Screening for Prediabetes and Diabetes in a National Network of Federally Qualified Health Centers: An Observational Study

Matthew J. O'Brien, MD, MSc[1,2,3], Stacy C. Bailey, PhD, MPH[1,2], Dyanna L. Gregory, MSc[1,2], Andrew L. Owen, PhD[2], Sadiya S. Khan, MD, MSc[3,4], Ronald T. Ackermann, MD, MPH[1,2], Amro Hassan, MS[5], Nivedita Mohanty, MD[5,6], and Michael E. Bowen, MD, MPH[7,8]

[1]Division of General Internal Medicine and Geriatrics, Department of Medicine, Northwestern University Feinberg School of Medicine, 750 N. Lakeshore Drive, Suite 680, Chicago, IL 60611, USA; [2]Institute for Public Health and Medicine, Northwestern University Feinberg School of Medicine, Chicago, IL, USA; [3]Department of Preventive Medicine, Northwestern University Feinberg School of Medicine, Chicago, IL, USA; [4]Division of Cardiology, Department of Medicine, Northwestern University Feinberg School of Medicine, Chicago, IL, USA; [5]AllianceChicago, Chicago, IL, USA; [6]Department of Pediatrics, Northwestern University Feinberg School of Medicine, Chicago, IL, USA; [7]Division of General Internal Medicine, Department of Medicine, University of Texas Southwestern Medical Center, Dallas, TX, USA; [8]Peter O'Donnell Jr. School of Public Health, University of Texas Southwestern Medical Center, Dallas, TX, USA

ABSTRACT

BACKGROUND: In 2021, the U.S. Preventive Services Task Force (USPSTF) recommended screening for prediabetes and diabetes among adults aged 35–70 years with overweight or obesity. Studying dysglycemia screening in federally qualified health centers (FQHCs) that serve vulnerable patient populations is needed to understand health equity implications of this recommendation.

OBJECTIVE: To investigate screening practices among FQHC patients who would be eligible according to the 2021 USPSTF recommendation.

DESIGN: Retrospective cohort study analyzing electronic health records from a national network of 282 FQHC sites.

PARTICIPANTS: We included 183,329 patients without prior evidence of prediabetes or diabetes, who had ≥ 1 office visit from 2018–2020.

MAIN MEASURES: Screening eligibility was based on age and measured body mass index (BMI). The primary outcome, screening completion, was ascertained using hemoglobin A1c or fasting plasma glucose results from 2018–2020.

KEY RESULTS: Among 89,543 patients who would be eligible according to the 2021 USPSTF recommendation, 53,263 (59.5%) were screened. Those who completed screening had higher BMI values than patients who did not (33.0 ± 6.7 kg/m^2 vs. 31.9 ± 6.2 kg/m^2, $p < 0.001$). Adults aged 50–64 years had greater odds of screening completion relative to younger patients (OR 1.13, 95% CI: 1.10–1.17). Patients from racial and ethnic minority groups, as well as those without health insurance, were more likely to complete screening than White patients and insured patients, respectively. Clinical risk factors for diabetes were also associated with dysglycemia screening. Among patients who completed screening, 23,588 (44.3%) had values consistent with prediabetes or diabetes.

CONCLUSIONS: Over half of FQHC patients who would be eligible according to the 2021 USPSTF recommendation were screened. Screening completion was higher among middle-aged patients, those with greater BMI values, as well as vulnerable groups with a high risk of developing diabetes. Future research should examine adoption of the 2021 USPSTF screening recommendation and its impact on health equity.

KEY WORDS: screening; prediabetes; diabetes; primary care; federally qualified health centers.

J Gen Intern Med 38(16):3541–8

DOI: 10.1007/s11606-023-08402-1

Received March 3, 2023
Accepted August 28, 2023
Published online September 20, 2023

INTRODUCTION

An estimated 37 million U.S. adults have diabetes and 96 million have prediabetes,[1] which are collectively called dysglycemia. Thirty-six percent of adults with diabetes and 85% of those with prediabetes are unaware of having the condition.[1] Nationally representative data highlight the following racial and ethnic disparities in the proportion of diabetes cases that remain undiagnosed: Asian 50.9%, Hispanic/Latino 49.0%, Black 36.8%, and White 32.3%.[2] Undiagnosed dysglycemia, delayed diagnosis of dysglycemia, and lack of awareness about glycemic status result in missed opportunities to improve lifestyle behaviors and initiate other treatments that are known to delay or prevent disease progression. This represents a significant health equity concern, given a large body of evidence documenting higher rates of poor glycemic control, diabetes complications, and diabetes-related mortality among racial and ethnic minority groups relative to non-Hispanic White adults.[3–6]

Screening for dysglycemia represents the primary strategy for detecting prediabetes and diabetes before the conditions become clinically evident. In 2021, the United States Preventive Services Task Force (USPSTF) recommended dysglycemia screening every three years among asymptomatic adults aged 35–70 years with overweight or obesity.[7] This lowered the screening age from 40–70 years in the USPSTF's prior 2015 screening recommendation,[8] which represents the only change to the guideline. Recent research highlights potential for the current USPSTF guideline to promote health equity given its similar performance across racial and ethnic groups.[9] However, nationally representative survey studies report that only half of eligible adults complete recommended screening tests.[10–12] This highlights a critical gap in efforts to detect dysglycemia early, when interventions to prevent or treat diabetes have the greatest impact and potential to narrow disparities.

Federally qualified health centers (FQHCs) represent an important primary care setting for promoting health equity related to prediabetes and diabetes. FQHCs constitute the largest safety-net system of primary care practices in the U.S., which are funded in part by grants from the Health Resources and Services Administration.[13] FQHCs serve over 25 million U.S. adults, including large proportions of racial and ethnic minorities, as well as those who are living in poverty and are uninsured or underinsured.[14] In addition, the burden of diabetes is high among FQHC patients, with a prevalence of 21%.[14] Prior research in FQHCs has shown variable rates of dysglycemia screening.[15, 16] To our knowledge, no studies have examined dysglycemia screening among primary care patients who would be eligible according to the 2021 USPSTF recommendation. These data are needed to highlight gaps and opportunities that should be addressed during its ongoing implementation.

The current study objectives were to: 1) characterize the population of FQHC patients who would be eligible for screening according to the 2021 USPSTF criteria; 2) examine screening completion and the screening positivity rate in this cohort; and 3) identify predictors of screening completion.

METHODS

Data Source

This retrospective cohort study analyzed electronic health record (EHR) data from a nationwide network of FQHCs located in 20 states across the entire U.S. EHR data from routine primary care encounters were collected by AllianceChicago, a Health Center Controlled Network that provides health information technology, clinical collaboration and research infrastructure to its participants. Overall, 282 clinic sites contributed data, including sociodemographic characteristics (age, sex, race and ethnicity, family history of diabetes, and insurance status), laboratory test results, physical measurements (height, weight, and blood pressure), medications ordered, comorbidities (coded according to the International Classification of Diseases, Tenth Revision [ICD-10]), and dates of service. We used structured query language to extract data from AllianceChicago's centralized data warehouse.

Participants

Adult patients included in the analysis had at least one primary care office visit from January 1, 2018 to December 31, 2020. Screening completion was ascertained during this three-year study period. Patients' glycemic status prior to the study period was assessed between January 1, 2015 and December 31, 2017. However, patients were not required to have office visits or glycemic testing during this prior period. We excluded pregnant women, as well as patients with evidence of prediabetes or diabetes before 2018 using EHR diagnosis codes, laboratory values, and medications (Appendix Table 1).

Key Variables

Screening eligibility according to the 2021 USPSTF recommendation was determined based on EHR variables for age and measured body mass index (BMI). Following an approach suggested in the 2021 USPSTF screening guideline, and recommended by other expert groups, a BMI threshold of ≥ 23 kg/m^2 was used for Asian patients to define overweight or obesity.[7, 17] For all other patients, BMI measurements ≥ 25 kg/m^2 were used for this purpose. The following BMI cutoffs were used to define obesity class in Asians patients and all other groups, respectively: Class 1 (25–29.9 kg/m^2 and 30–34.9 kg/m^2); Class 2 (30–34.9 kg/m^2 and 35–39.9 kg/m^2); and Class 3 (≥ 35 kg/m^2 and ≥ 40 kg/m^2).[18, 19] According to widely accepted practice standards, we used hemoglobin A1c (A1c) or fasting plasma glucose (FPG) results to define completion of screening.[20] We did not use results from oral glucose tolerance tests, another recommended dysglycemia screening modality,[20] because none were performed in the study cohort. We did not analyze random glucose results because this test is not recommended for dysglycemia screening.[20] We included the following diabetes risk factors as covariates: age, self-reported sex, self-reported race and ethnicity, insurance status, family history of diabetes, hypertension, dyslipidemia, and polycystic ovary syndrome. The latter risk factor was assessed only in women, and EHR-based definitions of all risk factors are reported in Appendix Table 1. The number of primary care office visits during the study period was also analyzed as a covariate.

Statistical Analysis

Descriptive statistics were used to characterize all adult FQHC patients with respect to sociodemographic and clinical characteristics, with stratification by screening eligibility. Chi-square tests examined the bivariate association between patient characteristics and screening completion among patients who would be eligible according to the 2021

USPSTF guideline. In the same population, we estimated the relative odds of completing dysglycemia screening by sociodemographic and clinical characteristics using logistic regression adjusted for all other covariates. We estimated the yield of screening by calculating the proportion of screened patients whose test results indicated prediabetes (i.e., A1c 5.7–6.4% or FPG 100-125 mg/dL) or diabetes (i.e., A1c $\geq$ 6.5% or FPG $\geq$ 126 mg/dL).[20] In a series of sensitivity analyses, we repeated the same bivariate and multivariable analyses after including patients with pre-existing prediabetes in the eligible population. A p-value of < 0.05 was considered significant for all statistical testing. All analyses were conducted using SAS, version 9.4 (SAS Institute, Cary, NC). The research protocol was approved by the participating FQHCs and was deemed exempt from review by the Northwestern University Institutional Review Board.

RESULTS

Among 183,329 adult FQHC patients, 89,543 (48.8%) would be eligible for dysglycemia screening according to the 2021 USPSTF screening guideline (Table 1). Overall, slightly more than half of patients were women and two-thirds were from racial or ethnic minority groups. Almost 60% of patients were uninsured or had Medicaid coverage. A substantial proportion of patients had hypertension or dyslipidemia. Documentation of family history of diabetes, as ascertained by ICD-10 code, was only present for only ~ 3% of patients. Two-thirds of ineligible patients were aged younger than 35 years and approximately half had a normal BMI. Those who would be ineligible also exhibited a substantially lower burden of other diabetes risk factors, with the exception of polycystic ovary syndrome. Prior to the study period, patients who would be ineligible for screening had more primary care office visits.

Of the 89,543 patients who would be eligible according to the 2021 USPSTF recommendation, 53,263 (59.5%) completed dysglycemia screening. The screening rate among 35–39 year-old patients (57.7%) was similar to those aged 40–70 years old (59.9%). Table 2 presents bivariate associations between patient characteristics and completion of dysglycemia screening. Patients who completed screening were more often women or from racial and ethnic minority groups. The presence of most clinical risk factors for diabetes, as well as the number of office visits during the study period, were also associated with dysglycemia screening. However, those who were not screened still had opportunities to complete dysglycemia screening with a mean of 4.7 ($\pm$ 5.0) visits during the study period. Patients who completed screening had a higher BMI than those who did not (33.0 ± 6.7 kg/m^2 vs. 31.9 ± 6.2 kg/m^2, $p < 0.001$).

Table 3 presents multivariable associations between patient characteristics and screening completion. Adults aged 50–64 years were more likely to complete dysglycemia screening relative to their younger counterparts; and women were more likely to be screened than men. Patients from racial or ethnic minority groups were more likely to complete screening than White patients, with the greatest odds of screening observed among Hispanic/Latino and Black patients (OR 2.51, 95% CI: 2.42–2.61; and OR 1.97, 95% CI: 1.90–2.05, respectively). Patients without health insurance were the most likely to complete dyglycemia screening relative to insured patients. All clinical risk factors except hypertension were significantly associated with screening completion. Patients with obesity were more likely to be screened than those with overweight, and successively higher odds of screening were observed by obesity class. The strongest predictor of screening completion was the number of office visits during the follow-up period. All findings from descriptive, bivariate, and multivariable analyses were similar when including patients with prediabetes among the population who would be eligible for screening (Appendix Tables 2–4).

Of the 53,263 patients who completed screening, 23,588 (44.3%) were found to have dysglycemia (Table 4). The overwhelming majority completed A1c tests (n = 52,631, 98.8%), resulting in 15,847 (30.1%) whose values indicated prediabetes and 7,494 (14.2%) whose values indicated diabetes. Among the 632 patients who completed screening with FPG tests, 192 (30.4%) had results in the prediabetic range and 55 (8.7%) had results in the diabetic range.

DISCUSSION

To our knowledge, this is the first study of dysglycemia screening in a national network of federally qualified health centers (FQHCs), and the first to examine screening eligibility and completion among patients who are now eligible according to the 2021 USPSTF recommendation. We found that approximately 60% of FQHC patients who would be eligible according to this current guideline were screened from 2018–2020. Greater screening completion was observed among middle-aged patients, as well as those with higher BMI values and most other clinical risk factors for diabetes. Interestingly, patients from racial and ethnic minority groups exhibited higher screening rates than White patients, and those without health insurance were screened more often than insured patients. Our findings document screening practices prior to the 2021 USPSTF recommendation, thereby highlighting opportunities and gaps that should be addressed during ongoing implementation of this current recommendation. Given the slow adoption of many clinical guidelines,[21] studying dysglycemia screening in response to the 2021 USPSTF guideline will require years of data after its implementation.

Prior literature on dysglycemia screening has used diverse data sources and methods. Nationally representative survey studies have examined self-reported screening completion across the entire U.S. adult population. For example, prior

Table 1 Baseline Characteristics of Adult Federally Qualified Health Center Patients*

Characteristic	Eligible for Screening, n (%)†	Ineligible for Screening, n (%)
Number	89,543 (100)	93,786 (100)
Mean age, years	49.1 (9.4)	36.1 (15.9)
Age categories, years		
18–34	0 (0.0)	63,524 (67.7)
35–39	17,242 (19.3)	4,536 (4.8)
40–49	31,387 (35.1)	6,904 (7.4)
50–64	35,170 (39.3)	10,624 (11.3)
65–70	5,744 (6.4)	2,126 (2.3)
70+	0 (0.0)	6,072 (6.5)
Sex		
Male	39,376 (44.0)	42,461 (45.3)
Female	50,167 (56.0)	51,325 (54.7)
Race and ethnicity		
Non-Hispanic Asian	2,798 (3.1)	3,146 (3.4)
Non-Hispanic Black	24,831 (27.7)	26,017 (27.7)
Hispanic/Latino	33,007 (36.9)	32,127 (34.3)
Non-Hispanic White	24,728 (27.6)	28,285 (30.1)
Other or unknown	4,179 (4.7)	4,211 (4.5)
Insurance status		
Uninsured	30,849 (34.5)	25,439 (27.1)
Medicaid	20,937 (23.4)	28,235 (30.1)
Medicare	5,311 (5.9)	5,303 (5.7)
Private	17,172 (19.2)	19,026 (20.3)
Other or unknown	15,274 (17.1)	15,783 (16.8)
Family history of diabetes	2,511 (3.0)	2,970 (3.2)
Hypertension	64,627 (72.2)	53,833 (57.4)
Dyslipidemia	42,130 (47.1)	24,831 (26.5)
Polycystic ovary syndrome‡	333 (0.7)	1,821 (3.5)
Mean body mass index, kg/m^2	32.5 (6.5)	27.8 (7.6)
Weight status		
Normal	0 (0.0)	45,291 (48.3)
Overweight	36,984 (41.3)	19,580 (20.9)
Class 1 obesity	28,275 (31.6)	14,140 (15.1)
Class 2 obesity	13,729 (15.3)	7,595 (8.1)
Class 3 obesity	10,555 (11.8)	7,180 (7.7)
Mean baseline number of office visits§	3.2 (5.5)	3.8 (5.7)
0 baseline visits	46,136 (51.5)	40,082 (42.7)
1 baseline office visit	6,221 (6.9)	7,801 (8.3)
2–3 baseline office visits	10,532 (11.8)	12,990 (13.9)
≥4 baseline office visits	26,654 (29.8)	32,913 (35.1)

* Unless noted otherwise, data are presented as column percentages for each of the patient characteristics. Percentages may not add to 100 due to rounding within strata of patient characteristics

† Screening eligibility was determined according to the 2021 USPSTF recommendation, namely age 35–70 years old and overweight or obesity

‡ The denominator for the reported proportions was the total number of women

§ The number of baseline office visits was determined during the three years preceding the study period (i.e., January 1, 2015-December 31, 2017), during which glycemic status was ascertained

research using the National Health and Nutrition Examination Surveys have found that approximately half of U.S. adults who were eligible according to contemporary criteria reported completing screening during the previous three years.[10–12] However, these estimates may be biased by participants' self-report or lack of engagement in primary care.

Clinic-based estimates of dysglycemia screening vary widely. One large academic health system found a 78% screening completion rate among all adults aged ≥ 45 years,[22] following the contemporary ADA screening criteria.[23] However, this estimate included random glucose tests that are not recommended for dysglycemia screening, with only 14% of patients completing A1c tests.[22] A different academic health system examined screening according to the 2015 USPSTF criteria, and found that less than 15% of eligible patients received recommended glycemic tests during three years of follow-up.[24] Another study examining adherence to the 2015 USPSTF screening guideline in a mid-Atlantic primary care network reported that 31.3% of eligible patients completed screening.[25] Differences in these clinic-based

Table 2 Completion of Dysglycemia Screening among Eligible Patients by Sociodemographic and Clinical Characteristics*

Characteristic	All Eligible Patients (N = 89,543)[†]		
	Completed Screening (n = 53,263)	Did Not Complete Screening (n = 36,280)	P-value
Mean age, years	49.0 (9.2)	49.3 (9.6)	0.00
Age categories, years			
35–39	9,952 (18.7)	7,290 (20.1)	< 0.001
40–49	19,397 (36.4)	11,990 (33.0)	< 0.001
50–64	20,891 (39.2)	14,279 (39.4)	0.84
65–70	3,023 (5.7)	2,721 (7.5)	0.01
Sex			
Male	21,917 (41.2)	17,459 (48.1)	< 0.001
Female	31,346 (58.8)	18,821 (51.9)	< 0.001
Race and ethnicity			
Non-Hispanic Asian	1,611 (3.0)	1,187 (3.3)	0.72
Non-Hispanic Black	14,858 (27.9)	9,973 (27.5)	0.55
Hispanic/Latino	23,188 (43.5)	9,819 (27.1)	< 0.001
Non-Hispanic White	11,253 (21.1)	13,475 (37.1)	< 0.001
Other or unknown	2,353 (4.4)	1,826 (5.0)	0.37
Insurance status			
Uninsured	8,360 (15.7)	6,921 (19.1)	< 0.001
Medicaid	9,033 (17.0)	8,146 (22.4)	< 0.001
Medicare	12,589 (23.6)	8,352 (23.0)	0.37
Private	2,764 (5.2)	2,549 (7.0)	0.01
Other or unknown	20,526 (38.5)	10,330 (28.5)	< 0.001
Family history of diabetes	507 (4.7)	414 (2.2)	0.03
Hypertension	35,355 (66.4)	29,272 (80.7)	< 0.001
Dyslipidemia	28,201 (52.9)	13,940 (38.4)	< 0.001
Polycystic ovary syndrome[‡]	226 (0.7)	107 (0.6)	0.85
Mean body mass index, kg/m^2	33.0 (6.7)	31.9 (6.2)	< 0.001
Weight status			
Normal	0 (0.0)	0 (0.0)	--
Overweight	20,378 (38.3)	16,006 (45.8)	< 0.001
Class 1 obesity	17,113 (32.1)	11,162 (30.8)	0.05
Class 2 obesity	8,767 (16.5)	4,962 (13.7)	< 0.001
Class 3 obesity	7,005 (13.2)	3,550 (9.8)	< 0.001
Mean number of office visits[§]	6.0 (5.2)	4.7 (5.0)	< 0.001
1 office visit	4,330 (8.1)	7,505 (20.7)	< 0.001
2–3 office visits	16,736 (31.4)	12,332 (34.0)	< 0.001
≥ 4 office visits	32,197 (60.5)	16,443 (45.3)	< 0.001

* Unless noted otherwise, data are presented as column percentages for each of the patient characteristics. Percentages may not add to 100 due to rounding within strata of patient characteristics

† Screening eligibility was determined according to the 2021 USPSTF recommendation, namely age 35–70 years old and overweight or obesity

‡ The denominator for the reported proportions was the total number of women

§ The number of office visits were recorded during the entire study period from January 1, 2018 to December 31, 2020, during which screening completion was ascertained

screening estimates are likely due to studying distinct clinical populations, including diverse types of health systems, using alternate definitions of screening eligibility, and examining different glycemic tests.

One prior analysis examined dysglycemia screening in an integrated safety-net health system in Texas, investigating a vulnerable population that is most similar to the current report. This study found a screening completion rate of 70% over three years among those eligible according to the contemporary USPSTF or ADA criteria.[16] The higher rate observed in this prior study may be related to its inclusion of patients with prediabetes, in whom annual glycemic testing is recommended. Our findings from safety-net FQHCs demonstrate higher screening rates than most estimates from other clinical settings. This may stem from providers' recognition of the high diabetes risk experienced by FQHC patients, or from dedicated efforts to increase dysglycemia screening that are not observed in our data.

We found that almost half of patients who completed screening had values that indicate dysglycemia. Earlier research reported a similar overall yield of patients found to have dysglycemia with a lower proportion of diabetes cases.[16, 25] Our analysis, and prior studies, demonstrate that dysglycemia screening among eligible adults identifies a significant proportion who could benefit from evidence-based interventions to prevent or treat diabetes.[26, 27] Future research should examine uptake of those services among patients who screen positive for dysglycemia.

Table 3 Odds of Completing Screening among Eligible Patients by Sociodemographic and Clinical Characteristics (n = 89,543)*

Characteristic	Odds Ratio (95% CI)
Age	
35–49	REF
50–64	1.13 (1.10–1.17)
65–70	0.97 (0.91 -1.03)
Sex	
Male	REF
Female	1.13 (1.09–1.16)
Race and ethnicity	
Non-Hispanic White	REF
Asian	1.44 (1.33–1.57)
Black	1.97 (1.90–2.05)
Hispanic/Latino	2.51 (2.42–2.61)
Other or unknown	1.67 (1.56–1.79)
Insurance status	
Medicare	REF
Private	1.04 (0.97–1.11)
Medicaid	1.18 (1.10–1.26)
Uninsured	1.46 (1.36–1.56)
Other or unknown	0.96 (0.89–1.03)
Family history of diabetes	1.58 (1.44–1.74)
Hypertension	0.42 (0.40–0.43)
Dyslipidemia	1.82 (1.76–1.87)
Polycystic ovary syndrome	1.31 (1.02–1.67)
Weight status	
Overweight	REF
Class 1 obesity	1.29 (1.24–1.33)
Class 2 obesity	1.59 (1.52–1.66)
Class 3 obesity	1.97 (1.88–2.07)
Number of office visits†	
1 office visit	REF
2–3 office visits	2.47 (2.36–2.59)
≥ 4 office visits	4.07 (3.89–4.26)

* Screening eligibility was determined according to the 2021 USPSTF recommendation, namely age 35–70 years old and overweight or obesity

† The number of office visits were recorded during the entire study period from January 1, 2018 to December 31, 2020, during which screening completion was ascertained

Table 4 Yield of Dysglycemia Screening Among Eligible and Tested Patients*

Glycemic Screening Test Results	N (%)
Total number screened	53,263 (100)
With hemoglobin A1c test	52,631 (98.8)
With fasting plasma glucose test	632 (1.2)
Hemoglobin A1c, % †	
< 5.7	29,290 (55.7)
5.7–5.9	10,018 (19.0)
6.0–6.4	5,829 (11.1)
≥ 6.5%	7,494 (14.2)
Mean (SD)	6.0 (1.6)
Fasting plasma glucose, mg/dL‡	
< 100	385 (60.9)
100–125	192 (30.4)
≥ 126	55 (8.7)
Mean (SD)	102.3 (28.6)

* Categorical data are presented as n (%) within strata of glycemic test results

† Proportions reported within each category of hemoglobin A1c values used the denominator of all patients who completed screening with this test (n = 52,631)

‡ Proportions reported within each category of fasting plasma glucose values used the denominator of all patients who completed screening with this test (n = 632)

Strengths of our analysis include examining dysglycemia screening patterns among patients who would be eligible according to the current USPSTF recommendation. The study setting is also novel, as our analysis is the first to examine dysglycemia screening across a national network of FQHCs. Analyzing data from this national network may provide a more accurate assessment of screening in this setting nationwide, rather than studying data from a single FQHC site where differences in clinical populations, provider practices, state-specific reimbursement, or local quality improvement initiatives may produce variation in screening rates. As the largest system of primary care clinics serving vulnerable populations with documented diabetes disparities, FQHCs also represent an important venue for examining health equity in dysglycemia screening.

This study also has notable limitations. Due to the time period of available data, our analysis examined screening practices before the 2021 USPSTF recommendation. Therefore, overweight or obese patients aged 35–39 years who completed screening in our analysis were not eligible at that time. Similar screening rates observed in this subgroup relative to those who were eligible during the study period suggests that patients were likely screened according to clinicians' perceptions of their diabetes risk.[16] Evaluating uptake of this guideline in practice requires years of data post-implementation, which should be examined in future research.

Some clinical risk factors for diabetes are underreported in EHR data. For example, it is estimated that approximately 30% of U.S. adults have a family history of diabetes and up to 13% of U.S. women have polycystic ovary syndrome.[28, 29] While the prevalence of these risk factors was much lower in our study that used EHR data for their ascertainment, they remained significant predictors of dysglycemia screening completion. Because FQHC patients are more likely to have low socioeconomic status, minority race or ethnicity, and lack health insurance,[14] our findings may not be generalizable to other U.S. primary care populations. Finally, the study period included nine months of the Covid-19 pandemic, which may have impacted dysglycemia screening practices in FQHCs. However, almost 80% of patients who did not complete screening had at least two office visits during the study period when they could have been screened.

Our study examined screening eligibility according to the 2021 USPSTF recommendation, which was based on a rigorous evidence review conducted by an independent panel of experts.[30] Other expert recommendations for dysglycemia screening were not analyzed here. For example, the American Diabetes Association (ADA) currently recommends screening all adults aged 35 years or older, as well as those younger than age 35 who have overweight or obesity and an additional diabetes risk factor.[20] Patients should not incur out-of-pocket costs for receiving tests recommended by USPSTF,[31] which mitigates financial barriers that may be particularly relevant for patients served in FQHCs.

The current study has implications for dysglycemia screening in FQHCs nationwide. The high rate of screening observed among uninsured patients suggests that lack of insurance reimbursement may not be a significant barrier to dysglycemia screening in this setting. FQHCs support uncompensated care through a variety of mechanisms including federal and philanthropic grants, patient cost sharing on a sliding fee scale, and reduced laboratory pricing,[13] which may not be available in other primary care settings. Importantly, we also found higher odds of screening completion among patients from racial and ethnic minority groups than White patients, which was reported previously in a nationally representative sample of ambulatory clinics.[32] Our results imply that FQHC clinicians recognize the higher risk of diabetes experienced by these vulnerable groups and are appropriately screening a greater proportion of them. While these findings suggest that current screening practices may promote health equity in detecting prediabetes and diabetes, maximizing equity across all racial and ethnic groups will require achieving a higher overall screening rate.

This suggests a potential opportunity for new policies, quality improvement initiatives, and implementation strategies in individual FQHCs, health center networks, or from the Health Resources and Services Administration, the federal agency that provides funding for community health centers. There are many ongoing policies and programs in FQHCs focused on diabetes management,[13] and greater adherence to dysglycemia screening guidelines could expand these existing efforts. Identifying patients with prediabetes and diabetes earlier may enhance their engagement with evidence-based treatment and help prevent disease progression in a setting where diabetes complications are prevalent.[33]

In conclusion, we found that screening for prediabetes and diabetes occurred in approximately 60% of FQHC patients who would be eligible according to the 2021 USPSTF recommendation. Our findings highlight gaps and potential opportunities for effective and equitable implementation of this guideline. Future qualitative research with patients and primary care providers should explore potential strategies to improve dysglycemia screening. While some prior intervention research has focused on increasing adherence to dysglycemia screening guidelines, these studies have been conducted in single clinics or have employed non-randomized designs.[34, 35] Therefore, developing effective and scalable approaches that maximize screening completion is urgently needed. Future research should rigorously evaluate these interventions in FQHCs given the diversity of the patient populations they serve and the high burden of diabetes in this setting.

Supplementary Information *The online version contains supplementary material available at https://doi.org/10.1007/s11606-023-08402-1.*

Acknowledgements: *We gratefully acknowledge the FQHCs who contributed data to the current study, and their leadership for agreeing to make the data available for analysis.*

Corresponding Author: *Matthew J. O'Brien, MD, MSc; Division of General Internal Medicine and Geriatrics, Department of Medicine, Northwestern University Feinberg School of Medicine, 750 N. Lakeshore Drive, Suite 680, Chicago, IL, 60611, USA (e-mail: matthew.obrien1@northwestern.edu).*

Funding *This work was supported by a grant from the National Institute of Diabetes and Digestive and Kidney Diseases (P30-DK092949).*

Data Availability *Those interested in accessing the study data should contact the corresponding author.*

Declarations

Conflicts of Interest *Matthew J. O'Brien: No financial conflicts of interest to report.*
Stacy C. Bailey: Dr. Bailey reports receiving research grants from the following organizations that were paid to Northwestern University: NIH, Gordon and Betty Moore Foundation, Pfizer, Eli Lilly, Lundbeck, Merck, Gilead, and the Retirement Research Foundation for Aging. Dr. Bailey reports receiving personal consulting fees from Lundbeck, Pfizer, Sanofi, Luto UK, and the University of Westminster. Dr. Bailey reports receiving personal fees for participation on a scientific advisory board at Gilead and support for travel from NIH and Gilead. None of these potential financial conflicts of interest are related to the current work.
Dyanna L. Gregory: No financial conflicts of interest to report.
Andrew L. Owen: No financial conflicts of interest to report.
Sadiya S. Khan: No financial conflicts of interest to report.
Ronald T. Ackermann: Dr. Ackermann reports receiving personal consulting fees from UnitedHealth Group unrelated to the current work.
Amro Hassan: No financial conflicts of interest to report.
Nivedita Mohanty: No financial conflicts of interest to report.
Michael Bowen: No financial conflicts of interest to report.

REFERENCES

1. Centers for Disease Control and Prevention. National Diabetes Statistics Report, Estimates of Diabetes and Its Burden in the United States. Centers for Disease Control and Prevention; U.S. Department of Health and Human Services. Updated January 18, 2022. Accessed April 8, 2022. https://www.cdc.gov/diabetes/data/statistics-report/index.html
2. Menke A, Casagrande S, Geiss L, Cowie CC. Prevalence of and Trends in Diabetes Among Adults in the United States, 1988-2012. *JAMA.* 2015;314(10):1021-1029. https://doi.org/10.1001/jama.2015.10029
3. Preston SH, Choi D, Elo IT, Stokes A. Effect of Diabetes on Life Expectancy in the United States by Race and Ethnicity. *Biodemography Soc Biol.* 2018;64(2):139-151. https://doi.org/10.1080/19485565.2018.1542291
4. Egede LE, Gebregziabher M, Hunt KJ, et al. Regional, geographic, and racial/ethnic variation in glycemic control in a national sample of veterans with diabetes. *Diabetes Care.* 2011;34(4):938-43. https://doi.org/10.2337/dc10-1504
5. Walker RJ, Strom Williams J, Egede LE. Influence of Race, Ethnicity and Social Determinants of Health on Diabetes Outcomes. *Am J Med*

Sci. 2016;351(4):366-73. https://doi.org/10.1016/j.amjms.2016.01.008
6. Spanakis EK, Golden SH. Race/ethnic difference in diabetes and diabetic complications. *Curr Diab Rep.* 2013;13(6):814-23. https://doi.org/10.1007/s11892-013-0421-9
7. Davidson KW, Barry MJ, Mangione CM, et al. Screening for Prediabetes and Type 2 Diabetes: US Preventive Services Task Force Recommendation Statement. *JAMA.* 2021;326(8):736-743. https://doi.org/10.1001/jama.2021.12531
8. Siu AL. Screening for Abnormal Blood Glucose and Type 2 Diabetes Mellitus: U.S. Preventive Services Task Force Recommendation Statement. *Ann Intern Med.* 2015;163(11):861-8. https://doi.org/10.7326/m15-2345
9. O'Brien MJ, Zhang Y, Bailey SC, et al. Screening for Prediabetes and Diabetes: Clinical Performance and Implications for Health Equity. *Am J Prev Med.* in press;
10. Bullard KM, Ali MK, Imperatore G, et al. Receipt of Glucose Testing and Performance of Two US Diabetes Screening Guidelines, 2007-2012. *PLoS One.* 2015;10(4):e0125249. https://doi.org/10.1371/journal.pone.0125249
11. Kiefer MM, Silverman JB, Young BA, Nelson KM. National patterns in diabetes screening: data from the National Health and Nutrition Examination Survey (NHANES) 2005-2012. *J Gen Intern Med.* 2015;30(5):612-8. https://doi.org/10.1007/s11606-014-3147-8
12. Casagrande SS, Cowie CC, Genuth SM. Self-reported prevalence of diabetes screening in the U.S., 2005-2010. *Am J Prev Med.* 2014;47(6):780-7. https://doi.org/10.1016/j.amepre.2014.07.039
13 Kelley AT, Nocon RS, O'Brien MJ. Diabetes Management in Community Health Centers: a Review of Policies and Programs. *Curr Diab Rep.* Feb 6 2020;20(2):8. https://doi.org/10.1007/s11892-020-1289-0
14. National Association of Community Health Centers. Community Health Center Chart Book. http://www.nachc.org/wp-content/uploads/2018/06/Chartbook_FINAL_6.20.18.pdf
15. O'Brien MJ, Lee JY, Carnethon MR, et al. Detecting Dysglycemia Using the 2015 United States Preventive Services Task Force Screening Criteria: A Cohort Analysis of Community Health Center Patients. *PLoS Med.* 2016;13(7):e1002074. https://doi.org/10.1371/journal.pmed.1002074
16. Obinwa U, Pérez A, Lingvay I, Meneghini L, Halm EA, Bowen ME. Multilevel Variation in Diabetes Screening Within an Integrated Health System. *Diabetes Care.* 2020;43(5):1016-1024. https://doi.org/10.2337/dc19-1622
17. Hsu WC, Araneta MR, Kanaya AM, Chiang JL, Fujimoto W. BMI cut points to identify at-risk Asian Americans for type 2 diabetes screening. *Diabetes Care.* 2015;38(1):150-8. https://doi.org/10.2337/dc14-2391
18. Girdhar S, Sharma S, Chaudhary A, Bansal P, Satija M. An Epidemiological Study of Overweight and Obesity Among Women in an Urban Area of North India. *Indian J Community Med.* 2016;41(2):154-7. https://doi.org/10.4103/0970-0218.173492
19. Centers for Disease Control and Prevention. Defining Adult Overweight & Obesity. U.S. Department of Health & Human Services. Accessed Feb 7, 2023. https://www.cdc.gov/nccdphp/dnpao/index.html
20 ElSayed NA, Aleppo G, Aroda VR, et al. 2. Classification and Diagnosis of Diabetes: Standards of Care in Diabetes-2023. *Diabetes Care.* 2023;46(Suppl 1):S19-s40. https://doi.org/10.2337/dc23-S002
21. Cabana MD, Rand CS, Powe NR, et al. Why don't physicians follow clinical practice guidelines? A framework for improvement. *JAMA.* 1999;282(15):1458-65. https://doi.org/10.1001/jama.282.15.1458
22. Evron JM, Herman WH, McEwen LN. Changes in Screening Practices for Prediabetes and Diabetes Since the Recommendation for Hemoglobin A(1c) Testing. *Diabetes Care.* 2019;42(4):576-584. https://doi.org/10.2337/dc17-1726
23. 2. Classification and Diagnosis of Diabetes: Standards of Medical Care in Diabetes-2019. *Diabetes Care.* 2019;42(Suppl 1):S13-s28.https://doi.org/10.2337/dc19-S002
24. Thomas TW, Golin C, Samuel-Hodge CD, Kirkman MS, Golden SD, Lightfoot AF. Race and gender differences in abnormal blood glucose screening and clinician response to prediabetes: A mixed-methods assessment. *Prev Med.* 2021;148:106587. https://doi.org/10.1016/j.ypmed.2021.106587
25. Banerjee ES, Shaak K, Burgess N, Johnson M, Careyva B. Factors Associated with Clinician Adherence to USPSTF Diabetes Screening Recommendations. *J Prim Care Community Health.* 2021;12:21501327211016579. https://doi.org/10.1177/21501327211016579
26 ElSayed NA, Aleppo G, Aroda VR, et al. 9. Pharmacologic Approaches to Glycemic Treatment: Standards of Care in Diabetes-2023. *Diabetes Care.* 2023;46(Suppl 1):S140-s157. https://doi.org/10.2337/dc23-S009
27. Knowler W, Barrett-Connor E, Fowler S, et al. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *N Engl J Med.* 2002;346(6):393-403. https://doi.org/10.1056/NEJMoa012512.
28. Valdez R. Detecting undiagnosed type 2 diabetes: family history as a risk factor and screening tool. *J Diabetes Sci Technol.* 2009;3(4):722-6. https://doi.org/10.1177/193229680900300417
29. Lizneva D, Suturina L, Walker W, Brakta S, Gavrilova-Jordan L, Azziz R. Criteria, prevalence, and phenotypes of polycystic ovary syndrome. *Fertil Steril.* 2016;106(1):6-15. https://doi.org/10.1016/j.fertnstert.2016.05.003
30. Jonas DE, Crotty K, Yun JDY, et al. U.S. Preventive Services Task Force Evidence Syntheses, formerly Systematic Evidence Reviews. *Screening for Prediabetes and Type 2 Diabetes Mellitus: An Evidence Review for the US Preventive Services Task Force.* Agency for Healthcare Research and Quality (US); 2021.
31. Bauchner H, Fontanarosa PB, Golub RM. JAMA Welcomes the US Preventive Services Task Force. *JAMA.* 2016;315(4):351-2. https://doi.org/10.1001/jama.2015.18448
32. Shealy KM, Wu J, Waites J, Taylor NA, Blair Sarbacker G. Patterns of Diabetes Screening and Prediabetes Treatment during Office Visits in the US. *J Am Board Fam Med.* 2019;32(2):209-217. https://doi.org/10.3122/jabfm.2019.02.180259
33. National Association of Community Health Centers. Community Health Center Chartbook. Community Health Center Chart Book. Accessed September 19, 2022. http://www.nachc.org/wp-content/uploads/2018/06/Chartbook_FINAL_6.20.18.pdf
34. Albu JB, Sohler N, Li R, et al. An Interrupted Time Series Analysis to Determine the Effect of an Electronic Health Record-Based Intervention on Appropriate Screening for Type 2 Diabetes in Urban Primary Care Clinics in New York City. *Diabetes Care.* 2017;40(8):1058-1064. https://doi.org/10.2337/dc16-2133
35. Iyengar JJ, Fisher MEK, Ziegler JE, et al. Increasing Diabetes Screening in a Primary Care Setting. *Clin Diabetes.* 2022;40(1):87-91. https://doi.org/10.2337/cd21-0039

Publisher's Note *Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.*