change and verified the number of messages sent and the number of those read. The monitoring of read receipts was used to review and revise to ensure participation. The number of prescriptions being requested by participants was counted to measure if the process of reading and receiving messages improved self-medication management assuming that if patients were reading the messages this would motivate them to be adherent to their medications. The primary outcome measure was a change in HgBA1c, determined by blood tests at baseline and the conclusion of intervention. Consistent with the current standard of care HgBA1c was collected every three months and provided a lab value for the past three months. Blood tests occurred at the hospital and were sent to the practice for consultation and follow up. A paired T-Test was used as a test of significance.

Ethical Considerations

Non-adherence to medications is common in patients with chronic disease and reduces the effectiveness of prescribed medications (Usherwood, 2017). Mobile health systems, such as automatic messaging to promote adherence may be a cost-effective way to improve the self-management of chronic illness such as diabetes and enhance patient's compliance with their medication regimens (Fioravanti et al., 2015).

All patients with HgBA1cs of 7 or above were invited to participate in this quality improvement project, however, patients were not required to participate and could opt-in or out based on their preferences. The University of New Hampshire Nursing Quality Review

Committee approved this project as a quality improvement project and thus exempt from IRB. A letter of determination was obtained from the VP of Quality at the hospital who also indicated that because this is a quality improvement project it is exempt from IRB review. There are no conflicts of interest present for this quality improvement project.

While this private practice that has a large number of patients with diabetes and chronic illness who have difficulty with medication adherence, the practice has not fully utilized the patient portal to attempt to communicate more effectively with patients and encourage and improve medication adherence. Therefore, this quality improvement project was created to utilize the patient portal and/or email to provide electronic reminders for patients with diabetes to help them be more adherent with their medications and help improve their HgBA1c.

ACKNOWLEDGMENTS The author would like to acknowledge the cooperation of the nursing and medical staff in the study hospital.

COMPETING INTERESTS There are no competing interests.

ETHICS APPROVAL Local research ethics committee approval was obtained for this quality improvement study from the University of New Hampshire and the participating hospital.

Results

A total of 21 participants with HgBA1cs of 7 or above participated in the project. We invited 125 people to participate in the quality improvement project via letters. There were a total of five patients who responded to the letter. The DNP student called 120 patients to invite the remainder of patients to participate in the project and 23 more patients volunteered to join the project bringing total participants to 28. Seven patients were excluded from the project due to

recent HgBA1c which was below 7, bringing the participant number to 21. Table 2 shows the population demographics for the participants in the project.

Table 2

Demographics of Participants

Demographics of Participants	Percent
Male	76%
Female	24%
30-39 years	4.5%
40-49 years	14%
50-59 years	24%
60-69 years	29%
70-79 years	24%
90-99 years	4.5%

It is not surprising that 89.5% of the participants were aged 55 and above due to the demographics of the area, as according to NH Employment Security (2019), 92% of the population in this area are 55 and above. The large percentage of participants that were male (76%) is not surprising either, as type two diabetes is more frequently diagnosed at lower age and body mass index in men (Kautzky-Willer, Harreiter & Pacini, 2016). Table 3 outlines the comorbid illnesses that the participants had.

Table 3

Comorbid Illnesses of Participants

Comorbid Illnesses of Participants	Percent
Hypertension	76%
Hyperlipidemia	42%
Obesity	33%
Major Depressive Disorder	29%
Gastroesophageal Reflux Disease	19%
Sleep Apnea	19%
Coronary Artery Disease	24%
Benign Prostatic Hyperplasia	14%
Chronic Obstructive Pulmonary Disease	14%
Chronic Kidney Disease	14%
Generalized Anxiety Disorder	14%
Asthma	14%
Arthritis	9.5%
Alcohol Abuse	9.5%
Heart Failure	9.5%
Neuropathy	9.5%
Atrial Fibrillation	9.5%
Hyperthyroidism	9.5%
Cancer	9.5%
Venus Insufficiency	5%
Gout	5%
Cirrhosis	5%
Post-Traumatic Stress Disorder	5%
Eating Disorders	5%

Individual HgBA1cs at the beginning of the project ranged from the lowest at 7.4 to the highest at 10.4. The mean HgBA1c at the beginning of the project was 8.5. The mean HgBA1c after the intervention was 7.7, with a range of HgBA1c from 6.5 to 9.1. The mean difference in HgBA1cs represented a significant 9.2 % change. Prescription requests totaled 46 pre-intervention and 37 post-intervention. A total of 95% of participants read the electronic messages. Contextual elements that interacted with the interventions were structural variables including the practice type, volume, electronic health record use, and geographical location. The practice is located in a wealthy, small town with a large percentage of patients over the age of 55 and an electronic health record that is in need of some updating along with a patient portal that is not easy to navigate or join. Because of those factors, most patients participating in the QI project were over 55 and potentially unfamiliar or uneasy with using technology. We were able to successfully contact and obtain post-intervention HgBA1cs on 14 of the 21 patients in the QI project.

Throughout this three month initiative, 21 patients were sent electronic reminders. Delivery of messages was tracked with read receipts. Prescription monitoring data from the 21 participants receiving the messages for the three months before the intervention were 44 while during the three-month intervention totaled 37, which indicated a 16% decrease in prescription requests. Read receipts were recorded for each message sent with a read rate of 95% throughout which exceeded the goal of a 50% read rate. Only one participant consistently did not read some of the electronic messages and that was due to technical difficulties on the participant's end with their internet provider.

Of the 21 participants who received the messages, 14 completed the pre and post HgBA1c monitoring (Appendix B). The aggregate HgBA1c for these 14 pre-intervention was 8.5 and was 7.7 post-intervention. This was a 9.2% aggregated decrease in HgBA1c. This was a significant change with a p-value of 0.003 (Appendix C). HgBA1cs decreased for 13 out of the 14 participants in the project who completed both the before and after HgBA1c test. We were unable to obtain post-HgBA1cs on seven participants, however, they participated in all other pieces of the intervention. These patients were unable to come to get their HgBA1c citing personal issues including not having the time to come in for the test, having other responsibilities that made them unable to come in and simply not wanting to come to the office.

Discussion

Summary

This quality improvement (QI) project was conducted to determine if in adult patients with diabetes are electronic reminders effective in increasing medication adherence as evidenced by an overall decrease in the populations HgBA1c. This QI project has shown that utilizing electronic reminders to improve medication adherence can be an effective strategy for improving HgBA1cs and thus can improve patient quality of life and potentially decrease healthcare costs. Adherence is especially important in diabetes management because of its significant consequences both long and short term. This project demonstrated that electronic reminders have the potential to help patients be more adherent with their medicines as evidenced by the 9.2 % decrease in HgBA1c in 14 of 21 participants who completed the intervention.

Mobile health systems, such as automatic messaging to promote adherence are a cost-effective way to improve the self-management of chronic illness such as diabetes and enhance

patient's compliance with their medication regimens. The practice has a large number of patients with diabetes and chronic illness who have difficulty with medication adherence. This QI project using electronic reminders and education in the patient portal and email has strengthened tertiary prevention for patients and has increased patient engagement and communication with healthcare providers, therefore, improving patient medication adherence and quality of life. The project has shown that the patients are receptive to the process of electronic messaging which is an effective and affordable way to communicate more effectively with patients and encourage and improve medication adherence.

Interpretation

After the QI intervention, 13 of the 14 patients had an improvement in their HgBA1c with a 9.2% decrease which exceeded our goal of 1%. Additionally, 95% of the patients read the electronic messages. A systematic approach to electronic reminders resulted in a statistically significant change in HgBA1c and helped participants get closer to the recommendation of the American Diabetes Association of achieving an HgBA1c of 7 or below.

The pilot test was critically important, as it revealed that some modifications were needed to messages and frequency, as messages were being sent too often. It also revealed that the portal has fundamental issues in design and structure as all of the providers in the pilot attempted to sign up for the portal and none of them were able to do so successfully. This was concerning because if healthcare providers have difficulty navigating and signing up for the portal, the average patient is likely to have significant issues as well. Additionally, the healthcare providers wanted to make sure that the messages reflected the education and needs of the patient in the primary care setting and did not overwhelm them in frequency. Therefore messages were sent

three days a week for the duration of study instead of the five times a week for the first month as previously planned.

Modifications of message content were based on the Executive Summary: Standards of Medical Care in Diabetes by the American Diabetes Association (2019). The original messages were not focused enough on the needs of the primary care practice and their patients and were too general. This modification was especially important because healthcare providers have very limited time during office visits with patients and much of that time is spent covering basic information such as weight, blood pressure and other standard measurements and questions which are critically important for billing. Often providers simply do not have the time to discuss other issues with patients, perform in-depth patient education and provide reinforcement of learning. Therefore these messages can fill that void and provide, expand and reinforce knowledge and education giving providers valuable time back with their patients in the office visit to focus on specific issues.

During the post-intervention, results were analyzed and management guidelines were developed and suggested for the future. We learned that patients are eager to have more communication with their healthcare team and obtain more education and knowledge so that they can manage their illness better. They also want to have more meaningful communication and rapport with their providers. This was supported by the fact that almost half of the patients in this study consistently replied to messages and wanted to learn more and asked meaningful questions. Participants verbalized that the information they received was so helpful that they printed out the information so that they would have it for future reference.

In the future having the office nurse in charge of the electronic messages and encouraging bi-directional messaging between provider and patient would help potentially

increase patient engagement in the process and further improve communication between providers and patients. Patients could reach out to providers via phone or patient portal or email if they had questions, but more direct back and forth messaging between provider and patient may have increased the number of participants whose HgBA1c was monitored. Allowing the nurse to load all messages into templates within the messaging system would be helpful so that it is less time consuming for the nurse when sending the messages out, yet she still can modify the messages if needed.

Utilizing electronic messaging resulted in a positive culture change at the practice regarding the use of electronic reminders to help patients be more proactive and better armed to face their illnesses. Helping participants become more adherent to their medications is a challenging task for healthcare providers because there are so many factors that impact whether or not they will be adherent. This is supported by the Transtheoretical Model which has found that health behavior change involves progress through six stages of change: pre-contemplation, contemplation, preparation, action, maintenance, and termination (Prochaska, 2008). The participants in this project were at all different stages in their willingness to make the necessary changes.

Some participants were highly motivated and able to make changes, while others were not. Factors that inhibited participants from making changes included comorbid physical and psychiatric illness as well as psychosocial factors such as family dynamics, demanding careers, finances, transportation, and competing responsibilities. Providing opportunities for learning and reinforcement of learning through electronic reminders can expose participants to the knowledge that they can use now if they are ready to make changes and for those that are not ready to make changes, the information can lay the foundation for future change.

Although the decrease in HgBA1c was statistically significant, we were only able to get post-HgBA1cs on 14 of the 21 participants. Therefore it is difficult to say that this intervention improved adherence definitively, however we can say that it has the potential for improved adherence. The decrease in HgBA1cs represents a positive impact on patients and provides opportunities for improvement. It helps the healthcare providers and the nurses in the practice provide more effective care in a cost-effective way and allows them to provide office visits that are tailored to the needs of the participants. Our data is in agreement with the literature which indicates that electronic reminders have shown promising results as an intervention for patients with chronic illness and have the ability to achieve high levels of engagement with broad population reach while requiring minimal resources (Waller et al., 2019).

Limitations

This QI project had several limitations. There were 125 letters of invitation mailed to potential participants. Only 28 people volunteered to participate with the sample further reduced to 21 based on A1C numbers of some participants not meeting A1C requirement. The participant letter sent out to recruit participants proved to be a limitation of the project, as patients were overwhelmed by the detail in the letter.

Despite multiple attempts being made to contact patients to schedule their HgBA1c test, via phone and email and point of care the total number of participants was further reduced to 14 when 7 participants had no post-intervention HgBA1c documented. It is not unusual that not all patients would participate fully, as this is consistent with the Theory of Planned Behavior which forms the framework for this project. The participants planned to adhere but intervening variables may have gotten in the way. For example, some participants voiced they were too busy to come to the office and others stated they had responsibilities that made it impossible to come

to the office. Regardless of the reason, some patients were just not motivated to follow through. This is supported by Ajzen (1991) who writes that a central factor in the Theory of Planned Behavior is the individual's intention to perform a given behavior and captures the motivational factors that influence behavior.

The low participation could potentially be attributed to the contextual elements specifically the population being older patients who may or may not be comfortable with utilizing technology. The practice is located in a very small town and many patients chose to get their care at a larger medical center which is only a thirty-minute drive away. HgbA1cs were offered free of charge for all patients to try to encourage patients to come in.

Replication of these processes could be hindered by lack of personnel, lack of buy-in by the hospital administration, a patient portal that needs significant updating and lack of participant involvement and interest in the patient portal. Barriers to using the portal to send electronic messages to patients include the need for IT to create the message templates which is an added step and additional work for IT and lack of nurses available to monitor the portal messages from patients. While bi-directional messaging has the potential to provide an even more meaningful communication between providers and participants, it also creates more work and time commitment from providers.

The patient portal system is not widely known and/or accepted by patients and the hospital has not done much marketing around the portal to get patients interested, so that lack of knowledge about the portal makes it challenging to get patient participation. The majority of the participants that volunteered for the quality improvement project were adamant about their disdain for the portal and only were willing to participate if they could get emails through the

hospital email system instead of using the portal. Accordingly, the portal was used only for those participants that were comfortable with it initially.

The portal is known to be difficult for patients to use especially when they forget their password. Of the five participants who were willing to use the portal, all five opted out of the portal by week four of the messages and asked instead to receive all future messages through email, indicating that the portal was too cumbersome and difficult to navigate and use. Allowing the participants to switch from the portal to email ensured that the participants remained involved in the project. An updated patient portal would be a good investment for the hospital so that patients are more willing to use it.

During the project the person that manages the portal terminated her employment and it was not clearly articulated or shared who would be replacing her in managing the portal duties. Without proper management of the portal and support of patients interested in joining the portal, the portal is an ineffective tool. Due to policies around template creation in the portal system only IT could prepare the messages for the portal which was inconvenient and inefficient as changing message content was not easy to do. Allowing the nurse the ability to create the templates in the system would allow for more flexibility with message delivery and content, however, this might be difficult for nurses to manage when they are already very busy.

Conclusions

Medication adherence is a significant issue for patients with one or more chronic illnesses and co-morbidities. Despite strong evidence on the negative impact of medication non-adherence on patients' health and the increased cost of care associated with it, a gap exists. A response that strengthens tertiary prevention and increases patient engagement through electronic reminders

can improve patient medication adherence and quality of life. This is the first quality improvement project done at the hospital that focused on medication adherence and electronic messaging with patients.

While the outcome results only reflected 14 of the 21 participants, we know that the process worked because the read receipts indicated messages were being read. Although the electronic messages were getting to the end-user, we are unable to say what happens after the participant gets the information. Thus we are unable to say that it has improved adherence except that it has the potential to do so because of the results of the 14 who did get post-intervention HgBA1c. Like any behavior change intervention, a longer intervention phase may be necessary to establish if it will change outcomes. Additionally, in future interventions, there should be a focus on follow up.

Our findings have implications for hospital administrators given the national emphasis on increasing the quality of healthcare and reducing costs. Using electronic messages is a cost-effective way to reach a large number of patients, reinforce learning from their primary care visits and help patients potentially be more adherent with their medications. Given the complexity and cost of diabetes management and the need for improved diabetes self-management education, this technology plays a critical part in meeting the needs of the patient effectively and efficiently.

Quality improvement initiatives to improve medication adherence often depend on front line workers, particularly nurses. It will be critically important to be able to staff effectively at the practice to allow a nurse the time to invest in this important work. The sustainability of this quality improvement initiative will ultimately depend on the nurse's ability to direct meaningful

time and attention to these efforts which will require the buy-in of hospital administrators and physicians in the practice.

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Appendix A Cost Benefit Analysis

Cost Benefit Analysis	Current Practice (no intervention)	Electronic Reminders
Initial costs	Total= \$0.00	IT worker input of messages into individual templates 44 messages. 5 hours x \$25 per hour = \$125.00 IT worker meeting with DNP student for initial meeting and follow up meeting for revisions. 2 hours x \$25= \$50 Patient Portal Manager entering of patients into portal and technical help. 10 hours x \$25 per hour= \$250. Total= \$425.00
Ongoing costs	Total= \$0.00	Total= \$0.00
Time savings	There are no time savings with current system.	Time savings will result in the ability of provider to better document for value based reimbursements
Value based reimbursement	Estimate cannot be measured per VP of Quality	An increase in value based reimbursements' could occur with implementation of this quality improvement project
Total Cost	\$0.00 for cost However, it could be argued there is a significant cost due to providers not having the time to do the documentation to qualify for the value based incentives.	\$425.00 for startup costs Benefit= potential increase in value based incentives received.

Appendix B HgBA1c Pre and Post Intervention Individual Scores

Patient	HgBA1c Pre	HgBA1c Post	% Change Pre to Post ↑ or ↓
1	9.5	6.7	29.4% ↓
2	7.9	6.7	15.1% ↓
3	7.6	8.3	9.2% ↑
4	9.1	8.4	7.7% ↓
5	8.5	8.4	1.1% ↓
6	10.4	9.1	12.5% ↓
7	8.6	7.9	8.1% ↓
8	8.4	8.2	2.4% ↓
9	8.4	7	16.6% ↓
10	7.9	7.7	2.5% ↓
11	8.3	7.9	4.8% ↓
12	8.6	8.1	5.8% ↓
13	8.5	6.5	23.5% ↓
14	7.4	7.3	1.3% ↓

Appendix C T-Test Calculation for Two Dependent Means

HgBA1c Pre	HgBA1c Post	Diff (T2 - T1)	Dev (Diff - M)	Sq. Dev
9.5	6.7	-2.8	-2.02	4.09
7.9	6.7	-1.2	-0.42	0.18
7.6	8.3	0.7	1.48	2.19
9.1	8.4	-0.7	0.08	0.01
8.5	8.4	-0.1	0.68	0.46
10.4	9.1	-1.3	-0.52	0.27
8.6	7.9	-0.7	0.08	0.01
8.4	8.2	-0.2	0.58	0.33
8.4	7	-1.4	-0.62	0.39
7.9	7.7	-0.2	0.58	0.33
8.3	7.9	-0.4	0.38	0.14
8.6	8.1	-0.5	0.28	0.08
8.5	6.5	-2	-1.22	1.49
7.4	7.3	-0.1	0.68	0.46
		M: -0.78		S: 10.42