ORIGINAL RESEARCH

Survey of primary care providers' knowledge of screening for, diagnosing and managing prediabetes

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BACKGROUND: Prediabetes affects 86 million US adults, but primary care providers' (PCPs') knowledge, practices, attitudes and beliefs toward prediabetes are unclear.

OBJECTIVE: Assess PCPs' (1) knowledge of risk factors that should prompt prediabetes screening, laboratory criteria for diagnosing prediabetes and guidelines for management of prediabetes; (2) management practices around prediabetes; (3) attitudes and beliefs about prediabetes.

DESIGN: Self-administered written survey of PCPs.

PARTICIPANTS: One hundred forty of 155 PCPs (90%) attending an annual provider retreat for academically affiliated multispecialty practices in the mid-Atlantic region.

MAIN MEASURES: Descriptive analyses of survey questions on knowledge, management, and attitudes and beliefs related to prediabetes. Multivariate logistic regression was used to determine the association between provider characteristics (gender, race/ethnicity, years since training, specialty and provider type) and knowledge, management, and attitudes and beliefs about prediabetes.

KEY RESULTS: Six percent of PCPs correctly identified all of the risk factors that should prompt prediabetes screening. Only 17% of PCPs correctly identified the laboratory parameters for diagnosing prediabetes based on both fasting glucose and hemoglobin A1c. Nearly 90% of PCPs reported close follow-up (within 6 months) of patients with prediabetes. Few PCPs (11%) selected referral to a behavioral weight loss program as the recommended initial management approach to prediabetes. PCPs agreed that patient-related factors are important barriers to lifestyle change and metformin use. Provider characteristics were generally not associated with knowledge, management, attitudes and beliefs about prediabetes in multivariate analyses.

CONCLUSIONS: Addressing gaps in knowledge and the underutilization of behavioral weight loss programs in

prediabetes are two essential areas where PCPs could take a lead in curbing the diabetes epidemic.

INTRODUCTION

Eighty-six million US adults have prediabetes, a major public health issue that the Centers for Disease Control (CDC) has addressed through a screening campaign for prediabetes.[1, 2] Diagnosing prediabetes is important for diabetes prevention since an estimated 70% of individuals with prediabetes will eventually develop diabetes.[3] Prediabetes is diagnosed based on laboratory tests: fasting glucose, 100-125 mg/dl; hemoglobin A1c, 5.7–6.4%; or 2-h post-stimulation glucose, 140–199 mg/dl.[4] Prediabetes is associated with premature mortality[5, 6] and increased risk of autonomic neuropathy and idiopathic polyneuropathy.[3] Behavioral lifestyle interventions are effective in preventing the development of diabetes.[7, 8] In the Diabetes Prevention Program (DPP) clinical trial, there was a reduction in diabetes incidence of 27% with lifestyle intervention and 18% with metformin compared to placebo over a mean follow-up of 15 years.[9] Based on the DPP, the American Diabetes Association (ADA) recommends an intensive diet and physical activity behavioral counseling program for all patients with prediabetes and suggests that metformin be considered in patients with additional risk factors (BMI $\geq$35 kg/m^2, age <60, history of gestational diabetes or rising hemoglobin A1c despite lifestyle intervention).[10] The Affordable Care Act authorized the establishment of the CDC National Diabetes Prevention Program (NDPP), a lifestyle change program, which targets 5–7% body weight loss and 150 min per week of moderate intensity physical activity.[11]

Despite the success of preventive interventions, evidence suggests that 90% of individuals with prediabetes are unaware of their diagnosis.[11] Furthermore, most patients with prediabetes are not receiving the evidence-based recommendations from their providers for prevention, especially specific

counseling and referral for lifestyle modification.[12–15] To our knowledge, there is no prior literature on why prediabetes is not being diagnosed by providers; therefore, we sought to understand the factors involved by surveying providers.

Understanding primary care providers' (PCPs') knowledge about screening and diagnosing prediabetes is important for informing and improving screening and referral rates to effective interventions. To improve the care of patients with prediabetes, we must also understand how PCPs are managing these patients and what the perceived barriers are in treating these patients. We conducted a survey among PCPs to assess (1) knowledge of risk factors that should prompt prediabetes screening, laboratory criteria for diagnosing prediabetes, and guidelines on recommended therapy for prediabetes; (2) management practices for prediabetes; and (3) attitude and beliefs regarding prediabetes and its management (lifestyle modification and metformin). We evaluated provider characteristics associated with these domains to understand potential determinants of knowledge, current practices, and attitudes and beliefs.

METHODS

Setting and survey design

We surveyed PCPs from multispecialty practices affiliated with one academic system that served over 244,000 patients in 2015 at 40 practice sites across the mid-Atlantic region. These practices employ a total of 166 PCPs, including physicians, nurse practitioners and physician assistants. The patient population is diverse: patients are 28% African American, 5% Asian and 5% Hispanic. Insurance coverage varies (62% commercial, 15% Tricare/other government programs, 11% Medicaid, 9% Medicare). At the time of survey administration, these practices did not have behavioral weight loss programs available (i.e., DPP).

The survey domains were designed based on clinical experience, existing literature and input from practice leaders. We conducted a pretest of the written survey among a small group of primary care providers (n = 15) and refined the instrument to enhance the clarity and interpretability of the questions. We distributed the survey to PCPs from the practices at their annual provider retreat in 2015. The 156 adult PCPs who attended the meeting were invited to participate in the survey on-site. Participants received a $10 gift card.

Survey instrument

We designed the survey to evaluate: (1) knowledge of risk factors that should prompt prediabetes screening, laboratory criteria for diagnosing prediabetes and guidelines on recommended therapy for prediabetes; (2) management practices around prediabetes; and (3) attitude and beliefs regarding prediabetes and its management (see Online). The ADA and American Association of Clinical Endocrinologists (AACE) have screening and management guidelines for prediabetes, whereas the US Preventive Services Task Force (USPSTF) has only screening guidelines, and the American College of Physicians (ACP) has neither.[10, 16] We used the ADA guidelines for this survey because the AACE guidelines target endocrinologists.

Risk factors for prediabetes screening. Providers were given a list of potential risk factors and asked to select which ones might prompt them to screen for prediabetes. These risk factors are defined by the ADA as ones to consider for prediabetes screening among adults who are overweight.[4] Providers were also asked to select which guidelines they use for prediabetes screening.

Laboratory criteria for diagnosing prediabetes. Providers were asked to circle the numerical values corresponding to the upper and lower limits of the laboratory criteria for diagnosing prediabetes based on fasting glucose (answer range 70–160 mg/dl in 2 mg/dl increments) and HbA1c (answer range 5–7% in 0.1% increments).

Guideline recommendations for treatment of prediabetes. Providers were asked to circle the values corresponding to the ADA recommendations for minimum weight loss (% of body weight) and minimum physical activity (minutes per week) for patients with prediabetes. Providers were also asked to identify the "best (recommended) initial management approach" to a patient with prediabetes (Online).

Management practices for prediabetes. Providers were asked about their use of prediabetes screening tests (non-fasting glucose, fasting glucose, 2-h oral glucose tolerance test and/or HbA1c), initial management approach (including metformin use), and intervals for repeat laboratory work and follow-up visits. Finally, we assessed whether the ADA guidelines for prediabetes have been helpful for managing patients with prediabetes.

Attitudes and beliefs about prediabetes and management of prediabetes. To evaluate attitudes and beliefs regarding prediabetes, we used a 5-point Likert scale (strongly agree to strongly disagree) to assess whether providers believe it is important to identify prediabetes and whether they believe that lifestyle modification and metformin can reduce the risk of progression to diabetes.

Additionally, we used a similar 5-point Likert scale to evaluate what providers perceive as patient barriers to lifestyle modification and metformin use (Table 2). As follow-up to the above questions, we presented several possible interventions for improving the management and treatment of prediabetes and asked providers whether they agreed that these would be helpful (Table 2).

Provider characteristics. We asked about provider training (internal medicine, internal medicine-pediatrics or family medicine), provider type (physician, nurse practitioner or

physician assistant), number of years since completing residency or clinical training, gender and race/ethnicity.

Statistical analysis

Survey data were entered and managed using Microsoft Access (2013). We conducted descriptive analyses to quantify responses to survey questions related to the outcomes (knowledge, management practices, and attitudes and beliefs related to prediabetes). We used multivariate logistic regression to determine the association between provider characteristics and these outcomes. In the multivariate model, provider characteristics (gender, race, number of years since training completed, specialty and provider type) were added simultaneously with a separate model for each outcome. For questions with a Likert scale, we dichotomized the answers by combining agree and strongly agree vs. neutral, disagree and strongly disagree. We estimated the adjusted percentage for each model using the *margins* command in STATA. Analyses were conducted using STATA 13.0 (College Station, TX). This study was exempted by the Johns Hopkins University School of Medicine Institutional Review Board.

RESULTS

Of 156 adult PCP attendees, 140 (90% of attendees) completed the survey (84% of all PCPs in the practice). The majority of respondents were physicians (93%) who were trained in internal medicine (43%), family medicine (40%) or internal medicine-pediatrics (15%) (Table 1). Providers were mostly female (72%), white (55%), Asian (23%) or African American (14%) and had been in practice for at least 10 years (59%).

Based on internal data from practice leaders, survey respondents ($n = 140$) were comparable to the 166 providers of the

Table 1 Demographics of survey respondents (total *n* = 140)
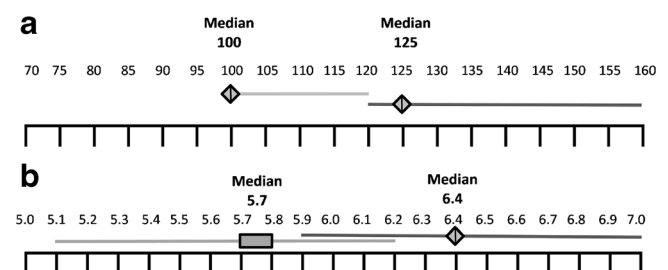
Provider characteristics	N (%)
Specialty*	
Family medicine	57 (40.4)
Internal medicine	61 (43.3)
Internal medicine-pediatrics	21 (14.9)
Provider type	
Physician	130 (92.9)
Nurse practitioner	9 (6.4)
Physician assistant	1 (0.7)
Number of years since completing training†	
<5 years	24 (17.1)
5–10 years	33 (23.6)
10+ years	83 (59.3)
Gender‡	
Female	99 (72.3)
Race/ethnicity§	
Asian	31 (23.0)
Black	19 (14.1)
Hispanic or Latino	2 (1.5)
White	74 (54.8)
Other or mixed	9 (6.6)

*n = 137
†n = 139
‡n = 136
§n = 135

practice within the selected specialties in gender and specialty. However, survey respondents were more likely to self-report Asian ethnicity (23% vs. 10%).

Risk factors for prediabetes screening

On average, providers selected 8 out of the 11 correct risk factors for prediabetes screening (Online Fig.). Thirty-nine percent of providers identified all of the traditional or "medical" risk factors (age ≥45, BMI ≥25 kg/m², hypertension, dyslipidemia, heart disease, family history of diabetes, sedentary lifestyle, history of gestational diabetes). Six percent of providers correctly identified all 11 of the risk factors for prediabetes screening (Online Fig.). The most commonly identified risk factors were family history of diabetes (94%), overweight (89%), history of gestational diabetes (87%), dyslipidemia (86%), hypertension (77%) and history of heart disease (75%). The least-commonly identified risk factors were Hispanic ethnicity (52%) and Asian race (38%). Asian providers were more likely to correctly identify Asian race as a risk factor compared to white providers (adjusted percentage, 66% vs. 31%, $p = 0.008$).

Nearly 20% of providers did not favor any specific guideline for prediabetes screening. The remainder reported using the ADA (63%), USPSTF (30%) and AACE (5%) guidelines.

Laboratory criteria for diagnosing prediabetes

Only 17% of providers correctly identified the laboratory parameters for diagnosing prediabetes based on both fasting glucose and HbA1c. We found a range in the distribution of answers selected (Fig. 1). In the multivariate model, family medicine and medicine-pediatrics providers picked the correct HbA1c criteria for prediabetes more often than internal medicine providers (adjusted percentage, 20%, 43% and 12%, respectively, $p = 0.02$) (Online Table 1).

Guideline recommendations for treatment of prediabetes

One-quarter of providers selected values between 5 and 7% as the minimum amount of weight loss recommended for

Fig. 1 Selected range of upper and lower limits of diagnostic criteria for prediabetes by PCPs based on (a) fasting glucose (mg/dl) ($n = 74$) and (b) hemoglobin A1c (%) ($n = 69$). Note. Lines and rectangles/diamonds represent range and interquartile range of selected values, respectively. The diamonds are used when the interquartile range was one value

patients with prediabetes (ADA guidelines recommend 7% of body weight and the CDC NDPP recommends 5–7%).[10, 11] Nearly 30% answered "Do not know." Fewer than half of providers (45%) chose 150 min per week as the recommended minimum amount of physical activity. When asked to identify the "best (recommended) initial management approach" to a patient with prediabetes, the majority (96%) selected counseling on diet and physical activity, and only 11% selected referral to a behavioral weight loss program (Table 2). We did not find a significant association between provider characteristics and knowledge of guideline recommendations for the treatment of prediabetes (Online Tables 2 and 3).

Management practices for prediabetes

Providers most commonly use fasting blood glucose (90%) and HbA1c (89%) for prediabetes screening. When considering their current clinic resources, providers identified counseling on diet and physical activity (99%) as their initial management strategy for patients with prediabetes (Table 2). Only 12% of providers selected referral to a behavioral weight loss program as their initial management in actual practice. For repeat laboratory work and follow-up visits, 88% of providers selected between 3 and 6 months for both questions (Table 2).

Metformin use for prediabetes was uncommon; 25% of providers never prescribed metformin (Table 2), 36% prescribed it for 5% or less of their patients, while 26% prescribed it for up to 25% of their patients. Providers were more likely to prescribe metformin if the patient's BMI was ≥35 kg/m^2 (58%), HbA1c was ≥6% (51%) and/or the patient did not respond to lifestyle change (63%). Sixteen percent of providers did not believe in prescribing metformin for patients with prediabetes. Provider characteristics were not associated with metformin use.

Forty-two percent of providers found the ADA guidelines on prediabetes helpful in management, and 30% of providers were unfamiliar with them.

Attitudes and beliefs about prediabetes and management of prediabetes

The majority of providers agreed or strongly agreed that diagnosing prediabetes is important for managing their patients' health (96%) and determining whether to treat comorbid conditions (85%) or elevated blood sugars (87%) (Table 2). Providers also agreed (86%) that patients with prediabetes progress to diabetes more quickly than those with normoglycemia and that lifestyle modification reduces that progression (96%). Fewer providers (78%) agreed that metformin can do the same. Post-hoc analyses showed that those who disagreed or were neutral about metformin's ability to reduce the progression from prediabetes to diabetes were more likely not to prescribe metformin (adjusted percentage, 61% vs. 23%, p = 0.02).

Most providers selected lack of motivation (91%), patients' physical limitations in doing activity (73%), and lack of weight or nutrition resources (65–71%) as barriers to lifestyle

Table 2 Reported knowledge, practice, and barriers and interventions for prediabetes

Knowledge	N (%)
Correct identification of diabetes laboratory criteria (fasting glucose)	94 (67.6)
Correct identification of diabetes laboratory criteria (HbA1c)	97 (69.8)
Correct identification of prediabetes laboratory criteria (fasting glucose)	58 (41.1)
Correct identification of prediabetes laboratory criteria (HbA1c)	30 (21.3)
Correct body weight loss recommendation of 5.7%	30 (21.9)
Correct physical activity recommendation of 150 min/week	64 (45.4)
Correct initial management recommendation of referral to behavioral weight loss program	16 (11.3)
Practice	
Initial management approach*	
Counseling on diet changes and physical activity	139 (98.6)
Refer to nutritionist	45 (31.9)
Refer to behavioral weight loss program	17 (12.1)
Discuss starting metformin	41 (29.1)
Refer to bariatric surgery	3 (2.1)
Repeat laboratory work	
3 months	56 (39.7)
6 months	67 (47.5)
1 year	14 (9.9)
2 years	0
No specific recommendation	1 (0.7)
Return for follow-up clinic visit	
3 months	68 (48.2)
6 months	56 (39.7)
1 year	7 (5.0)
2 years	0
No specific recommendation	3 (2.1)
% Patients with prediabetes you have prescribed metformin	
0%	34 (24.5)
1–5%	50 (36.0)
>5–25%	36 (25.9)
>25–50%	8 (5.8)
>50–75%	8 (5.8)
>75%	3 (2.2)
Barriers to lifestyle modification (strongly agree and agree)	
Patient's lack of motivation	127 (90.7)
Patient's physical limitation in doing activity	103 (73.5)
Lack of weight loss resources for patient	91 (65.0)
Lack nutrition resources for patient	97 (70.8)
Patients do not think it is important to make these changes	95 (67.9)
Financial limitations	78 (55.7)
Barriers to metformin use (strongly agree and agree)	
Patients dislike taking medications	122 (89.1)
Medication cost to patient	59 (43.7)
Poor patient adherence	95 (69.9)
Potential side effects	109 (80.7)
Providers' lack of awareness of clinical guidelines for metformin use	92 (68.1)
Lack of FDA approval for metformin use in prediabetes	43 (32.1)
Intervention to improve management of prediabetes (strongly agree and agree)	
More time for doctors to counsel patients	119 (84.8)
More educational resources for patients	123 (87.9)
Improved access to diabetes preventive programs	134 (95.7)
Improved nutrition resources for patients	132 (94.3)
Improved access to weight loss programs	127 (90.7)
Improved access to bariatric surgery	50 (35.7)

Adds up to >100% because more than one answer could be selected

modification (Table 2). Regarding interventions for improving prediabetes management, PCPs reported that more time for counseling (85%), more educational resources for patients (88%), improved nutrition resources (94%) and access to DPPs (96%) and weight loss programs (91%) would be helpful (Table 2).

For barriers to metformin use in prediabetes, providers selected patients' dislike of taking medications (89%), potential side effects (81%) and anticipated poor adherence (70%) as influential factors (Table 2). In contrast, medication cost (43%) and lack of FDA approval for metformin use in prediabetes (32%) were not common barriers.

DISCUSSION

In this study, we found important gaps in PCP knowledge of risk factors (i.e., Asian race and Hispanic ethnicity), diagnostic criteria and evidence-based recommendations for prediabetes. PCPs follow their patients with prediabetes closely but infrequently recommend behavioral weight loss programs or metformin. PCPs believe that patient-related factors are important barriers to managing prediabetes, and their own perceptions of the harms and benefits of metformin may be limiting its use. Although provider type was associated with knowledge of certain diagnostic criteria, most provider characteristics were not associated with knowledge of guideline recommendations for prediabetes. Asian providers were more likely to correctly identify Asian race as a risk factor compared to white providers; in a prior study, Chinese patients whose family physicians were also Chinese were more likely to receive recommended diabetes care compared to patients without race-concordant providers.[17]

Prior literature on the current practices of PCPs regarding prediabetes screening, diagnosis or management is sparse. Prior studies used electronic health data and administrative claims data to examine practices in prediabetes care but were not specific to PCPs.[14, 15] We describe PCP knowledge around prediabetes for the first time. The clinical implications from providers' under- or over-estimation of laboratory diagnostic parameters are unclear. However, given that nine out of ten people with prediabetes are unaware of the diagnosis,[2] our work supports that low provider knowledge about risk factors and diagnostic criteria may be contributing.

In our survey, PCPs reported following their patients with prediabetes closely with nearly all providing counseling on lifestyle change. However, PCPs had incomplete knowledge of evidence-based ADA recommendations[10] for specific lifestyle changes (e.g., weight loss and activity goals) to prevent diabetes. Similarly, a prior study that found only a quarter of patients with prediabetes reported receiving recommendations for lifestyle modification.[13] Since 2003, the ADA guidelines for prediabetes have focused on lifestyle modification for prediabetes, and recommendations for metformin use were added in 2007.[18] In our survey, nearly a third of providers reported unfamiliarity with the ADA guidelines for prediabetes;

addressing this lack of awareness may improve delivery of evidence-based care for prediabetes. Notably, key professional organizations for PCPs (e.g., ACP and American Academy of Family Physicians) do not have practice guidelines related to prediabetes; this may contribute to what PCPs know about prediabetes and their perspectives on its importance. Consensus guidelines by the professional homes of PCPs may help improve the identification and management of prediabetes.

Other factors may influence providers' adherence to screening and management guidelines for prediabetes, including inertia of previous practice,[19] low self-efficacy due to a lack of confidence in one's ability, and lack of outcome expectancy (i.e., expectation that a given recommendation will not lead to an improved outcome).[19] Other barriers include time constraints, limited staffing resources, and clinician skepticism and knowledge of guidelines.[20] At the system and practice level, facilitators for adherence to guidelines include engaging stakeholders, leadership support and clinical decision support.[20, 21] Economic incentives may be helpful although prior literature shows mixed results.[22]

Behavioral weight loss programs are very effective at preventing or delaying diabetes onset (8, 23 24), but PCPs infrequently recommend such programs to patients with prediabetes; understanding reasons for this beyond knowledge gaps (e.g., lack of accessibility, lack of insurance coverage) is important. In terms of accessibility, the CDC is partnering with private and public organizations through the NDPP to provide resources and set standards for program recognition.[11] Currently, there are approximately 1300 DPPs across the US that are recognized or applying for CDC recognition.[11] Coverage of the DPP by Medicare[25] and other commercial insurers is expected.

As expected, metformin use for prediabetes appeared low but was reported as higher than in prior studies using claims[15] or patient self-report.[26] A quarter of providers did not believe that metformin reduces the risk of diabetes in patients with prediabetes. This disagreement may represent some providers' belief that treating prediabetes with metformin is similar to treating patients early in the diabetes spectrum and may not reduce the risk of diabetes. In the DPP Outcomes Study, while persons on lifestyle or metformin treatment who did not develop diabetes had a lower risk of microvascular complications than those who did develop diabetes, data are still lacking on macrovascular complications.[9] In a recent study of family physicians, respondents with a more negative attitude toward prediabetes were less likely to recommend metformin.[27]

PCPs identified patients' lack of motivation as the biggest barrier to lifestyle modification and patient-related factors, including dislike of taking medications and poor adherence, as barriers to metformin use. Some providers perceived the cost of metformin as a barrier, but metformin is inexpensive. In the family physicians survey, providers similarly felt that patient motivation and their ability to make lifestyle change were significant barriers to prediabetes care.[27] Therefore, understanding patients' perspectives and preferences will be key to effectively managing prediabetes.

Several limitations to our study deserve mention. First, this survey was conducted among providers from multi-specialty practices associated with a single academic medical center so findings may not be generalizable. However, the clinic sites are located in both the community/suburbs and city (Baltimore City and Washington, DC). Second, there may be recall bias (unmotivated misreporting) regarding provider practices. Third, social desirability bias (motivated misreporting in a socially desirable direction) may be problematic, particularly when reporting attitudes and barriers. This bias could have led to more respondents agreeing that prediabetes is an important condition to identify when they do not feel this way. The strengths of our study include a high response rate (90%), a comprehensive, detailed survey and, to our knowledge, the first data on PCPs' knowledge around prediabetes.

One in three Americans are at risk of developing diabetes, and this number continues to rise. In our sample, PCPs had substantial gaps in knowledge about prediabetes that need to be addressed for interventions, such as the CDC prediabetes screening and prevention campaign,[1] to be successful. Educating providers on screening guidelines, diagnostic criteria and management options will be the important first step to filling these gaps. The role of professional societies in improving knowledge and addressing attitudes cannot be underestimated. Systems changes to support provider behavior are also important. Despite substantial evidence for the effectiveness of DPPs, they remain underutilized. Reasons for this are likely complex and warrant further investigation. Expanding insurance coverage and the availability of these high quality, comprehensive programs are essential. With these changes, PCPs are optimally positioned to take a lead in curbing the diabetes epidemic.

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