Published in final edited form as:
Am J Prev Med. 2023 June ; 64(6): 814–823. doi:10.1016/j.amepre.2023.01.007.

Screening for Prediabetes and Diabetes: Clinical Performance and Implications for Health Equity

Matthew J. O'Brien, MD, MSc[1,2,3,4], **Yan Zhang, MPH, MS**[5], **Stacy C. Bailey, PhD, MPH**[1,2], **Sadiya S. Khan, MD, MSc**[4,6], **Ronald T. Ackermann, MD, MPH**[1,2,3], **Mohammed K. Ali, MD, MSc**[5,7,8], **Stephen R. Benoit, MD, MPH**[5], **Giuseppina Imperatore, MD, PhD**[5], **Christopher S. Holliday, MPH, PhD**[5], **Kai McKeever Bullard, PhD, MPH**[5]

[1]Division of General Internal Medicine and Geriatrics, Department of Medicine, Northwestern University Feinberg School of Medicine, Chicago, IL

[2]Institute for Public Health and Medicine, Northwestern University Feinberg School of Medicine, Chicago, IL

[3]Chicago Center for Diabetes Translation Research, Northwestern University Feinberg School of Medicine and University of Chicago Pritzker School of Medicine, Chicago, IL

[4]Department of Preventive Medicine, Northwestern University Feinberg School of Medicine, Chicago, IL

[5]Division of Diabetes Translation, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, GA

[6]Division of Cardiology, Department of Medicine, Northwestern University Feinberg School of Medicine, Chicago, IL

[7]Hubert Department of Global Health, Rollins School of Public Health, Emory University

[8]Department of Family and Preventive Medicine, School of Medicine, Emory University, Atlanta, GA

Abstract

INTRODUCTION: In 2021, the U.S. Preventive Services Task Force (USPSTF) recommended prediabetes and diabetes screening for asymptomatic adults aged 35-70 years with overweight/obesity, lowering the age from 40 in its 2015 recommendation. USPSTF suggested considering earlier screening in racial and ethnic groups with high diabetes risk at younger ages or lower body mass index (BMI). The current study examined the clinical performance of these USPSTF

CORRESPONDING AUTHOR: Matthew J. O'Brien, MD, MSc / Northwestern University Center for Community Health / 750 N. Lake Shore Drive, 6th Floor / Chicago, IL 60611, matthew.obrien1@northwestern.edu / P: 312-503-5046 / F: 312-503-3350.

Author Contributions: Dr. Bullard had full access to all of the study data and takes responsibility for the integrity of the data and the accuracy of the data analysis. Drs. O'Brien and Bullard and Ms. Zhang contributed to the study concept and design. All authors contributed to the acquisition, analysis or interpretation of data. Dr. O'Brien drafted the manuscript. All authors contributed critical revisions of the manuscript for important intellectual content. Ms. Zhang and Dr. Bullard performed statistical analyses. Drs. Ackermann and O'Brien obtained funding. Dr. Bullard provided supervision.

screening recommendations, as well as alternative age and BMI cutoffs, in the U.S. adult population overall and separately by race and ethnicity.

METHODS: Nationally representative data were collected from 3,243 non-pregnant adults without diagnosed diabetes in January 2017-March 2020 and analyzed from 2021-2022. Screening eligibility was based on age and measured BMI. Collectively, prediabetes and undiagnosed diabetes were defined by fasting plasma glucose ≥100mg/dL or hemoglobin A_{1c} ≥5.7%. The sensitivity, specificity and predictive values of alternate screening criteria were examined overall, and by race and ethnicity.

RESULTS: Compared with 2015 criteria, the 2021 criteria exhibited marginally higher sensitivity [58.6% (95% CI: 55.5-61.6) vs. 52.9% (49.7-56.0)] and lower specificity [69.3% (65.7-72.2) vs. 76.4% (73.3-79.2)] overall, and within each racial and ethnic group. Screening at lower age and BMI thresholds resulted in even greater sensitivity and lower specificity, especially among Hispanic, non-Hispanic Black, and Asian adults. Screening all adults aged 35-70 regardless of BMI yielded the most equitable performance across all racial and ethnic groups.

CONCLUSIONS: The 2021 USPSTF screening criteria will identify more adults with prediabetes and diabetes in all racial and ethnic groups than the 2015 criteria. Screening all 35-70 year-old adults exhibited even higher sensitivity and performed most similarly by race and ethnicity, which may further improve early detection of prediabetes and diabetes in diverse populations.

INTRODUCTION

Approximately half of U.S. adults have type 2 diabetes (hereafter, diabetes) or prediabetes, representing a major public health concern.[1] Overall, 81% of adults with prediabetes are not aware of having the condition and 23% of diabetes cases remain undiagnosed.[1] Screening for prediabetes and diabetes is the primary method for detecting these conditions and enabling early intervention or treatment, which is associated with improved clinical outcomes.[2–4]

Certain racial and ethnic groups experience a disproportionate burden of diabetes, with a nearly two-fold higher prevalence among Hispanic, non-Hispanic Black (hereafter, Black), and non-Hispanic Asian (hereafter, Asian) adults compared with non-Hispanic White (hereafter, White) individuals,[5] as well as higher rates of poor glycemic control, complications, and diabetes-related mortality.[6–10] There is evidence that Black and Hispanic adults develop diabetes at younger ages than White individuals.[11,12] Asian Americans, as well as Hispanic and Black individuals, exhibit high diabetes risk at lower levels of body mass index (BMI).[13–15] These findings have implications for prediabetes and diabetes screening in the same racial and ethnic groups, where earlier detection could accelerate evidence-based care and improve outcomes, thereby promoting health equity.

In 2021, the United States Preventive Services Task Force (USPSTF) recommended screening for prediabetes and diabetes among asymptomatic adults aged 35-70 years with overweight or obesity, defined by BMI ≥25kg/m^2.[16] This guideline lowered the screening age from 40 years in the 2015 USPSTF recommendation,[17] a change that expands eligibility from 36.3% to 43.0% of U.S. adults.[18] The current USPSTF recommendation also suggests that clinicians consider screening at a lower BMI or at even younger ages among racial and ethnic minority groups. There are tradeoffs associated with any age or BMI threshold chosen, resulting in some individuals with prediabetes or undiagnosed diabetes who will not be eligible for screening, and others without either condition who will be eligible. These tradeoffs, evaluated by comparing the sensitivity, specificity, and predictive values of alternate screening criteria, represent critical data needed by clinicians and other stakeholders that have not been examined previously.

These clinical performance characteristics of the 2015 and 2021 USPSTF screening criteria were compared in a nationally representative sample of U.S. adults, stratifying by race and ethnicity to examine health equity implications of the recent guideline change. To explore fully the potential of the current recommendation to promote health equity, the authors also examined lowering thresholds for age and BMI suggested by USPSTF to promote early detection of prediabetes and diabetes among racial and ethnic minority groups. Screening performance was estimated separately based on age 30-70 years and 18-70 years, as well as BMI ≥23kg/m^2 and any BMI.

METHODS

Study Sample

The data source was the National Health and Nutrition Examination Surveys (NHANES) from January 2017-March 2020, with a response rate of 46.9%.[19] All examined participants completed a blood sample that included hemoglobin A1c (A1c), of which approximately half completed a fasting sample that included fasting plasma glucose (FPG).[20] Protocols for collecting interview data and biologic specimens in NHANES are described in-depth elsewhere.[21] NHANES uses a complex, multistage probability sample design to describe statistics related to the health of the non-institutionalized U.S. civilian population. The study participants were non-pregnant adults aged ≥18 years without a self-reported diabetes diagnosis who underwent fasting blood collection. Those missing data for self-report of clinician-diagnosed diabetes, BMI, or glycemic measures were excluded (n=57). The final analytic sample included 3,243 participants.

Measures

Screening eligibility according to the 2015 and 2021 USPSTF recommendations was based on NHANES variables for age and measured BMI. Following the suggestion to consider screening at younger ages and lower BMI among racial and ethnic minority groups, the authors examined screening criteria that incorporate alternate age cutoffs (i.e., 30-70 years and 18-70 years), as well as alternate BMI thresholds (i.e., ≥23kg/m^2 and any BMI). Because USPSTF provided no specific guidance about lower age cutoffs, the authors chose 18 years, representing all younger adults, and 30 years. The latter cutoff represents a 5-year age reduction from the current screening criteria, which is equivalent to the recent guideline change from 40 years to 35 years. Race and ethnicity were self-reported by participants. Racial and ethnic groups sampled in NHANES include Asian (comprising those with origins in the Far East, Southeast Asia, or the Indian subcontinent), Black, Hispanic, and White adults. Prediabetes was defined by FPG 100-125mg/dL or A_{1c} 5.7-6.4%.[22] Diabetes was defined by FPG ≥126mg/dL or A_{1c} ≥6.5%.[22] The authors also analyzed available data on the following participant characteristics that are associated with an elevated risk of prediabetes and diabetes: sex, waist circumference, educational attainment, household income, insurance status, and having a usual source of care.[22,23]

Statistical analysis

Descriptive statistics were used to characterize the subsamples of adults eligible for screening according to the 2015 and 2021 USPSTF screening criteria, as well as those newly eligible according to the 2021 recommendation. The authors also described characteristics of U.S. adults with prediabetes and undiagnosed diabetes, whom screening efforts aim to identify. In the full sample, the following performance characteristics of all screening criteria were examined: sensitivity (the proportion of adults with prediabetes or diabetes who meet the criteria), specificity (the proportion of those without prediabetes or diabetes who do not meet criteria), positive predictive value (PPV; the proportion of adults meeting the criteria who have prediabetes or diabetes), and negative predictive value (NPV; the proportion of those not meeting the criteria who are free of prediabetes and diabetes). The performance of all screening criteria was determined in the overall sample and separately within each racial and ethnic group; and the significance of differences between groups were examined using Chi-square tests. Sensitivity analyses estimated performance characteristics of the 2015 and 2021 USPSTF screening criteria using FPG alone and A_{1c} alone to define prediabetes and undiagnosed diabetes. A P-value of <.05 was considered significant for all statistical testing. SAS-callable SUDAAN version 9.4 (Research Triangle Park, NC) was used to conduct statistical analysis using fasting sample weights. All analyses of these de-identified, publicly available data were conducted from November 2021-November 2022.

RESULTS

Of the 3,243 participants, 1,261 [weighted 37.3% (95% CI: 35.0%-39.7%)] were eligible for screening according to the 2015 USPSTF criteria and 1,451 [weighted 43.8% (41.2%-46.3%)] were eligible according to the 2021 criteria. These subsamples represent 80.4 million and 94.3 million U.S. adults respectively, which corresponds to a 14.8% proportionate increase in the total population eligible for screening. The numbers of newly eligible adults expanded across all racial and ethnic groups, corresponding to the following proportionate increases in eligible participants from 2015: Asian (17.9%); Black (13.9%); Hispanic (30.6%); and White (14.0%) (data not shown). The sociodemographic characteristics and clinical measurements of those eligible in 2015 and 2021 were similar. Those newly eligible in 2021 were more likely to self-report Hispanic ethnicity, lower socioeconomic status, and lack of health insurance or a usual source of care. Newly eligible adults also exhibited lower levels of fasting glucose and A1c. (Table 1)

Overall, 46.8% of U.S. adults without diagnosed diabetes had prediabetes or undiagnosed diabetes, representing 100.7 million U.S. adults. Of those with prediabetes, 18.8% were aged less than 35 years and 14.4% were greater than 70 years old. A smaller proportion of participants with undiagnosed diabetes were under 35 years old (6.4%), and a comparable share were older than 70 (14.4%). (Table 2) While the racial and ethnic composition of participants with prediabetes reflected the overall U.S. adult population, minority groups were overrepresented among those with undiagnosed diabetes. The characteristics of U.S. adults with prediabetes and undiagnosed diabetes were similar when defined by FPG alone and A_{1c} alone (Appendix Table 1).

The 2021 USPSTF screening criteria exhibited marginally higher sensitivity and lower specificity than the 2015 criteria, with similar PPV and NPV. The absolute increases in sensitivity from the 2015 to 2021 criteria were as follows: total population (5.7%); Asian (5.5%); Black (6.6%); Hispanic (11.1%); and White (4.0%) (Table 3). Using the standard recommended BMI cutoff of ≥25kg/m^2, sensitivity of both the 2015 and 2021 screening criteria was significantly lower and the specificity significantly higher in Asian individuals than among other racial and ethnic subgroups. The sensitivity and specificity of both sets of criteria were similar in White, Black, and Hispanic adults. Similar trends in guideline performance were observed when using FPG alone (Appendix Table 2) and A_{1c} alone (Appendix Table 3) to define prediabetes and undiagnosed diabetes.

Table 4 displays the performance characteristics of alternate screening criteria. Lowering age and BMI cutoffs yielded progressively higher sensitivities and lower specificities in the overall adult population, and within each racial and ethnic subgroup. Lowering the age threshold for screening resulted in the largest increase in sensitivity and greatest decrease in specificity among Hispanic participants. A similar pattern was observed for lowering BMI thresholds, with the highest gain in sensitivity and largest decrease in specificity observed in Asian participants. Screening all adults aged 35-70 years exhibited the most similar sensitivity and specificity across racial and ethnic groups. The characteristics of 35-70-year-old adults, who would be eligible based on this approach, are presented in Appendix Table 4.

DISCUSSION

This is the first study examining health equity implications of the recent USPSTF recommendation for prediabetes and diabetes screening by quantifying its clinical performance characteristics. Lowering the screening age from 40 years to 35 years in 2021 results in 13.9 million U.S. adults newly eligible. The greatest proportionate gains in eligibility were observed among Hispanic adults. The 2021 criteria were associated with marginally higher sensitivity and lower specificity than the 2015 criteria across the entire U.S. adult population, and within all racial and ethnic groups examined. Screening based on lower age and BMI thresholds resulted in even greater sensitivity and lower specificity among all U.S. adults, and especially in Hispanic and Asian individuals. These findings demonstrate that the 2021 USPSTF recommendation will identify a greater proportion of adults with prediabetes and diabetes than the 2015 criteria in all race and ethnicity groups studied. Among the alternate age and BMI thresholds examined, screening all adults aged 35-70 years regardless of BMI achieved the most similar performance by race and ethnicity.

Choosing the optimal screening approach to promote health equity requires evaluating tradeoffs in sensitivity and specificity that occur when lowering BMI or age cutoffs. Adherence to screening criteria that maximize sensitivity would result in identifying the greatest proportion of adults with prediabetes and diabetes. Maximizing sensitivity could be considered most appropriate because glycemic testing is inexpensive, the harms of false positive results are low,[17] and evidence-based treatment options for prediabetes and diabetes are available.[24,25] Adopting criteria that maximize specificity would cause the highest proportion of adults without prediabetes or diagnosed diabetes to be ineligible. This approach might be favored if the diagnosis or treatment were not time-sensitive, screening tests were expensive, or the harms of a false-positive screening result were significant. Overall, the 2021 USPSTF recommendation to screen adults aged 35-70 years with a BMI ≥25kg/m^2 is associated with higher specificity than sensitivity.

Epidemiologic studies report that racial and ethnic minority groups experience greater risk of diabetes at younger ages than White individuals. One recent analysis of U.S. adults with diabetes found that 9.3% of White adults were diagnosed before age 35, compared with the following proportions of adults from other racial and ethnic groups: Asian (13.2%); Black (15.5%); and Hispanic (21.0%).[12] The prevalence of type 2 diabetes in children and adolescents, although less common than among adults, demonstrates even larger racial and ethnic disparities.[26] The current study found higher sensitivity and lower specificity when screening adults aged younger than 35 years, both in the total adult population and within each racial and ethnic subgroup. Gains in sensitivity were larger among racial and ethnic minority groups than White adults. Screening criteria that use lower age cutoffs exhibited the largest increase in sensitivity among Hispanic adults, which is likely related to this group's high diabetes risk and younger age distribution.[27,28]

USPSTF's suggestion to consider screening Asian individuals at a BMI ≥23kg/m^2 is based on research demonstrating greater visceral fat accumulation and elevated diabetes risk at lower BMI values in Asian adults than White adults.[13,16,29] Therefore, using a universal BMI cutoff of ≥25kg/m^2 to define screening eligibility will miss Asian adults with prediabetes or undiagnosed diabetes who would not be screened according to their lower BMI. Indeed, the current analysis demonstrates substantially lower sensitivity of screening criteria that use BMI ≥25kg/m^2 to define overweight/obesity in this group, compared with using the Asian-specific BMI ≥23kg/m^2 cutoff. Recent analyses report that Hispanic and Black adults also experience increased diabetes risk at lower BMI values than White individuals.[14,15] The current study's findings suggest that screening below a BMI of 25kg/m^2 may also increase detection of prediabetes and undiagnosed diabetes in these racial and ethnic groups. Lowering BMI thresholds was associated with higher sensitivity but decreased specificity across all racial and ethnic groups, highlighting the tradeoffs associated with this screening approach.

With the renewed imperative to promote health equity, some experts have suggested revising or discontinuing clinical algorithms that incorporate race as a basis for clinical decision-making.[30–32] For example, widely followed equations that use serum creatinine levels to estimate glomerular filtration rate (GFR) include a correction for Black race that results in a higher estimated GFR in this group. Ending this race-based GFR correction, as some health systems have recently done, could result in earlier referrals for specialty care and transplantation, thereby offering potential to promote health equity in a clinical area where stark disparities are consistently documented among Black patients.[33] Eliminating race-based clinical algorithms is further supported by scientific consensus that race represents a social construct and not a biologic one.[34]

However, this approach will not maximize equity in detecting prediabetes and undiagnosed diabetes if a BMI cutoff of ≥25kg/m^2 is used across the entire adult population. A recent study reporting greater diabetes prevalence at younger ages and lower BMI values among racial and ethnic minority groups concluded that using race- and ethnicity-specific thresholds may better promote health equity.[15] The current analysis demonstrates that screening all 35-70 year-old adults regardless of BMI exhibits greater sensitivity than using a BMI threshold, thereby maximizing detection of prediabetes and diabetes. Universal screening for all adults aged 35-70 years also yields the most equitable performance across racial and ethnic groups, while applying the same screening criteria across the entire adult population. Therefore, this approach for promoting health equity may be preferable to using race- and ethnicity-specific screening criteria. It may also be easier to implement by not requiring that clinicians remember alternate BMI or age thresholds when screening patients from different racial and ethnic groups. While lowering the screening age also increased sensitivity, this alternative was associated with less equitable performance across racial and ethnic groups.

The American Diabetes Association (ADA) currently recommends screening all adults aged ≥35 years, or at any age if they have overweight/obesity and an additional diabetes risk factor.[22] The ADA criteria differ from the USPSTF recommendation by routinely including adults younger than 35, which exhibited significant variability in performance across racial and ethnic groups in the current analysis, and those older than 70 years. Substantial debate exists about the value of screening older adults, who have a relatively short time horizon for developing diabetes and its complications, while experiencing a higher risk of all-cause mortality.[35] This analysis examined adults younger than 35 because USPSTF suggested considering this approach as a potential mechanism for promoting health equity. Because USPSTF did not include a similar suggestion for adults older than 70 years, that group is not examined here. USPSTF did not provide specific guidance on younger age cutoffs. This study demonstrates increased sensitivity and decreased specificity as age limits are lowered, highlighting the opportunity to identify a larger number of cases at the expense of screening more adults without prediabetes or diabetes.

This study is timely given its investigation of the recent USPSTF update in screening criteria for prediabetes and diabetes. The analysis focuses on health equity impacts of this guideline change, responding to urgent calls to eliminate diabetes-related disparities among racial and ethnic minority groups. Analyzing nationally representative data is another strength of this study. Examining guideline performance separately by A1c and FPG, and finding similar results, also represents a study strength. These findings provide further support for screening with A1c given its low cost and easy interpretability, regardless of fasting status.[36]

Limitations

Due to the cross-sectional design of NHANES, subsequent glycemic tests that are recommended for confirming a diagnosis of diabetes could not be examined.[22] The glycemic definitions used here did not include 2-hour postload glucose, which was last collected for NHANES in 2015-2016. This limitation may have underestimated the prevalence of prediabetes and diabetes. Some age-stratified estimates of undiagnosed diabetes may be statistically unreliable due to small sample sizes in narrow age categories. Finally, clinician-diagnosed diabetes was determined based on participants' self-report.

CONCLUSIONS

Following the 2021 USPSTF screening criteria will identify a greater proportion of adults with prediabetes and undiagnosed diabetes who are now eligible for screening, compared with 2015 criteria. Gains in sensitivity associated with the new criteria were greater among Black, Hispanic, and Asian individuals than White adults, especially when following USPSTF's suggestion to consider screening at younger ages and at lower BMI values. The study findings suggest that screening all 35-70-year-old adults, regardless of BMI, results in the most similar performance across racial and ethnic groups and may therefore promote equity in detecting prediabetes and undiagnosed diabetes. Achieving equity in diagnosing these conditions also requires addressing structural barriers, which include not having a usual source of primary care, lacking health insurance, or having copays for screening tests based on insurance coverage.[37,38] These barriers to receiving prediabetes and diabetes screening, which are especially prevalent among those newly eligible in 2021, may be best addressed through policy efforts. Expanding screening eligibility will likely increase healthcare costs, which highlights a need to study the costs and cost-effectiveness of any approach that is chosen. It could also be valuable for future research to examine the use of prediabetes and diabetes screening criteria in practice, studying their impact on diagnosis, treatment, and outcomes in diverse populations.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Funding/Support:

Drs. O'Brien and Ackermann were supported by a grant from the National Institutes of Health (P30-DK092949).

Disclosure of Financial Conflicts of Interest:

Dr. Bailey has received consultant fees from Lundbeck, Luto, Pfizer, and Sanofi. Dr. Bailey has received research support from Eli Lilly, Gordon and Betty Moore Foundation, Lundbeck, Merk, Pfizer, and Retirement Research Foundation for Aging. Dr. Ackerman has received consultant fees from UnitedHealth Group. Dr. Ali has received advisory panel support from Bayer AG and research support from Merk. All potential financial conflicts of interest reported here were unrelated to the current study. The other authors have no financial disclosures.

Role of the Funder/Sponsor:

The funders had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

Disclaimer:

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

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. 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. doi: DOI:10.1056/NEJMoa012512. [PubMed: 11832527]
3. UK Prospective Diabetes Study Group. Intensive blood-glucose control with sulphonylureas or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes (UKPDS 33). UK Prospective Diabetes Study (UKPDS) Group. Lancet. 1998;352(9131):837–53. [PubMed: 9742976]
4. Holman RR, Paul SK, Bethel MA, Matthews DR, Neil HAW. 10-year follow-up of intensive glucose control in type 2 diabetes. N Engl J Med. 2008;359(15):1577–1589. doi: doi: 10.1056/NEJMoa0806470 [PubMed: 18784090]
5. Cheng YJ, Kanaya AM, Araneta MRG, et al. Prevalence of Diabetes by Race and Ethnicity in the United States, 2011-2016. JAMA. 2019;322(24):2389–2398. doi:10.1001/jama.2019.19365 [PubMed: 31860047]
6. 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. doi:10.1080/19485565.2018.1542291 [PubMed: 31178981]
7. 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. doi:10.2337/dc10-1504 [PubMed: 21335370]
8. 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. doi:10.1016/j.amjms.2016.01.008 [PubMed: 27079342]
9. Spanakis EK, Golden SH. Race/ethnic difference in diabetes and diabetic complications. Curr Diab Rep. 2013;13(6):814–23. doi:10.1007/s11892-013-0421-9 [PubMed: 24037313]
10. Miech RA, Kim J, McConnell C, Hamman RF. A growing disparity in diabetes-related mortality U.S. trends, 1989-2005. Am J Prev Med. 2009;36(2):126–32. doi:10.1016/j.amepre.2008.09.041 [PubMed: 19062239]
11. 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. doi:10.1371/journal.pmed.1002074 [PubMed: 27403739]
12. Wang MC, Shah NS, Carnethon MR, O'Brien MJ, Khan SS. Age at Diagnosis of Diabetes by Race and Ethnicity in the United States From 2011 to 2018. JAMA Intern Med. 2021;181(11):1537–1539. doi:10.1001/jamainternmed.2021.4945 [PubMed: 34491260]
13. 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. doi:10.2337/dc14-2391 [PubMed: 25538311]
14. Gujral UP, Vittinghoff E, Mongraw-Chaffin M, et al. Cardiometabolic Abnormalities Among Normal-Weight Persons From Five Racial/Ethnic Groups in the United States: A Cross-sectional Analysis of Two Cohort Studies. Ann Intern Med. 2017;166(9):628–636. [PubMed: 28384781]
15. Aggarwal R, Bibbins-Domingo K, Yeh RW, et al. Diabetes Screening by Race and Ethnicity in the United States: Equivalent Body Mass Index and Age Thresholds. Ann Intern Med. 2022;176(6):765–773.
16. 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. doi:10.1001/jama.2021.12531 [PubMed: 34427594]

17. 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. doi:10.7326/m15-2345 [PubMed: 26501513]
18. Fang M, Wang D, Echouffo-Tcheugui JB, Selvin E. Prediabetes and Diabetes Screening Eligibility and Detection in US Adults After Changes to US Preventive Services Task Force and American Diabetes Association Recommendations. JAMA. 2022;327(19):1924–1925. doi:10.1001/jama.2022.5185 [PubMed: 35579650]
19. Centers for Disease Control and Prevention. Unweighted Response Rates for NHANES 2017-2020 by Age and Gender. Centers for Disease Control and Prevention, National Center for Health Statistics. Accessed April 20, 2022. https://wwwn.cdc.gov/nchs/data/nhanes3/ResponseRates/NHANES-2017-2020-Response%20Rates-2017-March2020-508.pdf
20. Centers for Disease Control and Prevention. National Health and Nutrition Examination Survey: 2017-March 2020 Data Documentation, Codebook, and Frequencies; Plasma Fasting Glucose (P_GLU). Accessed 11/22/22, https://wwwn.cdc.gov/Nchs/Nhanes/2017-2018/P_GLU.htm
21. Centers for Disease Control and Prevention. NHANES Questionnaires, Datasets, and Related Documentation. National Center for Health Statistics. Accessed April 20, 2022. https://wwwn.cdc.gov/nchs/nhanes/Default.aspx
22. American Diabetes Association Professional Practice Committee. 2. Classification and Diagnosis of Diabetes: Standards of Medical Care in Diabetes—2022. Diabetes Care. 2021;45(Supplement 1):S17–S38. doi:10.2337/dc22-S002
23. Haire-Joshu D, Hill-Briggs F. The Next Generation of Diabetes Translation: A Path to Health Equity. Anna Rev Public Health. 2019;40:391–410. doi:10.1146/annurev-publhealth-040218-044158 [PubMed: 30601723]
24. Jayapaul-Philip B, Dai S, Kirtland K, Haslam A, Nhim K. Availability of the National Diabetes Prevention Program in United States Counties, March 2017. Prev Chronic Dis. 2018;15:E109. doi:10.5888/pcdl5.180063 [PubMed: 30191810]
25. Armato JP, DeFronzo RA, Abdul-Ghani M, Ruby RJ. Successful treatment of prediabetes in clinical practice using physiological assessment (STOP DIABETES). Lancet Diabetes Endocrinol. 2018;6(10):781–789. [PubMed: 30224284]
26. Lawrence JM, Divers J, Isom S, et al. Trends in Prevalence of Type 1 and Type 2 Diabetes in Children and Adolescents in the US, 2001-2017. JAMA. 2021;326(8):717–727. doi:10.1001/jama.2021.11165 [PubMed: 34427600]
27. Pew Research Center. Age and Gender Distributions for Nativity Groups: 2013. Pew Research Center. Accessed April 15, 2022. https://www.pewresearch.org/hispanic/ph_2015-06_statistical-portrait-of-the-foreign-born_current-11/
28. Schneiderman N, Llabre M, Cowie CC, et al. Prevalence of diabetes among Hispanics/Latinos from diverse backgrounds: the Hispanic Community Health Study/Study of Latinos (HCHS/SOL). Diabetes Care. 2014;37(8):2233–2239. [PubMed: 25061138]
29. Araneta MR, Kanaya AM, Hsu WC, et al. Optimum BMI cut points to screen Asian Americans for type 2 diabetes. Diabetes Care. 2015;38(5):814–20. doi:10.2337/dc14-2071 [PubMed: 25665815]
30. Nabi J, Adam A, Kostelanetz S, Syed S. Updating Race-Based Risk Assessment Algorithms in Clinical Practice: Time for a Systems Approach. Am J Bioeth. 2021;21(2):82–85. doi:10.1080/15265161.2020.1861365
31. Richmond SP, Grubbs V. How Abolition of Race-Based Medicine Is Necessary to American Health Justice. AMA J Ethics. 2022;24(3):E226–232. doi:10.1001/amajethics.2022.226 [PubMed: 35325524]
32. Vyas DA, Eisenstein LG, Jones DS. Hidden in Plain Sight - Reconsidering the Use of Race Correction in Clinical Algorithms. N Engl J Med. 2020;383(9):874–882. doi:10.1056/NEJMms2004740 [PubMed: 32853499]
33. Eneanya ND, Yang W, Reese PP. Reconsidering the Consequences of Using Race to Estimate Kidney Function. JAMA. 2019;322(2):113–114. doi:10.1001/jama.2019.5774 [PubMed: 31169890]

34. Witzig R The medicalization of race: scientific legitimization of a flawed social construct. Ann Intern Med. 1996;125(8):675–9. doi:10.7326/0003-4819-125-8-199610150-00008 [PubMed: 8849153]

35. Rooney MR, Rawlings AM, Pankow JS, et al. Risk of Progression to Diabetes Among Older Adults With Prediabetes. JAMA Intern Med. 2021;181(4):511–519. doi:10.1001/jamainternmed.2020.8774 [PubMed: 33555311]

36. Little RR, Rohlfing C, Sacks DB. The National Glycohemoglobin Standardization Program: Over 20 Years of Improving Hemoglobin A(1c) Measurement. Clin Chem. 2019;65(7):839–848. doi:10.1373/clinchem.2018.296962 [PubMed: 30518660]

37. Hill-Briggs F, Adler NE, Berkowitz SA, et al. Social Determinants of Health and Diabetes: A Scientific Review. Diabetes Care. 2020;44(1):258–79. doi:10.2337/dci20-0053 [PubMed: 33139407]

38. O'Brien MJ, Kirley KA, Ackermann RT. Reducing Health Disparities Through Prevention: Role of the U.S. Preventive Services Task Force. Am J Prev Med. 2020;58(5):724–727. doi:10.1016/j.amepre.2019.11.022 [PubMed: 32107071]

Table 1:

Characteristics of U.S. Adults without Diagnosed Diabetes Eligible for Prediabetes and Diabetes Screening

Characteristic[a]	USPSTF 2015[b]	USPSTF 2021[c]	Newly Eligible[d]
	% (95% CI)	% (95% CI)	% (95% CI)
Unweighted n	1,261	1,451	190
Weighted n, millions[e]	80.4	94.3	13.9
Female sex	49.7 (46.6-52.8)	49.9 (46.8-52.9)	50.9 (41.9-59.8)
Age, years	54.6 (53.5-55.6)	52.0 (50.9-53.1)	37.1 (36.8-37.4)
Age categories, years			
18-34	0.0 (. -.)	0.0 (. -.)	0.0 (. -.)
35-39	0.0 (. -.)	14.7 (12.3-17.6)	100.0 (. -.)
40-70	100.0 (. -.)	85.3 (82.4-87.7)	0.0 (. -.)
≥71	0.0 (. -.)	0.0 (. -.)	0.0 (. -.)
Race and ethnicity			
Asian	4.0 (2.4-6.3)	4.0 (2.6-6.0)	4.1 (2.6-6.5)
Black	12.5 (9.4-16.4)	12.1 (9.3-15.7)	10.1 (6.9-14.5)
Hispanic	15.5 (12.5-19.0)	17.2 (14.0-21.1)	27.5 (19.6-37.1)
White	65.0 (60.2-69.5)	63.2 (58.4-67.8)	52.8 (42.3-63.1)
Educational attainment <High School	12.0 (10.1-14.1)	12.4 (10.8-14.2)	14.8 (10.7-20.2)
Income below the federal poverty level	13.2 (9.4-18.1)	13.9 (10.6-18.0)	17.9 (10.6-28.7)
Uninsured	12.7 (9.7-16.5)	13.7 (11.0-16.8)	19.4 (13.7-26.7)
Usual source of care	87.4 (82.2-91.2)	86.1 (81.2-89.8)	78.3 (70.9-84.2)
Weight status[f]			
Normal	0.0 (. -.)	0.0 (. -.)	0.0 (. -.)
Overweight	50.8 (46.4-55.2)	49.5 (45.5-53.5)	41.9 (35.5-48.6)
Obesity	49.2 (44.8-53.6)	50.5 (46.5-54.5)	58.1 (51.4-64.5)
Body mass index, kg/m^2	31.6 (31.1-32.2)	31.9 (31.4-32.4)	33.5 (32.2-34.8)
Waist circumference, cm	106.0 (104.8-107.3)	106.1 (104.8-107.4)	106.6 (103.6-109.5)
Fasting plasma glucose, mg/dL[g,h]			
100-109	40.9 (36.0-46.0)	39.5 (34.9-44.3)	33.9 (25.5-43.3)
110-125	18.3 (14.3-23.2)	16.6 (13.0-21.0)	7.0 (3.1-14.9)
≥126	5.6 (4.1-7.5)	5.4 (4.2-7.0)	4.6 (1.9-10.7)
Mean	106.9 (105.8-107.9)	106.7 (105.6-107.8)	105.7 (99.7-111.7)
Hemoglobin A_{1c}, %[g,h]			
5.7-5.9	25.1 (21.9-28.5)	23.4 (20.2-26.9)	14.0 (9.1-20.9)
6.0-6.4	12.5 (10.0-15.5)	11.7 (9.6-14.2)	7.1 (3.1-15.4)
≥6.5	4.0 (3.2-5.0)	3.9 (3.2-4.7)	3.1 (1.2-8.0)
Mean	5.62 (5.58-5.66)	5.60 (5.56-5.64)	5.40 (5.32-5.57)

USPSTF = United States Preventive Services Task Force

[a]Categorical variables are expressed as weighted column percentages (95% CI). Body mass index, waist circumference, and glycemic testing results are expressed as mean (95% CI).

[b]The 2015 USPSTF screening criteria were age 40-70 years and BMI ≥25kg/m^2.

[c]The 2021 USPSTF screening criteria are age 35-70 years and BMI ≥25kg/m^2.

[d]Those newly eligible are aged 35-39 years with BMI ≥25kg/m^2.

[e]These numbers represent the population size among all U.S. adults.

[f]Overweight and obesity status were determined based on a measured BMI of ≥25kg/m^2 and ≥30kg/m^2, respectively, for all racial and ethnic groups. Normal weight status was defined by a BMI <25kg/m^2.

[g]Glycemic measures are expressed as weighted column percentages (95% CI) within each specified range of test values, followed by the mean value for each glycemic test.

[h]Some estimates within strata of glycemic values may not be statistically reliable due to small sample sizes.

Table 2:

Characteristics of U.S. Adults with Prediabetes and Undiagnosed Diabetes

	Prediabetes		Undiagnosed Diabetes	
Characteristic[a]	**Population size**[b]	**% (95% CI)**	**Population size**[b]	**% (95% CI)**
Unweighted n	1,478		176	
Weighted n	92.5	43.0 (40.2-45.8)	8.2	3.8 (3.1-4.7)
Female sex	42.8	46.2 (42.5-50.0)	4.8	59.2 (45.5-71.6)
Mean age, years	92.5	52.2 (50.6-53.8)	8.2	55.7 (52.4-59.0)
Age categories, years				
18-29	11.1	12.1 (9.9-14.7)	0.4	4.3 (1.4-11.9)
30-34	6.2	6.7 (4.3-10.4)	0.2	2.2 (0.7-6.5)
35-39	6.3	6.8 (5.4-8.5)	0.6	7.5 (3.4-15.9)
40-70	55.5	60.0 (55.8-64.0)	5.9	71.3 (60.6-80.0)
≥71	13.3	14.4 (11.5-17.8)	1.2	14.4 (8.0-24.6)
Race and ethnicity				
Asian	5.2	5.7 (3.9-8.1)	0.8	9.2 (4.5-17.7)
Black	10.8	11.7 (8.7-15.6)	1.3	15.9 (9.4-25.5)
Hispanic	13.4	14.5 (11.4-18.1)	1.7	20.6 (14.4-28.6)
White	58.9	63.7 (59.6-67.5)	4.1	49.9 (35.1-64.7)
Educational attainment <High School	10.8	11.8 (10.2-13.7)	1.4	16.8 (10.9-25.0)
Income below the federal poverty level	10.3	12.4 (9.7-15.8)	1.1	15.2 (8.6-25.5)
Uninsured	11.3	12.3 (9.4-15.8)	1.7	21.2 (12.7-33.2)
Usual source of care	78.6	84.9 (81.4-87.9)	7.3	89.1 (82.5-93.4)
Weight status[c]				
Normal	16.3	17.6 (14.5-21.3)	0.8	9.6 (4.0-21.3)
Overweight	33.2	35.9 (32.2-39.8)	1.5	18.9 (11.8-29.0)
Obesity	43.0	46.5 (42.5-50.5)	5.9	71.5 (60.6-80.4)
Body mass index, kg/m^2	92.5	30.7 (30.2-31.3)	8.2	34.9 (32.3-37.5)
Waist circumference, cm	90.5	103.5 (102.2-104.8)	8.2	112.4 (107.4-117.4)
Fasting plasma glucose, mg/dL	92.5	108.4 (107.6-109.1)	8.2	151.2 (140.4-162.0)
Hemoglobin A_{1c}, %	92.5	5.63 (5.59-5.67)	8.2	6.92 (6.64-7.19)

[a]Categorical variables are expressed as weighted column percentages (95% CI). Body mass index, waist circumference, and glycemic testing results are expressed as mean (95% CI).

[b]These numbers represent the population size in millions among all U.S. adults.

[c]Overweight and obesity status were determined based on a measured BMI of $\geq 25 kg/m^2$ and $\geq 30 kg/m^2$, respectively, for all racial and ethnic groups. Normal weight status was defined by a BMI $<25 kg/m^2$.

Table 3:

Performance of Screening Criteria among U.S. Adults without Diagnosed Diabetes by Self-Reported Race and Ethnicity

Screening Criteria and Population group	Sensitivity, % (95% CI)	Specificity, % (95% CI)	Positive predictive value, % (95% CI)	Negative predictive value, % (95% CI)
2015 USPSTF Criteria [a]				
Total population	52.9 (49.7-56.0)	76.4 (73.3-79.2)	66.3 (63.0-69.4)	64.8 (61.0-68.5)
Asian	38.0 (29.1-47.8)	86.0 (79.9-90.5)	71.6 (64.0-78.2)	60.0 (53.5-66.2)
Black	57.0 (50.8-62.9)	73.5 (67.4-78.8)	68.9 (62.5-74.6)	62.4 (56.8-67.6)
Hispanic	50.9 (44.6-57.2)	75.3 (70.0-80.0)	61.7 (55.5-67.6)	66.3 (61.0-71.2)
White	55.1 (51.1-59.0)	75.8 (70.4-80.5)	66.4 (61.1-71.3)	66.0 (60.9-70.8)
P-value [b]	**<0.01**	**0.03**	0.37	0.40
2021 USPSTF Criteria [c]				
Total population	58.6 (55.5-61.6)	69.3 (65.7-72.7)	62.7 (59.3-65.9)	65.6 (61.7-69.3)
Asian	43.5 (34.1-53.3)	82.3 (76.7-86.7)	69.4 (62.8-75.3)	61.1 (53.8-67.9)
Black	63.6 (57.8-68.9)	68.4 (62.6-73.8)	67.5 (62.2-72.4)	64.6 (59.2-69.7)
Hispanic	62.0 (55.0-68.5)	64.2 (58.8-69.3)	57.5 (51.9-62.9)	68.4 (61.8-74.3)
White	59.1 (55.4-62.7)	69.3 (63.3-74.6)	62.5 (57.2-67.6)	66.1 (61.1-70.8)
P-value [b]	**0.02**	**0.02**	0.08	0.57

USPSTF = USPSTF = United States Preventive Services Task Force

[a] The 2015 USPSTF screening criteria were age 40-70 years and BMI ≥25kg/m^2.

[b] *P*-values for racial and ethnic differences in performance characteristics of the USPSTF screening criteria were determined using Chi-square tests. Boldface indicates statistical significance.

[c] The 2021 USPSTF screening criteria are age 35-70 years and BMI ≥25kg/m^2.

Table 4:

Performance of Alternate Screening Criteria by Self-Reported Race and Ethnicity

Screening Criteria and Population group	Sensitivity, % (95% CI)	Specificity, % (95% CI)	Positive predictive value, % (95% CI)	Negative predictive value, % (95% CI)
Lowering Age Cutoff				
Age 30-70 years + BMI ≥25kg/m^2				
Total population	64.0 (60.8-67.1)	61.7 (58.3-65.0)	59.5 (55.9-63.0)	66.1 (62.3-69.8)
Asian	50.7 (40.8-60.5)	72.2 (63.5-79.4)	62.8 (55.7-69.4)	61.2 (53.9-68.1)
Black	68.2 (62.6-73.3)	59.4 (53.1-65.5)	63.4 (58.1-68.4)	64.4 (58.3-70.2)
Hispanic	68.6 (60.9-75.4)	54.6 (48.4-60.7)	54.1 (48.7-59.5)	69.1 (62.1-75.2)
White	63.4 (59.2-67.5)	62.9 (56.3-69.0)	59.7 (54.0-65.1)	66.5 (61.2-71.3)
P-value[a]	**0.02**	**0.04**	0.14	0.63
Age 18-70 years + BMI ≥25kg/m^2				
Total population	72.5 (69.4-75.4)	45.1 (40.9-49.3)	53.7 (49.8-57.5)	65.1 (60.7-69.3)
Asian	58.4 (49.4-67.0)	59.8 (51.5-67.6)	57.4 (49.9-64.5)	60.8 (52.5-68.5)
Black	77.6 (71.4-82.8)	33.1 (27.3-39.6)	54.5 (49.2-59.6)	59.0 (51.7-65.9)
Hispanic	83.4 (76.4-88.7)	31.5 (25.2-38.6)	48.8 (44.7-52.8)	70.9 (60.7-79.4)
White	70.1 (66.3-73.5)	49.4 (43.5-55.4)	54.6 (49.2-59.9)	65.5 (60.0-70.7)
P-value[a]	**<0.001**	**<0.001**	0.17	0.39
Lowering BMI Cutoff				
Age 35-70 years + BMI ≥23kg/m^2				
Total population	63.8 (60.2-67.2)	60.8 (56.6-64.9)	58.8 (55.8-61.8)	65.7 (61.0-70.0)
Asian	57.3 (46.6-67.3)	69.6 (61.3-76.8)	63.5 (55.4-71.0)	63.7 (55.4-71.3)
Black	66.7 (61.8-71.2)	65.4 (58.9-71.4)	66.5 (60.9-71.7)	65.6 (60.3-70.5)
Hispanic	66.8 (59.3-73.5)	60.7 (55.7-65.5)	57.0 (51.6-62.3)	70.1 (63.7-75.7)
White	64.3 (59.3-69.0)	58.5 (51.7-65.1)	57.3 (52.5-62.0)	65.4 (58.8-71.4)
P-value[a]	0.16	0.10	0.12	0.47
Age 35-70 years + Any BMI				
Total population	67.8 (63.8-71.6)	52.1 (47.2-57.0)	55.4 (52.8-58.1)	64.8 (59.2-70.1)
Asian	70.1 (62.0-77.2)	53.8 (42.6-64.5)	58.4 (49.0-67.2)	66.0 (55.3-75.3)
Black	70.4 (65.8-74.6)	59.8 (51.4-67.7)	64.4 (58.3-70.0)	66.2 (60.2-71.8)
Hispanic	68.4 (61.2-74.9)	56.2 (50.1-62.1)	54.9 (49.4-60.4)	69.5 (62.9-75.3)
White	67.6 (61.9-72.8)	48.9 (41.6-56.2)	53.5 (49.6-57.3)	63.5 (55.1-71.2)
P-value[a]	0.67	0.09	0.09	0.60

BMI = Body mass index

[a] *P*-values for racial and ethnic differences in performance characteristics of the USPSTF screening criteria were determined using Chi-square tests. Boldface indicates statistical significance.