Rationale of family medicine physicians in effectively identifying patients with chronic hyperglycemia through point-of-care hemoglobin A1C screenings

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Abstract

Purpose Many patients are unknowingly living with chronic hyperglycemia, possibly due to low screening rates. We aimed to correlate detection of unidentified chronic hyperglycemia to practitioner reported rationale for conducting diabetes screening.

Methods Physicians screened patients via a point-of-care A1C tests and recorded corresponding rationales. Elevated outcomes (A1C $\geq 5.7\%$) were correlated to recorded rationales, frequency of repeat screenings, documented diagnoses, and therapeutic actions taken as a result of elevated A1C.

Results Nearly one-half (45%) of selected patients were unknowingly living with chronic hyperglycemia, having an average A1C of 7.92% for outcomes $\geq 6.5\%$. Most commonly recorded rationales were overweight status (71%), high-risk ethnicity (58%), and age > 45 years (48%); previously recorded A1C result of $\geq 5.7\%$ (χ^2 16.02, $p < 0.001$) and hypertension diagnosis (χ^2 10.37, $p = 0.0013$) showed statistically significant correlation with elevated A1C outcomes. A1C results $\geq 6.5\%$ versus 5.7–6.5% more frequently prompted repeat screenings (77% vs 20%), ICD-10 code documentation (91% vs 28%), lifestyle modification recommendations (78% vs 35%), and drug therapy initiation (78% vs 9%).

Conclusions Reported rationales were largely impacted by visual inspections of age, race, and weight, and prediabetic A1C values garnered less attention compared to higher values. Utilization of POC A1C screening followed by conformational repeat testing is a practical approach to improve diagnostic rates and initiation of care for diabetes.

Keywords Diabetes · Prediabetes · Screening · A1C · Prevention · Point-of-care

Introduction

In 2017, the Center for Disease Control and Prevention (CDC) estimated that nearly one quarter of the 30.3 million adult Americans with diabetes remain undiagnosed. Additionally, over one third of the nation has prediabetes, but nearly 9 out of 10 prediabetic Americans are unaware of their status [1]. Comparatively, Alabama exceeds the national average with 1/8th of its population having diagnosed diabetes and retains a large number of prediabetics who may remain unaware of their status [2, 3].

On sides of both practitioner and patient, lack of awareness for a diagnosable medical condition has obvious consequences affecting the management of any disease state. Diabetes is no exception to this rule. If left undiagnosed and unaddressed, the glycemic curve of 25–50% of prediabetic

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patients will gradually progress and ultimately cross the diagnostic threshold for type 2 diabetes mellitus (T2DM) within 5 years [4]. Detection of diabetes in its early stages allows for more thorough, proactive provision of care via initiation of lifestyle modifications, monitoring of disease progression, and utilization of appropriate pharmacologic interventions. Proactive assessment and glycemic control during the early course of diabetes may prevent the occurrence of unidentified extreme glycemic excursions, which otherwise lead to development of microvascular complications if left untreated [5–7]. For these reasons, diabetes screening plays a vital role in early identification, diagnosis, and initiation of appropriate treatment. While it remains unclear why such large proportions of those residing in the US and Alabama are unaware of their chronic hyperglycemia, one reasonable explanation is that rates of diabetes screenings remain low despite viable rationale for conducting them. Therefore, we aim to assess previously uninvestigated rationales which prompt clinicians to conduct diabetes screenings [8].

As T2DM begins to develop, one of the first homeostatic imbalances that occurs is loss of the first-phase insulin response, which allows for control of post-prandial blood glucose (PPBG) elevations in the fed state [9, 10]. Therefore, fasting blood glucose (FBG) values assessed during the early stages of T2DM may fall within normal limits, while elevated PPBG levels that still impact A1C remain unidentified. Additionally, accurate clinical assessment of PPBG control using an oral glucose tolerance test (OGTT) is inconvenient, requiring multiple finger sticks and a significant time investment on the part of both clinician and patient. Conversely, point-of-care hemoglobin A1C (POC A1C) testing requires only a single finger stick and results are available in less than 10 minutes. Performing the test is not only more convenient, but measuring glycosylated hemoglobin through A1C screening is also arguably more clinically relevant since it uniquely captures a 3-month average of various BG values. Notably, FBG and PPBG each affect A1C differently. For example, A1C values between 7 and 8.4% are more profoundly impacted by PPBG, while A1C values >8.4% are more readily affected by FBG [11]. Thus, this test not only paints a long-term picture of glycemic control, but it also provides insight relating problematic components of the glycemic curve to which therapies may be most beneficial for optimizing glycemic control.

This study was conducted using free-of-charge POC A1C tests to investigate outcomes in a geographically high-risk population of Alabama residents. The objectives of this study were to 1) identify unknown chronic hyperglycemia and determine the rate of occurrence among the selected patient population, 2) associate practitioner rationale for diabetes screening with glycemic outcomes, and 3) assess rates of repeat testing, newly recorded diagnosis codes, and initiation of therapeutic interventions as a result of elevated glycemic

outcomes. The study was approved by Baptist Health System Investigational Review Committee and Auburn University's Investigational Review Board.

Methods

Physicians were provided POC A1C tests to screen patients at a family medicine clinic between August 2015 and August 2016. The decision to screen patients was at the discretion of providers ($n = 26$ physicians), who documented their rationale at the point of A1C order entry into the electronic medical record (EMR). Using criteria defined by the Standards of Medical Care in Diabetes [4], physicians could simultaneously select multiple pre-specified screening rationale per patient.

At study completion, every patient that underwent screening was retrospectively verified as meeting appropriate eligibility criteria. Those with pre-existing diabetes or an A1C test within 12 months were excluded from analysis. Demographic characteristics were assessed using descriptive statistics. A1C outcomes were defined as euglycemia <5.7% (<39 mmol/mol), prediabetes 5.7–6.4% (39–46 mmol/mol), and diabetes $\geq 6.5\%$ (≥ 48 mmol/mol) and subsequently compared to the physician reported rationales for screening. Pearson's chi square analysis of independence compared rationales with positive A1C outcomes ($A1C \geq 5.7\%$), and adherence to screening recommendations according to American Diabetes Association (ADA) [4] versus United States Preventative Services Task Force (USPSTF) [12] was also examined. Lastly, a retrospective analysis of patients with elevated A1C outcomes at conclusion of the study period was performed to determine the frequency of repeat screenings for diagnostic verification, documentation of diagnosis with an appropriate ICD-10 code, and therapeutic interventions made by providers as a result of an elevated A1C.

Results

POC A1C tests were used to screen 333 patients throughout the study period. Retrospective verification identified 68 tests that were inappropriately ordered due to either a past medical history (PMH) of diabetes ($n = 57$) or A1C test conducted in the past 12 months ($n = 11$). Therefore, a total of 265 POC A1C test results were used for the final analysis. The majority of patients screened were African American (81%) and female (70%). Adults composed 91% of those screened, and ages ranged from 4 to 102 years with a mean of 45 years. Patients were predominately obese (70%) or overweight (17%) with an average body mass index (BMI) of 34.7 kg/m². (Table 1) Of the patients screened, 45% ($n = 121$) were above the prediabetic threshold ($A1C \geq 5.7\%$) and 8% ($n = 22$) were in the range for diabetes ($A1C \geq 6.5\%$). Euglycemia

Table 1 Patient demographics and A1C outcomes

Characteristics	<i>n</i> = 265	Mean A1C ± SD
Age (years; mean ± SD)	45 ± 17.52	
45+ years old (n/%)	140 (53%)	5.92 ± 1.07
< 45 years old (n/%)	125 (47%)	5.55 ± 0.72
Female	185 (70%)	5.70 ± 0.83
Ethnicity		
African American	214 (81%)	5.78 ± 1.00
Caucasian	39 (14%)	5.62 ± 0.60
Hispanic	7 (3%)	5.54 ± 0.53
Other	5 (2%)	5.30 ± 0.50
Weight (kg; mean ± SD)	97.87 ± 28.22	
BMI (kg; mean ± SD)	34.7 ± 9.28	
Morbidly Obese (BMI >40)	67 (25%)	5.83 ± 1.18
Obese (BMI 30–40)	118 (45%)	5.73 ± 0.89
Overweight (BMI 25–29)	44 (17%)	5.78 ± 0.84
Healthy Weight (BMI 18.5–24)	36 (13%)	5.61 ± 0.68
A1C Screening Outcome		
Diabetes (A1C ≥ 6.5%)	22 (8%)	7.92 ± 1.96
Pre-Diabetes (A1C 5.7–6.4%)	99 (37%)	5.91 ± 0.19
Healthy (A1C ≤ 5.6%)	144 (54%)	5.30 ± 0.30
Met ADA Screening Standards	243 (92%)	5.78 ± 0.96
Met USPSTF Screening Standards	127 (48%)	5.89 ± 1.06

(A1C ≤ 5.6%) was present in 54% (*n* = 144) of screened patients. The average A1C values for patients with euglycemia, prediabetes, and diabetes were 5.30%, 5.91%, and 7.92%, respectively. (Table 1).

On average, practitioners selected three rationale for screening per patient. The most commonly documented rationales were overweight status (71%), high-risk ethnicity (58%), and age ≥ 45 years (48%) (Fig. 1). Of these three, only age ≥ 45 years was closely correlated with elevated A1C outcomes (χ^2 11.96, p = 0.005), yet this correlation loses statistical significance when a Bonferroni correction is utilized. However, previous A1C ≥ 5.7% (χ^2 16.02, p < 0.001) and hypertension (χ^2 10.37, p = 0.0013) showed significant correlations with elevated A1C outcomes. Lastly, the retrospective analysis showed that when the POC A1C value fell within the diabetes versus prediabetes range, practitioners were more likely to conduct repeat screenings (77% vs 20%), document an ICD-10 code (91% vs 28%), recommend life style modifications (78% vs 35%), and initiate drug therapy (78% vs 9%) (Table 2). Rescreening confirmed the POC A1C diagnosis of diabetes 67% of the time, most commonly by a venipuncture blood glucose test (*n* = 22, 58%) (Table 2).

Out of the screenings included in the final analysis, 126 (48%) met criteria for both ADA and USPSTF guidelines, 127 (48%) met criteria according only to USPSTF recommendations, 243 (92%) met criteria according only to ADA recommendations, and 17 (6%) met criteria for neither.

Comparison of A1C outcomes influenced by both age and BMI as they relate to ADA versus USPSTF screening recommendations is depicted by the scatterplot in Fig. 2. Following ADA recommendations resulted in higher sensitivity (97% vs. 60%) and negative predictive value (82% vs. 64%), while adherence to USPSTF recommendations conversely exhibited greater specificity (62% vs. 13%) and positive predictive value (57% vs. 48%).

Discussion

Provision of free POC A1C tests allowed for identification of 121 individuals (45% of those screened) with previously unknown chronic hyperglycemia. While 37% had A1C outcomes in the prediabetes range (5.7–6.4%), the remaining 8% with outcomes ≥ 6.5% were critically above the diagnostic threshold with a mean A1C of around 8%. While an A1C elevation of this degree may not precipitate noticeable symptoms in all patients, a value in this range necessitates action to educate patients, recommend behavioral modifications, and to strongly consider initiation of antidiabetic pharmacotherapy following confirmatory testing. However, initiation of behavioral modifications, provision of antidiabetic pharmacotherapy, or both in combination only occurred for 82% of these individuals (Table 2). Furthermore, those in the prediabetes range received such interventions only 35% of the time, suggesting the need to remind clinicians of the impact and importance of counseling on critical lifestyle modifications to prevent or slow progression of prediabetes to diabetes [13].

Collection and assessment of practitioner-reported rationales for screening sheds light on common testing practices. Patient information documented in the EMR demonstrates that practitioners tend to follow ADA guideline recommendations rather than those outlined by USPSTF (Table 1). The most commonly documented rationale for screening (71% overweight, 58% high-risk ethnicity, and 48% age > 45 years) were those that are most easily identifiable by visual inspection upon entering a patient care room. This observation suggests that the primary mechanism for choosing to screen for diabetes relied on patient examination rather than more objective measures found in the EMR, particularly when not otherwise prompted by complaints of hyperglycemic symptoms. Previous A1C ≥ 5.7% (χ^2 16.02, p < 0.001) and documented hypertension (χ^2 10.37, p = 0.0013) are both examples of objective rationales for screening that were significantly correlated to an elevated POC A1C result (Fig. 1), yet these were documented far less often (8% and 32% respectively). Unfortunately, the low frequency of rescreening for those falling within the prediabetic range (20%) is problematic considering that roughly 1 in 10 patients with a recorded A1C of 5.7–6.4% will progress to diabetes within a year's time [14–18]. This observation highlights the need for reminding

Fig. 1 Practitioners' rationale for screening for diabetes by A1C correlated to elevated A1C outcomes. **** Indicates statistically significant ($p < 0.004$ after Bonferroni correction) relationship with positive A1C result ($A1C \geq 5.7\%$)

practitioners of guideline recommendations for annual retesting [4, 12]. Neither the ADA nor the USPSTF guidelines currently recommend screening asymptomatic adults based on the presence of hypertension alone. Interestingly, the 2008 USPSTF diabetes screening recommendation advised that asymptomatic adults with blood pressures $>135/80$ mmHg should be screened for diabetes [19]. Notably, this recommendation was not aimed specifically at improving diabetes care,

but at guiding clinicians toward more aggressive treatment of hypertension and dyslipidemia in the presence of diabetes. Future studies may reevaluate the need to screen for diabetes and prediabetes solely based on presence of other metabolic syndrome components.

One of the most interesting relationships discovered by this study is that between A1C outcomes influenced by both age and BMI as they relate to ADA versus USPSTF screening recommendations. The scatter plot of this data (Fig. 2) shows that the ADA-recommended screening of individuals aged ≥ 45 years and younger individuals with elevated BMI (>25 kg/m²) most comprehensively identified those with elevated A1C outcomes. In fact, use of these criteria alone would have only missed identifying two individuals with prediabetes. Comparatively, while using the USPSTF criteria of overweight individuals ages 40–70 concentrates screening at a significantly vulnerable population, utilization of these criteria alone would have failed to identify numerous individuals that the ADA criteria otherwise identified ($n = 40$ with prediabetes and $n = 9$ with diabetes). While neither set of screening criteria is perfect, following ADA recommendations offers greater sensitivity and negative predictive value compared to USPSTF recommendations. Conversely, adherence to USPSTF recommendations exhibited greater specificity and positive predictive value than those made by the ADA guidelines (Fig. 2).

Table 2 Therapeutic interventions made by practitioners based on A1C outcome

A1C Outcome Range	A1C ≥ 6.5	A1C 5.7–6.4	Total
	$n = 22$	$n = 99$	$n = 121$
Drug Therapy Only	1 (5%)	0 (0%)	1 (1%)
Lifestyle Modifications Only	1 (5%)	26 (26%)	27 (22%)
Both Lifestyle & Drug Therapy	16 (73%)	9 (9%)	25 (21%)
No Intervention	4 (18%)	64 (65%)	68 (56%)
ICD 10 Code	20 (91%)	28 (28%)	48 (40%)
Repeated Screening	18 (77%)	20 (21%)	38 (31%)
Tested by A1C POC	2 (11)	4 (20)	6 (16)
Tested by A1C Venipuncture	5 (28)	5 (25)	10 (26)
Tested by Blood Glucose	11 (61)	11 (55)	22 (58)
Within Appropriate Time	12	19	31
Outcome Confirmed Dx	12	10	22

Fig. 2 Sensitivity and predictive value of ADA vs. USPSTF recommendations. Scatter plot of A1C outcomes by age and BMI. ADA screening recommendations (solid gray lines): adults age 45 year or older and younger adults with BMI > 25 with risk factors displayed 97% sensitivity, 13% specificity, 48% positive predictive value, and 82%

negative predictive value. USPSTF screening recommendations (dashed lines): adults ages 40 to 70 who are overweight or obese displayed 60% sensitivity, 62% specificity, 57% positive predictive value, 64% negative predictive value

The lack of simultaneous high-sensitivity/high-specificity detection through adherence to either set of recommendations further justifies the importance of confirmatory rescreening, which was conducted reasonably often (77%) for those falling within the diabetes range after POC A1C testing in this study. Around two-thirds (67%) of these patients were confirmed to have diabetes upon rescreening with venipuncture, thus use of a POC A1C test necessitates a secondary method for diagnosis confirmation for obvious reasons. However, the test still optimizes convenience through its ease of use and could potentially bolster improvement of patient health outcomes by increasing the number of patients willing to be screened while simultaneously detecting T2DM at an earlier stage than FBG testing alone. Of note, the ADA does not currently recommend use of POC A1C testing alone for diagnostic purposes [4].

Concerns remain prevalent in regard to unwarranted diabetes screenings in the asymptomatic adult population. Past and present USPSTF recommendations note that diabetes screening by blood sugar may cause short-term anxiety in some people but does not instill long-term psychological harm inferentially due to rapid availability of screening results. While the USPSTF

does not explicitly define “short-term,” this terminology is likely reflective of the two to 3-day wait time for other diagnostic test results following venipuncture. Additionally, the USPSTF’s statement on harms associated with early detection and treatment further explains that lifestyle changes made as a result of screening test outcomes inflict no harm. Lastly, USPSTF articulates that the risks of drug therapy for prevention of diabetes are small to moderate, but this is dependent on the drug and dosage used [12]. Therefore, it seems reasonable to conclude that 1) screening for diabetes even in the face of false positives results in no harm, but may in fact positively influence patient health outcomes by encouraging implementation of healthy lifestyle modifications and 2) screening for diabetes using a POC A1C test may reduce development of short-term anxiety related to longer wait times associated with venipuncture test analysis.

Finally, diagnostic and therapeutic actions taken by practitioners were much more frequent when POC A1C values were elevated above 6.5%. The higher frequency of repeat screening between the two groups was expected due to the ADA recommendation for immediate retesting to confirm diabetes or to assess disease

progression annually in those with prediabetes. Interestingly, 91% of patients with an A1C outcome $\geq 6.5\%$ had an ICD-10 code for diabetes documented, suggesting that either their A1C was accompanied by unequivocal hyperglycemia (random BG >200 mg/dL and symptoms of hyperglycemia) or that a secondary screening (77%) confirmed results of the POC A1C test. These observations help validate the utility of POC A1C tests used for screening purposes, but it should be noted again that the ADA currently recommends against the use of POC A1C testing for diagnostic purposes even if the test itself is NGSP certified due to the lack of mandates for proficiency testing with these devices [4].

Many participants meeting A1C thresholds for diabetes (82%) were counseled on lifestyle modifications, initiated on antidiabetic pharmacotherapy, or a combination of both, further confirming the impact of POC A1C testing. However, the most alarming observation made was the low rate of therapeutic interventions for those with A1C outcomes in the prediabetes range. The majority of these patients (65%) were not provided any education or medication to help prevent or slow disease progression. This troublesome data highlights the importance of reminding practitioners of the remarkable benefits achieved through a healthy diet, physical activity, and weight loss to help slow advancement from prediabetes to diabetes.

Strengths and limitations

The correlation of practitioner rationale to A1C outcomes has been lacking in the literature until now, and this remains perhaps the greatest strength of our findings. While our study correlates A1C outcomes to practitioner-directed therapeutic interventions for glycemic control, it does not evaluate if new diabetes diagnoses impacted other therapeutic interventions for more stringent control of blood pressure or cholesterol as encouraged by previous USPSTF recommendations. As an example, a diabetes diagnosis potentially alters therapeutic goals for blood pressure and atherosclerotic cardiovascular disease risk reduction, resulting in more intensive antihypertensive or statin therapies [20, 21]. Investigation into how diagnosis of one component of the metabolic syndrome influences a practitioner's adjustment in care for other comorbidities would potentially strengthen the anticipated impact of diabetes screenings in the face of compounded risk for development of cardiovascular disease. The present study documents the variability of unknown chronic hyperglycemia in a predominately obese, African American population and articulates practitioner rationale for conducting diabetes screenings. However, evaluation of a more diverse

patient/practitioner population would strengthen recommendations for improving screening practices and appropriate interventions. Lastly, we did not predefine age limits for exclusion from this study, and 6 of the 99 participants falling within the pre-diabetes range were under the age of 18. In these patients, maturity onset diabetes of the young (MODY) or type 1 diabetes mellitus (T1DM) may have been the underlying cause of unknown chronic hyperglycemia and could have accordingly influenced practitioner strategies for disease state management (i.e. referral to endocrinologist). However, even with exclusion of these patients from the dataset, a majority of pre-diabetic participants still received no therapeutic intervention.

Concluding remarks and future directions

Overall, this study presents three key takeaways that could directly influence patient care. Firstly, practitioner rationales for conducting diabetes screenings closely align with ADA recommendations and rely on largely visual criteria such as elevated BMI, at-risk race, and advanced age. However, the only statistically significant correlates to the presence of diabetes or prediabetes in this population are hypertension and a previous A1C of $\geq 5.7\%$. This observation indicates that comorbidities like hypertension may warrant precedence over other risk factors in future rationale, especially considering how presence of multiple metabolic syndrome components compounds lifetime risk for cardiovascular morbidity and mortality. Secondly, A1C values falling within the prediabetes range of 5.7–6.4% garnered alarmingly low attention, indicating a significant need for education of practitioners on the risks of unaddressed prediabetic status. Lastly, diabetes screening using POC A1C tests with subsequent confirmatory testing is an efficient and reasonable method of risk assessment and diagnosis in this population. This form of diabetes screening offers low temporal, physical, and psychological burdens, and its utilization should be further assessed in larger populations to encourage widespread standardization and implementation. In the future, we hope that the POC A1C test will become the gold-standard for diabetes screening and diagnosis due to its obvious benefits. However, this must be preceded by development of mandates for proficiency assessments to overcome the ADA's hesitancy for diagnostic use of POC A1C tests. Future studies could be designed to develop a widespread proficiency assessment which addresses multiple components of POC testing and relates variability in performance to variability in diagnostic accuracy. Finally, future research should also assess practitioner rationale and patient outcomes in a more diverse population, as well as practitioner-guided adjustments to treatments for other comorbidities in the face of newly diagnosed diabetes.

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Compliance with ethical standards

Conflict of interest The author state that they have no conflict of interest and have nothing to declare.

Ethical approval The study was approved by Baptist Health System Investigational Review Committee and Auburn University's Investigational Review Board.

Informed consent An information letter was used as a waiver of documentation of consent for all healthcare providers participating in the study according to the guidelines of the Institutional Review Board for Human Studies at Auburn University.

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