# Improving Identification of Prediabetes and Undiagnosed Diabetes in Primary Care

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## Abstract

***Background*:** 84.1 million Americans over 18 have prediabetes, with 88.4% of those individuals remaining undiagnosed. Early diagnosis and treatment of prediabetes can prevent or deter Type 2 Diabetes Mellitus (T2DM). The American Diabetes Association (ADA) screening guidelines for T2DM focus on symptomatic individuals 45 and older. No standard risk assessment tool is in place for screening prediabetes and T2DM for asymptomatic, non-pregnant patients 18-44 years of age.

***Methods*:** Non-pregnant patients aged 18-44, without a diagnosis of prediabetes or T2DM, completed the ADA Diabetes Risk Test (ADADRT) during intake. ADADRT scores of 5 or greater received behavioral modification education and provider referral for diagnostic testing using $A_1C$ or fasting plasma glucose (FPG). Providers documented referral for testing and education provided in EHR. Patients with lab values in the prediabetes or T2DM range were notified of results and scheduled for a two-week return appointment, at which time providers used the treatment algorithm to determine the proper treatment.

***Interventions*:** ADADRT was used to guide providers on appropriate referrals for diagnostic testing and patient education. Lab results and the treatment algorithm determined appropriate treatment.

***Results:*** Staff administered the ADADRT to a convenience sample of 53 patients meeting participant criteria the ADADRT. Provider use of the ADADRT was documented 100% from the date of implementation. Secondary outcomes show the use of ADADRT increased proper screening for prediabetes and undiagnosed T2DM in the 18 – 44-year-old patient population by 19%. Fourteen at-risk patients were identified and received appropriate education and referral for diagnostic testing. Six patients had laboratory findings in the prediabetic range, received 100% follow-up and a treatment plan.

***Conclusions*:** ADADRT is effective as an assessment tool and improved patient identification for risk for prediabetes and T2DM. The provider educated at-risk patients on the benefits of behavior modification, ADA diet, and exercise recommendations and referred patients for diagnostic testing. Provider and patient discussed treatment options using the treatment algorithm provided.


*Keywords:* prediabetes, risk assessment, evidence-based practice, prevention, diabetes

**Improving Identification of Prediabetes and Undiagnosed Diabetes in Primary Care**

Prediabetes is a term used to identify a state of impaired blood glucose too high to be considered normal but not high enough to meet the criteria for Type 2 Diabetes Mellitus (T2DM) (American Diabetes Association [ADA], 2018). Patients with fasting plasma glucose (FPG) values of 100 to 125 mg/dL and/or hemoglobin $A_1C$ ($A_1C$) values of 5.7% to 6.4% meet the diagnostic criteria for prediabetes (ADA, 2018; Centers for Disease Control and Prevention [CDC], 2020a). Obesity, hypertension, and dyslipidemia are associated with prediabetes; these conditions are also risk factors for developing cardiovascular disease (ADA, 2018). According to the CDC (2020b), in 2018, 88 million Americans 18 or older had prediabetes, and 88.4% of those individuals were unaware of the diagnosis. Only 15.3% of those who meet the criteria for prediabetes reported their primary care provider (PCP) informed them of their diagnosis (CDC, 2020b). Early identification of patients at risk for prediabetes and T2DM provides an opportunity for PCPs to provide education and evidence-based treatment options that can prevent or deter progression to T2DM (ADA, 2018; Weber et al., 2016). When impaired glucose levels are uncontrolled, 15-30% will develop T2DM within 5 years (Chaudhari, Vallarino, Law & Seifeldin, 2016).

T2DM is diagnosed by laboratory values of FPG >125 and/or $A_1C$ values > 6.4% (ADA, 2018). Progression to T2DM occurs when the body is not producing enough insulin, and peripheral insulin resistance begins (ADA, 2018). Clinical presentation of T2DM could include all or some of the following symptoms: polyuria, polydipsia, polyphagia, blurred vision, fatigue, paresthesia, recurrent infections, and candidiasis (Kandula et al., 2017). 34.2 million people, 10.5% of the United States (US) population, 13 % of all adults in the US are diagnosed with T2DM (CDC, 2020b). The CDC reported 1.5 million adults newly diagnosed with T2DM in the US in 2018. An additional 7.3 million adults aged 18 years or older who met laboratory criteria for T2DM did not report having diabetes or were unaware of the diagnosis (CDC, 2020b). Patients experiencing T2DM have increased risk of heart failure, atherosclerosis, and mortality rates related to CVD complications (Perreault & Færch, 2014). In the US, T2DM is the seventh leading cause of death (CDC, 2020b). It is estimated 200,000 people die each year from complications of T2DM (Nhim et al., 2018).

Health care cost for those with diabetes is 2.3 times more than those without diabetes (ADA, 2018). Over 327 billion dollars a year is spent on those diagnosed with diabetes in the US (ADA, 2018). Individuals with diagnosed diabetes spend around $9,601 each year to manage diabetes (CDC, 2020b). Early identification and treatment of prediabetes can significantly reduce the long-term medical cost associated with T2DM (Chaudhari et al., 2016; Khan et al., 2017). Proper diagnosis and treatment of T2DM can decrease diabetic complications and reduce medical costs (ADA, 2018).

Advanced practice nurses (APNs) and other healthcare professionals practicing as PCPs must identify patients at risk for prediabetes and T2DM. Evidence-based guidelines recommend screening asymptomatic, non-pregnant adults to determine their degree of risk for prediabetes and T2DM (ADA, 2018; Handelsman et al., 2015). The ADA (2018) recommends informal screening for risk factors or the use of an assessment tool, such as the ADADRT, to assist providers in identifying patients who are appropriate for diagnostic testing for prediabetes and undiagnosed diabetes. Only 27% of PCPs report screening patients for prediabetes using a risk assessment test (Nhim et al., 2018). The ADA guidelines suggest diagnostic screening for all individuals should begin at age 45 unless the individual is symptomatic or has known risk factors for T2DM (ADA, 2018). Prediabetes and T2DM are often asymptomatic, which can make early detection difficult. Formal risk screening before the age of 45 can increase the identification of patients at risk for T2DM. A timely and accurate diagnosis of prediabetes or T2DM is vital for treatment. Behavioral modifications, weight loss, and physical activity can delay or prevent the development of T2DM in people with prediabetes, and early diagnosis of T2DM can delay or prevent complications of T2DM (ADA, 2018). Using the ADADRT in primary care for individuals age 18-44 is a proactive and preventative approach to T2DM.

**Purpose**

The purpose of this quality improvement (QI) project was to increase provider use of an evidence-based risk assessment tool, the ADADRT, in a primary care setting to assess patients at risk for T2DM.

Prior to the implementation of this QI project, there was no formal evidence-based screening process for asymptomatic, non-pregnant adults 18-44 years of age in this primary care facility. The use of the ADADRT will increase the identification of individuals at risk for prediabetes and T2DM. Based on scores from the ADADRT, providers will educate patients regarding the risks associated with prediabetes and T2DM, increasing patient knowledge of disease process, risk factors, and methods to deter disease progression. The provider will refer patients with a score of 5 or greater on the ADADRT for diagnostic testing, FPG or $A_1C$, increasing the number of appropriately screened patients for prediabetes and T2DM. Providers will notify patients with lab values in the prediabetes and T2DM range and schedule a follow-up appointment. Early diagnosis of prediabetes and patients at-risk for T2DM will increase patient education and treatment to prevent or deter the progression to T2DM, thereby improving patient health outcomes (ADA, 2018).

## Background and Review of Literature

A systematic review of the literature was completed to examine the evidence regarding the identification of patients at risk for T2DM in primary care settings, emphasizing epidemiology, medical complications, economic burden, prevention and treatment, risk factors, and screening processes of prediabetes and T2DM. Prediabetes and T2DM are common disease processes, and when unidentified and untreated, both increase medical and financial commitment. Prediabetes can be reversible when identified early (ADA, 2018).

### Epidemiology

The CDC (2020b) states 84.1 million Americans over 18 have prediabetes, with 88.4% of these individuals remaining undiagnosed. A study conducted by Menke et al. (2015) found 38% of the US population has prediabetes. 58% of the population has either a diagnosis of prediabetes or diabetes (Menke et al., 2015). The CDC (2020b) reports in 2018, 34.2 million Americans of all ages, or 10.5% of the US population, have diabetes, and 34.1 million adults aged 18 years or older, 13.0% of all US adults have diabetes. In the US, 7.3 million adults aged 18 years or older and who met laboratory criteria for diabetes did not report having diabetes or were unaware of the diagnosis (CDC, 2020b). The ADA

(2018) says that, on average, 1.5 million new cases of diabetes are diagnosed in the US every year, and T2DM accounts for 95% of all cases of diabetes. The consistent growth of prediabetes and diabetes cases over the past several decades proves these diseases are becoming an epidemic (ADA, 2018, CDC, 2020a). These rising trends placed diabetes and prediabetes on the list of focused topics for Healthy People 2020. Due to unmet Healthy People 2020 objectives related to diabetes and prediabetes, these goals will be included in the Healthy People 2030 goals (Office of Disease Prevention and Health Promotion, n.d.).

**Medical complications**

Dyslipidemia, hypertension, and obesity are associated with prediabetes and T2DM, which are risk factors for developing cardiovascular disease (CVD) (ADA, 2018; CDC, 2020; Handlesman, 2015; Siu, 2015). Studies using magnetic resonance imaging (MRI) show early signs of functional cardiac changes and increased vascular plaquing in patients with prediabetes (Bamberg et al., 2017). Patients with T2DM have an increased risk of heart failure, atherosclerosis, and mortality rates related to CVD complications (Einarson et al., 2018). In the US, 230 individuals with diabetes suffer an amputation daily; diabetic foot ulcers are the number one cause of non-traumatic lower leg amputation (Geiss et al., 2018). The seventh leading cause of death in the US is diabetes (ADA, 2018; CDC, 2020a).

**Economic burden**

The cost of diagnosed diabetes in 2017 was $327 billion, $237 billion in direct medical cost and $90 billion in decreased productivity, a 26% increase from $245 billion in 2012 (ADA, 2020). The ADA (2020) reports between 2012 and 2017, excess medical costs per person associated with diabetes increased from $8,417 to $9,601. Zhuo et al. (2014) found people with T2DM spend on average $13,966 more annually on medical treatment than those without diabetes. Having a diagnosis of T2DM can cost $43,900 to $121,400 in lifetime medical expenses (ADA, 2018).

Uninsured people with diabetes are less likely to manage their medical conditions effectively. Uninsured people with diabetes are prescribed 52% less medication and have 60% fewer PCP visits than those with insurance coverage (ADA, 2020). Without proper management, uninsured patients with T2DM have 168% more emergency department visits, increasing the financial burden for the patient and the

healthcare system (ADA, 2020). A cost-effective approach to T2DM is prevention. Toward that end, the Centers for Medicare and Medicaid Services (CMS) expanded reimbursement to cover the National Diabetes Prevention Program lifestyle intervention for organizations recognized by the CDC in April 2018 (ADA, 2018).

**Prevention and Treatment**

Prediabetes is reversible, but about two-thirds of people with the condition are undiagnosed and untreated (Perreault & Faerch, 2014). Only 15.3% of adults with prediabetes reported being told by a health professional of the situation (CDC, 2020b). Kandula et al. (2017) found PCPs screen over half of the patients seen in primary care for abnormal blood glucose levels. However, PCPs often fail to provide education on prediabetes or give patients information to prevent or delay progression to T2DM (Kandula et al., 2017). The ADA (2018) recommends providing education regarding the diagnosis and a treatment plan specifically designed for the patient diagnosed with prediabetes. Early identification of patients at risk for prediabetes and T2DM could prevent the disease progression to T2DM and CVD (CDC, 2020a; ADA, 2018). Identification and treatment of prediabetes can significantly reduce long-term medical costs (Chaudhari et al., 2016; Khan et al., 2017).

The ADA (2018) views patients with $A_1C$ 5.7-6.4% as ideal candidates for diabetes prevention efforts. Primary care providers (PCP) should refer patients with prediabetes to an intensive behavioral lifestyle modification program modeled on the Diabetes Prevention Program (DPP) (ADA, 2018). The United States Preventative Services Task Force (USPSTF) also recommends referral of patients diagnosed with prediabetes to a behavioral modification program (Kandula et al., 2018). Behavioral modification programs encourage patients to lose 7% of initial body weight and increase physical activity to at least 150 min/week (ADA, 2018). Technology-assisted interventions are an option for those who decline referral for a behavioral modification program; the CDC Diabetes Prevention Recognition Program (DPRP) has shown success using an approved curriculum with virtual physical activity and weight loss reporting (ADA, 2018).

The ADA (2018) suggests providers should consider the use of metformin as a pharmacological intervention in patients with body mass index (BMI) ≥35, those aged < 60 years, and for women with a history of gestational diabetes (ADA, 2018). Evidence shows metformin is a safe long-term pharmacological prevention therapy for T2DM (ADA, 2018). According to the ADA (2018), metformin and intensive lifestyle management decrease the risk of T2DM in patients with prediabetes or a history of gestational diabetes. Nhim et al. (2018) reports PCPs prescribed metformin as a preventive therapy to only 0.1- 3.7% of eligible patients.

**Risk factors**

Determination of risk factors for prediabetes and T2DM varies between medical agencies. The American Association of Clinical Endocrinologist/American College of Endocrinology (AACE/ACE), National Institute of Diabetes and Digestion and Kidney Disease (NIDDK), ADA, and USPSTF agree on the following risk factors: 45 or older, family history of T2DM, history of gestational diabetes, overweight, obese, sedentary lifestyle, and ethnicity of Asian, African American, Hispanic, Pacific Islander, or Native American (ADA, 2018; Handelsman et al., 2015; Siu, 2015). In addition, AACE/ACE and NIDDK include dyslipidemia, CVD, hypertension, polycystic ovarian syndrome, antipsychotic therapy, and sleep disorders as risk factors for T2DM (Handelsman et al., 2015).

Variation of risk factors among medical authorities creates difficulty identifying risk factors for prediabetes and T2DM in primary care. In a study of one hundred fifty PCPs, Tseng et al. (2017) found only 6% could correctly identify all of the risk factors that should prompt prediabetes screening. Varying risk factors and lack of provider knowledge of all risk factors limit the number of accurately screened and diagnosed patients with prediabetes (Thomas et al., 2019).

**Guidelines for screening and diagnosis**

AACE/ACE, ADA, and NIDDK agree individuals over 45 years of age should be tested for T2DM regardless of risk factors (ADA, 2018; Handelsman et al., 2015; Siu, 2015). Individuals of any age with at least one risk factor are candidates for testing according to AACE/ACE (Handelsman et al., 2015). The ADA recommends testing asymptomatic, non-pregnant patients who are overweight or obese and

have at least one risk factor for T2DM (ADA, 2018). The USPSTF targets asymptomatic patients aged 40-70 who are overweight but recommends testing younger individuals with one risk factor (Siu, 2015). Conflicting screening guidelines make a referral for diagnostic testing for prediabetes and T2DM difficult for PCPs.

Current guidelines identify $A_1C$, FPG, or oral glucose tolerance test (OGTT) as appropriate laboratory tests to diagnose prediabetes and T2DM (ADA, 2018; Handelsman et al., 2015; Siu, 2015). The ADA and USPSTF use the following criteria for the diagnosis of prediabetes and T2DM: Prediabetes: FPG 100 mg/dL – 125 mg/dL; $A_1C$ 5.7 – 6.4%; OGTT 140 mg/dL – 199 mg/dL. T2DM: FPG ≥ 126 mg/dL; $A_1C$ ≥ 6.5% or OGTT ≥ 200 mg/dL (ADA, 2018; Handelsman et al., 2015; Siu, 2015). The AACE/ACE recommends an $A_1C$ value of 5.5% to determine prediabetes, and the other diagnostic values are the same (Handelsman et al., 2015; Siu, 2015). In a clinical study of one hundred and fifty PCPs, only 17% could correctly identify the laboratory parameters for diagnosing prediabetes based on fasting glucose and $A_1C$ (Tseng et al., 2017). Provider knowledge of prediabetic guidelines limits the number of properly diagnosed patients (Thomas et al., 2019).

**Risk assessment screening tools for prediabetes and T2DM**

The CDC Prediabetes Screening test, Self-Assessment Risk Scores, Finnish Diabetes Risk Score (FINDRISC), Australian Type 2 Diabetes Risk Assessment (AUDRISK), and ADADRT are screening tools used to evaluate the risk for diabetes. Sathish et al. (2013) studied 11 risk screening tools and found similarities in prediabetes predictability, sensitivity 67.9-73.8% and specificity 70.3- 82.3%, in the ADADRT, FINDRISC, AUDRISK, and Self-Assessment Risk Scores. Risk assessment tools focus on modifiable and non-modifiable factors. Modifiable factors include weight and physical activity, and nonmodifiable factors include age, race, family health history, and personal health history (Kengne et al., 2014). Bang et al. (2009) validated these factors as predictors of prediabetes and T2DM. The AACE/ACE, ADA, and NIDDK recommend the early identification of diabetes. However, the ADA is the only organization that recommends screening for risk factors or using an assessment tool, such as ADADRT, to guide providers on whether performing diagnostic testing for prediabetes and undiagnosed

diabetes is appropriate (ADA, 2018). The ADA adopted the ADADRT developed by Bang et al. (2009) due to its ease of use and high predictive value. The ADA promotes ADADRT and laboratory testing to identify prediabetes and T2DM (ADA,2018). The ADADRT is evidence-based and validated for identifying at-risk patients in diverse clinical settings and different clinical encounter types (Bang, 2009). Nhim et al. (2018) found only 27% of PCPs screened patients for prediabetes using a risk assessment test, even though the ADA recommends it.

**Gaps in care**

Recommendations for screening for prediabetes and undiagnosed diabetes differ among national guidelines. The AACE/ACE, ADA, and NIDDK suggest diagnostic testing for diabetes should begin for all at age 45 using $A_1C$, FPG, or OGTT (Handelsman et al., 2015). Screening and testing for asymptomatic, non-pregnant patients differ, which can cause screening in primary care to be inconsistent, and often at-risk patients are not screened or diagnosed promptly. Despite evidence showing early identification of patients at risk for prediabetes can help prevent the progression to T2DM, screening guidelines continue to concentrate on identifying T2DM in adult populations between the ages of 45 to 70 (ADA, 2018; Handelsman et al., 2015; Siu, 2015).

Provider knowledge of guidelines and risk factors for prediabetes limits the number of accurately diagnosed patients (Thomas et al., 2019). Of one hundred fifty PCPs studied, only 6% could correctly identify all risk factors which should prompt prediabetes screening (Tseng et al., 2017). Tseng et al. (2017) determined only 17% of providers could correctly identify both FBG and $A_1C$ parameters for diagnosing prediabetes. The ADA (2018) suggests using ADADRT in primary care to help providers identify patients to refer for diagnostic testing. In a study completed by Marjama et al. (2016), nurse practitioners reported ADADRT as an effective way to increase screening of patients at risk for T2DM, and utilization would benefit the outpatient setting.

Kandula et al. (2018) state primary care facilities are an essential clinical setting for preventing diabetes due to the 350 million annual adult care visits. Keck (2019) found PCPs test half of primary care patients for abnormal blood glucose but rarely educate on the results, and only 7% -11% are aware of

impaired glucose conditions. Studies have shown that intensive lifestyle modification can deter or delay the progression of T2DM by 58%, and metformin can decrease the incidence of T2DM by 31% (Kandula, 2019). Despite strong evidence supporting intensive lifestyle modification programs and metformin in preventing T2DM, neither treatment is routinely used (Kandula, 2018).

## Theoretical Framework

A quality improvement framework, Plan-Do-Study-Act (PDSA), was used in the implementation of this project. The PDSA provides four stages to help plan for a system change that will improve a process or carrying out change. The primary investigator (PI) selected the evidence based ADADRT as a provider tool to identify patients at risk for T2DM in the clinical practice site during the planning stage. During the Do/implementation stage, the ADADRT was implemented into the clinical practice's intake process. In the Study stage, the PI completed an analysis of the data collected to determine if the ADADRT improved the identification of patients at risk for T2DM. The Act stage completes the PDSA cycle and places the ADADRT tool as a standard component of care in the clinical practice site to include incorporation in the EHR of the practice (Institute for Healthcare Improvement, n.d.)

## Methods

The Institutional Review Board (IRB) of Lenoir-Rhyne University and the health system, which holds ownership of the practice, approved this research. Data collection began in November 2020 and ended in February 2021.

The implementation site for this QI project is a rural family practice in North Carolina. Before implementing this project, no formal risk screening protocol for prediabetes and T2DM in non-pregnant adults, age 18-44 years of age, was utilized. Adherence to a risk factor screening protocol will increase identifications of individuals at risk for T2DM who are eligible for diagnostic testing.

Data collected will be placed on a password-protected computer, using an Excel format and Intellecutus®, a secure database. Intellecutus® is a password-protected website. The system affords the ability to download documents and data to be shared with individuals involved with the project.

**Ethical Considerations**

Patients were provided with a no-signature consent form and information about the QI project. Participation was voluntary. Staff members identified each completed ADADRT tool with the visit date, the patient's first and last initials, and the two-digit birth year on the ADADRT for identification purposes. Form identification allows for chart review to determine lab results and follow-up appointments and treatment but does not expose sensitive health or personal patient information. The PI stored all collected data from the ADADRT on a password-protected computer and shredded the paper forms. Data will be saved on a password protected external drive for 5 years, then destroyed.

**Intervention**

A risk assessment test is an appropriate approach to early detection of prediabetes and T2DM in primary care. Prediabetes and T2DM have a long pre-symptomatic phase which can make early detection difficult. The ADADRT is a seven-item questionnaire that gives a number value to question responses on age, gender, history of gestational diabetes, family history of diabetes, high blood pressure diagnosis, physical activity, and category (Bang et al., 2009). Possible risk scores using the ADADRT are 0-8, and a score of 5 or greater indicates a high risk for developing prediabetes or T2DM (Bang et al., 2009).

This QI project aimed to improve provider identification of patients at risk for T2DM. Initially, the PI created and presented an educational program for the provider and support staff on prediabetes, T2DM, and the use of ADADRT. Patients who met the participation criteria, between ages 18-44, with no current related diagnosis, and not pregnant, were given the ADADRT to complete during the intake process. The ADADRT forms were identified with the date of visit, patient initials, and two-digit birth year. A score of 5 or more on the ADADRT suggests an increased risk for T2DM. Patients identified as having an increased risk of T2DM were to receive an appropriate referral for diagnostic testing and an educational packet. The educational packet consisted of information on disease process, behavioral modification programs, technical assistance, and ADA diet and exercise recommendations.

The provider used the ADA (2018) recommendation of referral for diagnostic testing patients with a score of 5 or greater scores on the ADADRT. The provider assessed diagnostic testing results using

ADA evidence-based guidelines: $A_1C$ was assessed as normal (< 5.7%), prediabetes range (5.7%-6.4%), and suggestive of diabetes (> 6.4%). FPG was assessed as normal (>100 mg/dL), prediabetes range (100 mg/dL – 125 mg/dL), and suggestive of diabetes (≥ 126 mg/dL) (ADA, 2018).

Patients who met diagnostic criteria for prediabetes or T2DM were notified by support staff and scheduled for a follow-up appointment. Treatment options were discussed with the patient using the prediabetes and T2DM treatment algorithm. For each patient identified as being at risk, the provider made a note on the paper ADADRT and placed it in a secure file cabinet. At the end of the three-month implementation period, the PI used the paper ADADRT participant forms to evaluate provider compliance, diagnostic testing results, and appropriate treatment plans.

As a means of comparison, the PI conducted a retrospective chart review on patients seen at the practice for the six months before the ADADRT implementation. Patients meeting the same inclusion criteria, non-pregnant, 18-44 years old, and without a current related diagnosis, were assigned an ADADRT score using patient chart information. The PI assessed charts with ADADRT scores over 5 for information related to diagnostic testing to include test, test results and treatment plan.

### Measures

The outcome measures include provider adherence, provider referral for laboratory testing, at-risk patient education, the number of patients identified as at risk for T2DM, abnormal laboratory values, and the evaluation of the effect of age, BMI, and gender on predicting ADADRT scores.

To determine whether an accurate assessment occurred, the PI used the ADADRT scores to compare proper referral and education rates from the retrospective chart review to the provider participation group.

## Results

### Findings and Analysis

The quantitative data in this section shows the results of this QI project's primary outcome measures: provider adherence, provider referral for laboratory testing, patient education, the number of

patients identified as at risk for T2DM, abnormal laboratory values, and evaluation to determine if age, BMI, and gender significantly predicted ADADRT scores.

Subjects from the control and participant group were categorized based on gender, gestational diabetes history, family history of diabetes, hypertension, and physical activity. Frequencies and percentages were calculated for each nominal variable. Analysis of the patient participants during active project implementation (participant group) revealed a female gender majority, female (*n* = 44, 83%) and male (*n*=9, 17%); gestational diabetes history was No (*n* = 52, 98%); active was No (*n* = 44, 83%); hypertension was No (*n* = 39, 74%); family history of diabetes was No (*n* = 40, 75%). Likewise, analysis of the patients analyzed during the retrospective chart review prior to implementation (control group) revealed the most frequently observed category of gender was female (*n* = 40, 75%); gestational diabetes history was No (*n* = 51, 96%); active was No (*n* = 47, 89%); hypertension was No (*n* = 47, 89%); family history of diabetes was No (*n* = 35, 66%).

Subjects from the control and participant groups were also analyzed using age, BMI, and ADADRT score. The control and participant subjects' age ranged from 18 to 44 years. The control subjects had a greater mean age of 34.02 years than the participants' mean age of 32.81. Control and participant subjects' BMI were predominantly obese, control twenty-two (42%) and participant twenty-one (40%). The percentage of severely obese patients was markedly higher in the participant group twelve (23%) than in the control group five (9%). There were 14 (26.42%) participant subjects who scored 5 or higher on the ADADRT. Control subjects with a score of 5 or greater were 10 (18.86%). For those who scored 5 or greater on the ADADRT, 5 was the most common score in both groups; participant group ten and control group eight. Three participants members scored six, two control members scored six, and two participants scored seven.

**Control Group Results**

Control group participants were evaluated and treated during a comprehensive or episodic appointment by one provider at the primary care facility between May 2020 and October 2020. A

retrospective chart review was completed on subjects who met inclusion criteria. Fifty-three charts meeting inclusion criteria were reviewed and assigned an ADADRT score. From the control group, ten (18.86%) patients scored ≥5 on the ADADRT and therefore were not adequately screened for prediabetes and T2DM at a prior visit. There was no documented patient education on the disease process of prediabetes or T2DM. These patients did not receive educational information on behavioral modification and ADA recommendations. Individuals who score 5 or greater on the ADADRT are at risk for prediabetes and T2DM and should be educated about the risk and referred for FBG or HgbA1c laboratory testing. Lack of education in control group participants revealed missed opportunities for education, referral, and identification of individuals with prediabetes and T2DM.

## Participant Group Results

### *Provider adherence*

The QI project implementation started in November 2020 and finished in February 2021. During a comprehensive or episodic appointment, participants were evaluated and treated by one provider employed at the primary care facility. There was a 100% compliance rate for using the ADADRT as a risk screening tool during project implementation. A convenience sample of *n*=53 patients meeting inclusion criteria was screened using the ADADRT. Fourteen (26.42%) of the fifty-three assessed were newly identified as at risk for T2DM. All fourteen (100%) patients received education on prediabetes and T2DM and were given an educational information packet on behavior modification, ADA diet and exercise recommendations. The referral rate for diagnostic testing was thirteen out of fourteen (92.86%); one patient refused testing due to uninsured status. Provider use of ADADRT increased proper screening for prediabetes and undiagnosed T2DM in the 18 – 44-year-old patient population by 19%. Chi-square test results were significant, $p < .001$, suggesting that the implementation of the ADADRT and at-risk patients' education are related to one another. Table 1 presents the results of the Chi-square test.

**Table 1**

*Observed and Expected Frequencies*

| | EDUCATED | | | | |
|---|---|---|---|---|---|
| IMPLEMENTATION | No | Yes | $\chi^2$ | *df* | *p* |
| Before | 53[46.00] | 0[7.00] | 16.13 | 1 | < .001 |
| After | 39[46.00] | 14[7.00] | | | |

*Note.* Values formatted as Observed[Expected].

Of the thirteen participants with an ADADRT score of ≥5 referred for laboratory testing, six had a value in the prediabetes range, seven had a value within normal limits, and no participant values were in the T2DM range. Following ADA guidelines, the provider educated fourteen (100%) participants with an ADADRT score of 5 or greater and prescribed lifestyle changes at the initial screening visit. Of the six patients with laboratory values in the prediabetes range, four had a BMI between 30-39.9 (obese), and two had a BMI of 40+ (severely obese). All six patients were encouraged to adhere to ADA behavioral modifications related to diet and exercise; also, three patients were receiving pharmacological weight management interventions, and one patient received metformin.

***Assess if age, BMI category, and gender significantly predicted the ADADRT Score***

A linear regression analysis was conducted to assess whether age, BMI, and gender significantly predicted the ADADRT score. The linear regression model results were significant, $F(3,49) = 34.92$, $p < .001$, $R2 = 0.68$, indicating that approximately 68% of the ADADRT score variance is explainable by age, BMI category, and gender. Age significantly predicted ADADRT score, $p = .029$, which indicates that on average, a one-unit increase of AGE will increase the value of ADADRT score by 0.05 units. BMI category significantly predicted ADADRT score, $p < .001$, which indicates that on average, a one-unit increase of BMI category will increase the value of ADADRT by 1.32 units. The male category of gender did not significantly predict ADADRT score, $p = .097$. This sample suggests that moving from the female to male category of gender does not significantly affect the mean of ADADRT score. Table 2 represents the results of the linear regression.

**Table 2**

*Results from Linear Regression*

| Variable | *B* | *SE* | 95% CI | β | *t* | *p* |
|---|---|---|---|---|---|---|
| (Intercept) | -1.34 | 0.51 | [-2.35, -0.34] | 0.00 | -2.65 | .009 |
| BMI_CATEGORY2 | 1.59 | 0.32 | [0.95, 2.22] | 0.48 | 4.99 | < .001 |
| BMI_CATEGORY3 | 2.51 | 0.31 | [1.90, 3.12] | 0.79 | 8.13 | < .001 |
| BMI_CATEGORY4 | 3.93 | 0.36 | [3.21, 4.65] | 0.92 | 10.88 | < .001 |
| AGE | 0.07 | 0.01 | [0.04, 0.09] | 0.29 | 4.89 | < .001 |
| GENDERM | 0.67 | 0.23 | [0.22, 1.11] | 0.17 | 2.94 | .004 |

*Note*. Results: $F(5,100) = 43.08$, $p < .001$, $R^2 = 0.68$

**Summary of Findings**

During the project, the provider used the ADADRT to identify asymptomatic, non-pregnant patients 18-44 who are at risk for prediabetes and T2DM. The provider screened fifty-three patients using the ADADRT, and fourteen patients scored 5 or greater on the ADADRT. Provider adherence to using the ADADRT was 100%. Fourteen patients (100%) with an ADADRT score of 5 or greater were educated on prediabetes and T2DM and given an educational information packet on behavior modification and ADA diet and exercise recommendations. This process identified fourteen patients at risk for T2DM. The referral rate for laboratory testing was thirteen out of fourteen (92.86%); one patient refused testing due to uninsured status.

A total of six patients were found to have laboratory values in the prediabetes or T2DM range. Of the six patients with laboratory values in the prediabetes or T2DM range, four had a BMI between 30-39.9 (obese), and two had a BMI of 40+ (morbidly obese). 100% of patients were scheduled for follow-up appointments. All six patients were encouraged to adhere to ADA behavioral modifications related to diet and exercise; also, three patients were receiving pharmacological weight management interventions, and one patient received metformin.

**Interpretation**

This QI project successfully identified and educated fifteen asymptomatic patients under 45 who are at high risk for T2DM in the participant group. Participants received proper education on disease progression and prevention. Out of the total 106 patients evaluated, twenty-five (23.58%) were at high

risk for T2DM. Without the ADADRT implementation, the provider may have overlooked the patient's high-risk status due to lack of symptoms. When high-risk patients are not identified, there is a delay in proper education and interventions, which can deter progression to T2DM. Early identification and education promote disease prevention, and disease prevention improves patient health care outcomes and decreases financial burden.

## Discussion

This QI project shows the importance of having a formal process for screening patients, regardless of age, for risk factors for T2DM. Data from this project confirms the effectiveness of using the ADADRT as a screening tool for asymptomatic, non-pregnant patients age 18-44 in primary care. Early identification of T2DM risk is beneficial for the patient. PCPs can provide education, lifestyle modification instructions, and, when required, pharmacological interventions that could delay or deter progression to T2DM. Early identification and treatment can prevent long-term complications of the disease and decrease financial burden.

## Limitations

Limits to this QI project's generalizability include the unequal sampling of males and females and possible inadequate data collection in chart review and patient questionnaires. The chart review was completed by random selection resulting in forty women and thirteen men. The participant group was met by convenience sampling resulting in forty-four women and nine men. ADADRT scores could have been affected by the lack of information related to family history of diabetes, history of gestational diabetes, and activity level included in patient records. ADADRT scores could be affected by patients filling out questionnaires with untruthful information. This project used a paper ADADRT form which could make sustainability in everyday practice difficult. Imbedding the ADADRT into an electronic health records system would be beneficial and should be studied further in this environment.

The COVID-19 pandemic limited the referrals available for patients who scored a 5 or greater on the ADADRT. The ADA recommends referral to a behavioral modification program for patients who score 5 or more on the ADADRT; this was not an option during implementation. The pandemic also

decreased the number of patients coming into the office for scheduled appointments. The ADADRT was given only to patients in the office, not patients who scheduled telehealth visits.

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