PREVENTING CHRONIC DISEASE
PUBLIC HEALTH RESEARCH, PRACTICE, AND POLICY



Public Health Research and Program Strategies for Diabetes Prevention and Management



U.S. CENTERS FOR DISEASE CONTROL AND PREVENTION

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PCD Staff

Associate Editors

Table of Contents

10. **Prevalence of Self-Reported Diagnosed Diabetes Among Adults, by County Metropolitan Status and Region, United States, 2019–2022**
Onufrak S, Saelee R, Zaganjor I, Miyamoto Y, Koyama AK, Xu F, et al. Prevalence of Self-Reported Diagnosed Diabetes Among Adults, by County Metropolitan Status and Region, United States, 2019–2022. Prev Chronic Dis 2024;21:240221.

11. **Disparities in Cardiovascular Disease Prevalence by Race and Ethnicity, Socioeconomic Status, Urbanicity, and Social Determinants of Health Among Medicare Beneficiaries With Diabetes**
Onufrak S, Saelee R, Zaganjor I, Miyamoto Y, Koyama AK, Xu F, et al. Prevalence of Self-Reported Diagnosed Diabetes Among Adults, by County Metropolitan Status and Region, United States, 2019–2022. Prev Chronic Dis 2024;21:240221.

12. **State-Level Household Energy Insecurity and Diabetes Prevalence Among US Adults, 2020s**
Saelee R, Bullard KM, Wittman JT, Alexander DS, Hudson D. State-Level Household Energy Insecurity and Diabetes Prevalence Among US Adults, 2020. Prev Chronic Dis 2024;21:240087.

13. **Telemedicine Use Among Adults With and Without Diagnosed Prediabetes or Diabetes, National Health Interview Survey, United States, 2021 and 2022**
Zaganjor I, Saelee R, Onufrak S, Miyamoto Y, Koyama AK, Xu F, et al. Telemedicine Use Among Adults With and Without Diagnosed Prediabetes or Diabetes, National Health Interview Survey, United States, 202 and 2022. Prev Chronic Dis 2024;21:240229.

14. **Breaking Barriers: CDC and American Diabetes Association Unite to Combat Diabetes**
Holliday CS, Gabbay RA. Breaking Barriers: CDC and American Diabetes Association Unite to Combat Diabetes. Prev Chronic Dis 2025;22:240273.

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GUEST EDITORIAL

Public Health Research and Program Strategies for Diabetes Prevention and Management

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PEER REVIEWED

The year 2025 commemorates 50 years since Congress received the Report of the National Commission on Diabetes that established "the urgent need to address directly and fully the tragedy of diabetes mellitus" (1). The 1975 report indicated that the prevalence of diabetes had increased by 50% over the preceding decade, resulting in the condition affecting 5% of the population at that time. Since then, largely because of substantial increases in obesity, the prevalence of diabetes in the US has more than doubled, now nearing 12% of people in the US (2). Furthermore, notable disparities persist in the prevalence of type 2 diabetes, observed across characteristics such as race and ethnicity, socioeconomic status, and whether individuals live in rural or urban areas (2). Despite these challenges, in the past 50 years, public health and clinical researchers and professionals have greatly improved their understanding of how to prevent type 2 diabetes, manage type 1 or type 2 diabetes effectively to reduce complications, and address disparities related to the disease. Research has identified effective, scalable interventions to address modifiable risk factors such as poor diet, obesity, and physical inactivity, that can prevent or delay type 2 diabetes (3–5) as well as interventions to teach people with diabetes how to manage their condition through lifestyle modification, medication adherence, and glucose monitoring (5). Researchers have also begun to shed light on the underlying drivers of disparities in diabetes prevalence and complications observed across socioeconomic, geographic, and racial and ethnic subgroups. Specifically, the past 50 years have seen the creation of the National Diabetes Prevention Program (National DPP) to prevent or delay the onset of type 2 diabetes among those identified at high risk (6,7), the development of effective diabetes self-management education and support (DSMES) services to reduce the risk of complications among people with diabetes (8), and recognition of the critical role that social determinants of health (SDOH) play in disparities in the risk of type 2 diabetes and its complications (9–12).

In the late 1970s, the clinical community established diagnostic criteria to identify people with early indications of glucose dysregulation or prediabetes (13). People with prediabetes have blood glucose levels higher than normal but not yet high enough to be considered diabetes (14). Currently, 98 million adults in the US have prediabetes, putting them at high risk of developing type 2 diabetes and forming a critical population for focused prevention efforts (2). In 1996, the National Institutes of Health commenced the Diabetes Prevention Program (DPP) study, a multicenter randomized clinical trial that tested the efficacy of a structured lifestyle intervention, which constituted 1 of the 3 arms of the study. The findings from the DPP trial, published in 2002, indicated a 58% reduction in the risk of developing type 2 diabetes among adults with prediabetes who engaged in the lifestyle intervention (15).

National DPP Lifestyle Change Program

To increase implementation of type 2 diabetes prevention activities, Congress authorized the Centers for Disease Control and Prevention (CDC) to establish and manage the National DPP in 2010 (6). This partnership of public and private organizations is building a nationwide delivery system for a yearlong lifestyle change program (LCP) to help adults at high risk make modest behavior changes to prevent or delay the onset of type 2 diabetes (16). For more than 10 years, the National DPP LCP has been implemented in various settings, including workplaces (7,17). Workplaces play a crucial role in participant referral and identification, and CDC encourages employers to support their staff in taking preventive measures against type 2 diabetes and cardiometabolic diseases (18). Tsai and colleagues explored obstacles and facilitators to participant engagement in employer-sponsored clinic-based LCPs, suggesting that engagement in a workplace LCP can be supported by addressing specific workplace challenges and gaining buy-in from employers (19). Incorporating virtual approaches for delivering the National DPP in hybrid work settings promises to be an effective strategy to reduce barriers to referrals from providers (19).

Despite widespread implementation, significant challenges exist in recruiting, enrolling, and retaining participants from priority populations into the National DPP LCP (20,21,22). In this collection, authors examine National DPP LCP participation drivers, explore participant readiness to enroll, examine the use of technology to increase engagement, discuss the role of the workplace in program delivery, and provide program tailoring and adaptation recommendations to increase relevance and reach to particular racial and ethnic communities.

Saiki and colleagues (17) and Hulbert and colleagues (23) highlighted the approaches to recruit and engage racial and ethnic communities in DPP LCP programs. Saiki and colleagues identified barriers and facilitators to program recruitment and completion among native Hawaiian and Filipino populations residing in rural Hawai‘i. These barriers and facilitators suggest that programs should use trusted community members to motivate participants to enroll and that social support from lifestyle coaches and enrolled family and friends were motivators for program completion (17). Hulbert and colleagues examined the interests and barriers and facilitators for program participation and healthy behaviors in a group of non-Hispanic Black, Hispanic, Asian, American Indian or Alaska Native, and Native Hawaiian or Pacific Islander men, suggesting that program incentives, male-specific topics, and the involvement of family members may be motivators for participation (23). Likewise, Johnson and colleagues showed how technology, behavior change theories, and community-based participatory design may be promising strategies for increasing engagement in the National DPP LCP (24). These authors employ systematic research and program evaluation methods to test and refine the use of current evidence and other public health strategies. The results offer insights into the factors that influence engagement in the LCP, including the importance of tailoring programs to align with participants' interests and preferences. Additionally, the results underscore how understanding the preferences of people at risk for type 2 diabetes can enhance participation in health programs by selecting the most effective delivery methods and locations to encourage greater involvement and improve overall outcomes.

Addressing Diabetes Complications

People living with diabetes face an increased risk of serious complications, especially cardiovascular disease, kidney disease, eye disease, and lower limb amputations that result in substantial illness and death (25). For example, a 50-year-old adult recently diagnosed with type 2 diabetes currently has a life expectancy 6 years shorter than someone without diabetes (26). However, the reduced life expectancy associated with diabetes can be alleviated by effectively achieving treatment objectives related to glucose management, blood pressure control, and cholesterol levels to prevent complications (27). A fundamental strategy for accomplishing these treatment objectives is DSMES, which empowers individuals to effectively manage their diabetes (8). DSMES participation can improve glycemic control, management of blood pressure and cholesterol, medication adherence, nutrition, physical activity, and self-confidence to successfully manage diabetes, ultimately leading to a reduction in diabetes-related complications and decreased health care costs (28).

Diabetes Self-Management Programs

The American Diabetes Association (ADA) and the Association of Diabetes Care & Education Specialists (ADCES) support DSMES through program accreditation and recognition and accreditation of diabetes care and education specialists (8). CDC provides funding to state and local health departments and other organizations to increase access to and participation in DSMES services (8). As of 2020, recognized or accredited DSMES programs were offered in all 50 states, including 56% of all US counties (8), and nearly 1 million people diagnosed with diabetes accessed these DSMES services (5). Despite this number, less than 10% of those newly diagnosed with diabetes participate in DSMES within the first year of diagnosis (8). Thus, finding ways to expand access to and participation in DSMES is a key approach to preventing complications among people with diabetes. Hulbert and colleagues' work (23) regarding motivators for program participation provided insights that are useful for both National DPP and DSMES services. Simultaneously, Bing and colleagues described an approach to expanding DSMES access and enrollment by evaluating the programmatic work of state health departments, shedding light on how engaging the pharmacy sector, using an umbrella organization approach, and implementing continuous quality improvement efforts may help improve referral and enrollment in DSMES programs (29).

The burden of managing type 2 diabetes every day is substantial and can be overwhelming, affecting both mental health and the self-efficacy required for successfully preventing complications (30). This mental health impact is called diabetes distress (31). Alexander and colleagues investigated the prevalence and determinants of diabetes distress among US adults and recommended strategies that, if incorporated into interventions, could improve diabetes management (32). This study estimated the national prevalence of diabetes distress for the first time, finding that 1 in 4 adults with diabetes in the US experiences moderate or severe diabetes distress.

Other Factors in Diabetes Prevalence Disparities

Another key development in type 2 diabetes prevention and diabetes management has been the acknowledgment of the role of upstream social and environmental factors, such as employment and financial security, education, safe and stable housing, access to nutritious food, dependable transportation, and other stressors, on type 2 diabetes prevalence disparities (10,11,33). A clear example of how SDOH can impact diabetes risk and risk factors can be seen in the rural US (34). Rural residents often struggle to access health care; the prevalence of healthy behaviors is lower and the prevalence of chronic disease is higher compared with those in urban areas (35). Khavjou and colleagues analyzed rural–urban disparities in diabetes prevalence across states among US adults (36), and Onufrak and colleagues investigated diabetes prevalence in relation to county metropolitan status and region (37). While their findings correspond with known rural–urban disparities in diabetes deaths, hospitalizations, and incidence, the authors also examine the underlying SDOH factors that contribute to observed disparities and provide a more detailed picture of how rural disparities differ across the US. Both studies suggest that rural–urban disparities in diabetes prevalence are not homogeneous across the US and suggest that such disparities are at least partially explained by socioeconomic factors. Disparities include not only differences in prevalence and risk but also in complications for those who already have diagnosed diabetes. Zhou and colleagues studied cardiovascular disease prevalence among Medicare beneficiaries with diabetes, highlighting differences by race and ethnicity, socioeconomic status, and urbanicity (38). They found that cardiovascular disease prevalence varied by race and ethnicity and that a low income-to-poverty ratio and food insecurity were positively associated with myocardial infarction, stroke, and heart failure. These findings corroborate with existing literature on income and education disparities in diabetes in the US (39,40). Saelee and colleagues examined the link between household energy insecurity and diabetes prevalence (41), shedding light on a novel SDOH that may affect illness and death among persons with diabetes (42,43). They report that states with higher prevalence of diabetes also have greater prevalence of energy insecurity, a condition which may complicate diabetes management during times of severe weather.

While evidence-based programs such as the National DPP have demonstrated effectiveness (44), challenges related to cost, accessibility, and long-term adherence remain significant barriers to widespread implementation. Telehealth and telemedicine are approaches to addressing these issues among rural populations and others facing barriers to health care access because of distance, transportation, or difficulty taking time off from work (45). During the COVID-19 pandemic, telemedicine use surged, but data on its usage among US adults with prediabetes or diabetes are limited. Zaganjor and co-authors report variations in telemedicine use based on region, urban or rural status, insurance, and education, identifying specific populations with prediabetes or diabetes that may benefit from improvements in telemedicine access (46).

CDC and its partners are dedicated to addressing factors that contribute to the onset of type 2 diabetes and inadequate management of diabetes. In the commentary "Breaking Barriers: CDC and American Diabetes Association Unite to Combat Diabetes," authors Holliday and Gabbay detail the collaboration between CDC and ADA, along with other federal agencies, state and local health departments, health care providers, and community organizations, to combat the impact of diabetes on the nation (47). The authors specifically highlight the upstream, midstream, and downstream strategies that can be employed to improve the prevention and management of diabetes in the US.

Conclusion and Future Directions

The US diabetes epidemic is influenced by a myriad of complex factors, suggesting innovative methods may be required to stem the tide of both diabetes and its complications and comorbidities. The articles in this collection describe and consolidate research and evaluation related to identifying barriers to the prevention and management of diabetes, and effectively implementing and evaluating evidence-based approaches aimed at fighting this pervasive disease. They illuminate the challenges faced by priority populations in their everyday environments and showcase innovative approaches in public health practice, such as tracking national initiatives and embracing new technologies. This collection highlights opportunities for further research, applied public health research, and prioritization of the use of findings from program and implementation evaluation to further improve program development. Continued coordinated efforts among multilevel partnerships across all sectors, along with evaluating and implementing emerging and promising practices as they develop, will allow us to address diabetes effectively. Future work may also prioritize interventions that improve access to care for all populations. Further, incorporating behavioral interventions such as stress management, psychoeducation, and family support into diabetes care can improve patient well-being and adherence to treatment (32). Addressing these challenges may require a comprehensive approach, including tailored interventions and innovative health care delivery models such as telemedicine and community-based programs. In sum, the findings featured in this collection can, in various ways, help guide specific, focused interventions to reduce disparities in diabetes prevalence and complications.

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PROGRAM EVALUATION BRIEF

Recruitment and Retention in the National Diabetes Prevention Program Lifestyle Change Program in Two Federally Qualified Health Centers in Rural Hawai‘i

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PEER REVIEWED

Summary

What is already known on this topic?

The National Diabetes Prevention Program lifestyle change program (National DPP LCP) prevents or delays the onset of type 2 diabetes. Native Hawaiian, Other Pacific Islander, and Filipino adults have high rates of prediabetes and low rates of enrollment in these programs.

What is added by this report?

The perspectives of Native Hawaiian, Other Pacific Islander, and Filipino women provide insights into how program participation among these groups can be bolstered in rural communities.

What are the implications for public health practice?

Having trusted members of the community help with recruitment and lead the program is effective in engaging Native Hawaiian, Other Pacific Islander, and Filipino adults. Cultural tailoring and support from family contribute to engagement and enrollment in these lifestyle change programs.

Abstract

Prediabetes disproportionately affects racial and ethnic minority groups in Hawai‘i. The National Diabetes Prevention Program lifestyle change program (National DPP LCP) decreases the risk of developing diabetes. However, enrolling and retaining participants is a challenge for program providers. This evaluation aimed to understand factors that influence racial and ethnic minority groups in Hawai‘i to enroll in and complete the program. From 2018 through 2023, two federally qualified health centers (FQHCs) in rural Hawai‘i administered 6 year-long cohorts. Trained lifestyle coaches, who were FQHC staff members, recruited participants and facilitated the evidence-based curriculum. In 2023, the evaluation team conducted semistructured interviews with 14 of the 40 enrolled participants (35%), all of whom were women aged 25 to 74 years. Six participants identified as Native Hawaiian or Other Pacific Islander and 3 as Filipino. Eight participants reported completing the program. We used qualitative methodology to analyze transcripts. We identified themes around motivators, barriers, facilitators, and suggestions for improvement. Recruitment by trusted individuals in their communities motivated participants to enroll. Caregiving and work obligations were attendance barriers for early withdrawers and graduates. Social support from lifestyle coaches and enrolled friends and family were facilitators for program completion. Suggestions included improving class availability and incorporating culturally relevant recipes. Barriers experienced by Native Hawaiian or Other Pacific Islander and Filipino participants were similar to those reported by racial and ethnic groups in other studies. Program providers in rural communities should use trusted individuals as lifestyle coaches and recruit family and friends, regardless of National DPP LCP eligibility, to reduce caregiving barriers and engage critical support systems to facilitate completion.

Introduction

Prediabetes affects 38% of adults in the US (1), but only 14.9% of adults in Hawai‘i (2). When data from Hawai‘i are disaggregated, substantial racial and ethnic disparities exist, with Native Hawaiian (NH, 17.2%), Other Pacific Islander (OPI, 16.9%), and Filipino (17.3%) adults having higher rates than non-Hispanic White (9.0%) adults (2-4). Various behavioral, socioeconomic, and cultural reasons contribute to this disparity (4,5).

The Centers for Disease Control and Prevention (CDC) implemented the National Diabetes Prevention Program lifestyle change program (National DPP LCP) for people with prediabetes to reduce their risk of progressing to type 2 diabetes. National DPP LCP participants who were successful in making lifestyle changes have reduced their risk of progressing to diabetes by up to 58% (6). Despite the program's benefits and the high rates of prediabetes in the US, enrolling and retaining people in the program is challenging. Less than 1% of people with prediabetes enroll in the National DPP LCP, and even fewer graduate (1,7,8); in Hawai‘i, 1.3% of those diagnosed with prediabetes enroll (2,9).

Disparities in enrollment and retention are further evident when rates are disaggregated by race and ethnicity. US enrollment data from 2012 through 2019 identified 0.8% as NHOPI (Native Hawaiian, Other Pacific Islander), 3.1% as Asian American, and 64.6% as non-Hispanic White adults (7). Enrollment barriers include lack of program awareness, inconvenient locations, shock about their diagnosis, and feeling unmotivated or overwhelmed by other health conditions (10–12). Data suggest that people do not complete the year-long National DPP LCP because of scheduling conflicts, lack of childcare or transportation, inability to relate to other participants, dissatisfaction with the lifestyle coach, and/or class content not meeting expectations (10–12). However, these data have been mostly among non-Hispanic White, Hispanic, and Black adults (11,13). Little is known about barriers among NHOPI and Filipino adults, who are underrepresented in both enrollment and retention in the National DPP LCP (7,8). One study among NHOPI and Filipino adults examined the Partnership for Improving Lifestyle Intervention (PILI) ‘Ohana Project, a culturally adapted diabetes prevention program focused on weight loss that did not meet the duration requirements of a CDC-approved program (4). That study explored barriers and facilitators encountered by NHOPI and Filipino adults in participating and completing the program, but it did not exclusively examine data for people with prediabetes. Therefore, a critical gap in the literature needs to be filled to increase enrollment and retention of NHOPI and Filipino adults in the National DPP LCP.

In 2018, the Hawai‘i Department of Health received a 5-year grant from CDC to improve the identification of patients with prediabetes and enroll people in National DPP LCPs at federally qualified health centers (FQHCs). The evaluation focused on programs at 2 FQHCs located in rural, medically underserved areas on Hawai‘i Island and O‘ahu (14). Hawai‘i Island is nearly 7 times larger than O‘ahu, with many residents needing to travel long distances to access health care. The Hawai‘i Island FQHC has 4 clinic sites located across 50 miles of coastline and serves nearly 8,000 patients (15). Most people they serve belong to racial and ethnic minority groups, one-third are Medicaid beneficiaries, and one-quarter live at or below 100% of the federal poverty level (15). Most of the O‘ahu FQHC's nearly 5,000 patients belong to racial and ethnic minority groups, and one-half are Medicaid recipients or earn below 100% of the federal poverty level (15,16). During the 5-year grant, the Hawai‘i Island FQHC completed 5 year-long cohorts and the O‘ahu FQHC completed 1 year-long cohort comprising employees who were diagnosed with prediabetes. Employees were recruited to pilot the program before the National DPP LCP was promoted to the patient population.

Purpose and Objectives

The purpose of this evaluation was to understand factors influencing enrollment and retention in the National DPP LCP from the perspectives of NHOPI and Filipino participants at 2 FQHCs in rural Hawai‘i. Funders selected these FQHCs because the FQHCs' leadership was receptive to participating in an evaluation and because funders wanted to collect information on the perspectives of participants in an established program and a newly implemented program, which were represented by these 2 FQHCs. This process evaluation was guided by CDC's Framework for Program Evaluation (17) and sought to gather information to help other organizations tailor their recruitment and implementation to support engagement of NHOPI and Filipino adults in rural communities.

Intervention Approach

Participants were recruited into the National DPP LCP at each FQHC either by a referral from their health care provider or directly by lifestyle coaches, who were trusted health center staff and community members. Classes were conducted via 3 modes: exclusively in-person, exclusively virtually, or a hybrid of the 2 modalities. During classes, lifestyle coaches led participants through designated lessons by using a standard training manual and incorporated interactive components, such as local food demonstrations, group physical activities, and stress management techniques, to build participant self-efficacy to implement lifestyle changes. Lifestyle coaches tracked participant progress through weight changes and minutes of physical activity, facilitated goal setting to support lifestyle changes, and provided encouragement via text messages between classes.

Evaluation Methods

In 2023, the University of Hawai‘i evaluation team conducted 45-to-60–minute semistructured interviews with 14 former and current participants of the National DPP LCP via Zoom (10 participants turned their video on and 4 did not). Participants also completed an online survey that asked about age, race and ethnicity, family history of diabetes, participation modality, completion status, and familiarity with the lifestyle coach before the program. The University of Hawai‘i Institutional Review Board designated this evaluation project as non–human subjects research, per the revised Common Rule of 2018.

Recruitment and interview guides

The evaluation team developed interview guides in collaboration with FQHC lifestyle coaches, key partners, and the Hawai‘i Department of Health. The semistructured interviews were used to understand participant experiences and reasons they enrolled, attended, or withdrew from the program. Questions included characteristics of their program classes and feelings about their lifestyle coach. Participants in all 6 cohorts at the 2 participating FQHCs were eligible to participate in the study, and lifestyle coaches personally reached out to their participants to assess their interest in participating in this study.

Data analysis

Of the 40 people enrolled in the 6 cohorts, 14 agreed to be interviewed. Interviews were recorded, transcribed, and analyzed by using the “Sort and Sift, Think and Shift” qualitative data analysis methodology (18). During an initial learning period, 2 coders (K.S. and A.S.) used NVivo version 20 Pro/Plus to independently review 3 transcripts and identify themes across participants. They then discussed any divergence until reaching a consensus for each transcript. They repeated this process for all transcripts. The evaluation team summarized findings and reported them to the FQHCs, the Hawai‘i Department of Health, and other health providers implementing the National DPP LCP. The audience appeared to accept the themes and requested future evaluations of additional programs.

Results

Thirteen of 14 interviewed participants completed the survey (Table 1). All participants were women, and most (n = 9) were aged 25 to 44 years. Six reported being NHOPI and 3 Filipino. All but 2 participants attended classes in person. One participant attended classes exclusively virtually because the FQHC was an hour away, and the other attended hybrid classes because their cohort transitioned online during the COVID-19 pandemic.

Eight participants reported completing the year-long cohort. The reasons participants dropped out included caregiving issues, being too busy at work, and moving out of state. Of the 6 participants who withdrew early, 4 were FQHC employees.

Interview themes were 1) motivators to enroll in the National DPP LCP, 2) barriers to participation, 3) facilitators that increased participation, and 4) suggestions to improve the program (Table 2).

Motivators to enroll in the National DPP LCP

Participants were motivated to enroll in the program to prevent progressing to diabetes; many reported a family history of diabetes and had witnessed its effect on their family members’ lives or had seen the consequences of diabetes among their FQHC patients. Nearly three-quarters were completely shocked and/or scared by their diagnosis. Even those who were not surprised by their diagnosis expressed alarm. Familiarity with and trust in the lifestyle coaches made people receptive to learning about and willing to enroll in the program. Participant success stories shared by lifestyle coaches were also motivating.

Barriers to participation

Participants reported barriers to both enrollment and attendance. Although all interviewees had enrolled in the National DPP LCP, not all were initially highly motivated to participate. The program seemed too intrusive or overwhelming, or presented another task for their day. For 1 individual, the fear of losing autonomy over her dietary choices was an enrollment barrier, but the lifestyle coach helped her overcome those fears.

The most common barriers to attending classes were scheduling conflicts and caregiving responsibilities. Scheduling conflicts were often reported by participants who were FQHC employees because their schedule or required clinic commitments overlapped with class times. Barriers faced by the 6 women who did not complete the program included work scheduling conflicts, lack of childcare, and moving out of state.

Facilitators that increased participation

The biggest factor facilitating both enrollment and attendance was social support from the lifestyle coach and other participants. Lifestyle coaches’ support and confidence in participants’ ability to make behavior changes bolstered participation. Lifestyle coaches also provided make-up classes, sometimes one-on-one, to help retain participants who were unable to attend scheduled classes.

Most participants felt that the group dynamic provided them with peer support and accountability, which helped them to continue attending and striving for their health goals. They valued having a space to discuss ways to improve their diet and/or their fitness plans by sharing what had and had not worked for them. Other facilitators included having tools such as step counters and social media to track and share their progress in meeting goals.

Suggestions to improve the program

Participants recommended offering more classes at different times and allowing family members to attend regardless of their diabetes status. They suggested holding classes in a private space to help participants feel comfortable. Tailoring the nutrition content from the standardized workbook recipes to healthier versions of culturally relevant recipes allowed participants to further engage in lessons.

Implications for Public Health

The main barriers experienced by our sample of majority NHOPI and Filipino participants were similar to those reported in studies of other racial and ethnic populations participating in the National DPP LCP. Scheduling conflicts were the most reported barrier in studies of non-Hispanic White and Hispanic adults (10,11) and remained so for NHOPI and Filipino adults. Even with leadership support and a work culture that prioritizes health — factors that facilitate employee participation in LCPs — FQHC employees encountered difficulties attending classes held at their worksite. More evening and weekend classes would help to reduce participation barriers and were recommended by other studies (11,19). However, offering more classes poses a financial challenge for the National DPP LCP sites in terms of hiring additional lifestyle coaches and having areas to offer classes in facilities with limited space.

NHOPI and Filipino interviewees in our study reported that lack of childcare and other caregiving responsibilities interfered with their ability to participate, in alignment with other studies (19,20). To alleviate caregiver barriers, participants suggested including family members regardless of their prediabetes status and expanding eligibility criteria to include children. Literature shows that participating in the National DPP LCP with a household member can increase engagement, suggesting that including family members in classes can address caregiving barriers and increase social support to bolster program retention (21,22). Additionally, because many interviewees had a family history of diabetes, and Asian and NHOPI people are more likely than non-Hispanic White people to live in multigenerational households (23), a family-centered approach to LCPs could produce a generational effect on diabetes.

Despite barriers, effective recruitment of NHOPI and Filipino adults to the National DPP LCP in these rural communities is possible. These rural FQHCs addressed transportation barriers by offering the program virtually, similar to what was recommended in other studies (19). Promoting the program through community FQHCs and using trusted community members (eg, community health workers, FQHC employees) to conduct classes were effective strategies for recruiting these populations. Establishing community relationships is key to improving engagement of NHOPI and Filipino people in National DPP LCPs. Data from the PILI ‘Ohana Lifestyle Project showed that partnerships with trusted community organizations dedicated to serving NHOPI people facilitated enrollment of racial and ethnic minority adults (4).

Our evaluation study had several limitations. First, the evaluation sample was small. Despite the low response rate, the sample was demographically similar to all who participated in the 2 FQHC programs in terms of gender (100% vs 92.5% women, respectively) and race (64.3% NHOPI and Asian vs 72.5%, respectively). Second, the sample mostly comprised FQHC employees, which may limit the generalizability of findings to other National DPP LCP sites. However, it is not unique for employees to participate in a diabetes prevention program held at their worksite (24). Third, lifestyle coaches recruited participants to the study, which may have resulted in more participation from people who had positive feelings about their experience than from people who had negative feelings. Fourth, the evaluation lacks the perspectives of participants who were referred to the program but did not enroll, which is critical to understanding barriers to enrollment. Fifth, because this evaluation occurred 4 years after the first cohort, participants in the earlier cohorts may have had limited recall of their experiences in the program. Despite these limitations, a strength of this study was that it documented the perspectives of ethnically diverse participants who were from rural communities and included perspectives of both those who completed the program and those who withdrew early. Most importantly, most participants were NHOPI or Filipino, which contributes new information on the experiences of groups that are underrepresented in research and disproportionately affected by diabetes.

Overall, our study found that barriers and facilitators experienced by NHOPI and Filipino people are similar to those experienced by people of other races and ethnicities and people in rural communities. Addressing attendance barriers through expanded class times and engaging whole families could improve engagement and retention not only of these populations, but other racial and ethnic groups as well. Our study showed that NHOPI and Filipino adults can be successfully enrolled and retained in the National DPP LCP through cultural tailoring of the curriculum and emphasizing support from trusted community members and families. These strategies can be applied to other organizations looking to enroll and retain NHOPI and Filipino populations in the National DPP LCP to reduce disparities in prediabetes and diabetes rates.

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Tables

Table 1. Characteristics of Survey Participants (N = 13) and Interview Participants (N = 14) and How They Experienced the National Diabetes Prevention Program (DPP) Lifestyle Change Program at Two Federally Qualified Health Centers in Rural Hawai'i, 2023[a]

Characteristic	No.
Race and ethnicity[b] (n = 13)	
NHOPI	6
Filipino	3
Non-Hispanic White	3
Did not want to answer	1
Age group, y (n = 13)	
18–24	0
25–34	6
35–44	3
45–54	1
55–64	1
65–74	2
≥75	0
Family history of diabetes (n = 13)	
Yes	11
No	2
Family member with diabetes[c] (n = 11)	
Parent	6
Grandparent	6
Sibling	3
Other family member	1
Observed gender (n = 14)	
Woman	14
Man	0
Program modality experienced (n = 14)	
In-person exclusively	12
Virtual exclusively	1
Hybrid	1
Self-reported completion of the National DPP Lifestyle Change Program (n = 14)	
Yes	8
No	6
Familiar with lifestyle coach before enrollment (n = 14)	
Yes	12

Abbreviations: FQHC, federally qualified health center; NHOPI, Native Hawaiian and Other Pacific Islander.
[a] All 14 interviewees were asked to complete the survey after they were interviewed; 13 completed it.
[b] Participants were first asked to mark all race and ethnicities that applied to them, followed by the race or ethnicity that best represents them; values here are the latter.
[c] Eleven participants with a family history reported multiple family members with diabetes.

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Table 1. Characteristics of Survey Participants (N = 13) and Interview Participants (N = 14) and How They Experienced the National Diabetes Prevention Program (DPP) Lifestyle Change Program at Two Federally Qualified Health Centers in Rural Hawai'i, 2023[a]

Characteristic	No.
No	2
Participant type (n = 14)	
FQHC employee	9
Non-FQHC employee	5

Abbreviations: FQHC, federally qualified health center; NHOPI, Native Hawaiian and Other Pacific Islander.
[a] All 14 interviewees were asked to complete the survey after they were interviewed; 13 completed it.
[b] Participants were first asked to mark all race and ethnicities that applied to them, followed by the race or ethnicity that best represents them; values here are the latter.
[c] Eleven participants with a family history reported multiple family members with diabetes.

Table 2. Barriers and Facilitators to Enrolling and Participating in the National DPP Lifestyle Change Program: Quotes From Interview Participants (N = 14) From Two Federally Qualified Health Centers in Rural Hawai'i, February 2023

Theme	Quote	Participant identifier
Motivators to enroll in the National DPP lifestyle change program		
Reaction to diagnosis	I was shocked at that time, and like that's when I told myself I need to like change how I eat, to be better for myself and to be healthy . . . not only for myself [but also for the] people around me, like my family, friends.	Participant 13
Family history of diabetes	I was surprised, but not too surprised, only because I know how much I love my sweets. . . . But with them telling me, hey, you're prediabetic, you gotta start doing something. It was a shock, it was like an eye opener for me. . . . And of course, seeing my dad's situation. He's the only one, really, in my family who had diabetes. No one else did. So, I don't want to go through the same route that my dad did.	Participant 14
Trust in their lifestyle coach	Well, [the lifestyle coach and I] we're friends. . . . It's nice living in a small town, because everybody knows everybody. She had talked to me about it, and asked me if I wanted to go on this plan, and I said, "Sure, you know every little thing you can learn helps."	Participant 1
Barriers to participation		
Initial feelings about the program/barrier to enrollment	When you hear something about people trying to tell you how to eat, you don't want to hear that. It's no, you're going to eat whatever you want to eat. But then, after that first initial [meeting with the lifestyle coach], I thought like, "Oh, wow! This is something different, like maybe I'm gonna like it after all."	Participant 9
Caretaking responsibilities/barrier to attendance	I had, like, a lot of things going on that I couldn't really commit to leaving my house, and then going to, you know, the facility, and then sitting there with everybody . . . when you have to be at home with the kids, watching your parents, anything like that.	Participant 2
Facilitators that increased participation		
Social support from lifestyle coach	When she talks, I know she's talking to me . . . as a friend. So, it's a caring kinda talk, and when somebody talks to you in a caring way, you kind of more believe them.	Participant 1
Social support from cohort members	It just motivated us because we were all just doing a competition with each other, like, you know, who loses more weight? Who eats cleaner? . . . And then our favorite thing was every Wednesday we came together, and we're like, "Guess what, guys? I'm like one pound less, or like five pounds less."	Participant 12
Suggestions to improve the program		
Increasing class availability and offerings	Not just having one time available [for class]. I think that would be helpful. Instead of just having one class, I think it'd be nice if maybe you have multiple classes. Let's see, [issues with classes at a certain] time of the day [or lack of] multiple classes. That's just what was hard for me, personally.	Participant 14
Expanding eligibility to National DPP Lifestyle Change Program	Not just for the patients who currently have prediabetes, but like just sending it out to their families, because family . . . [may] know of other people who might be interested.	Participant 14
Providing culturally relevant content and resources	If we talked about something, and it wasn't so localized, we always think about how we could make it. . . . I think we talked about lau lau [traditional Hawaiian dish] one time, and someone was saying…to switch it out. You just put in sweet potato, no need put the meat. . . . We always talked about local food but how we were going to make it healthier. You know our workbook would be like, just eat potatoes.	Participant 5

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IMPLEMENTATION EVALUATION

Moving Diabetes Prevention Programs to the Workplace: A Qualitative Exploration of Barriers and Facilitators to Participant Engagement When Implemented by an Employer-Based Clinic

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PEER REVIEWED

Summary

What is already known on this topic?

Most participants who enroll in the Diabetes Prevention Program (DPP) do not remain engaged for the recommended 12 months.

What is added by this report?

Delivering the DPP as a virtual, synchronous class through an integrated health care model of an employer-based clinic (EBC) reduced barriers to referrals from providers and facilitated participant employees' engagement through the pandemic.

What are the implications for public health practice?

Using the EBC to deliver the DPP may be an important strategy in engagement for employee participants. Virtually delivered DPPs may play an important role with the increasing prevalence of hybrid work models, and they offer the potential to reach participants who cannot attend in-person classes.

Abstract

Purpose and Objectives

The Diabetes Prevention Program (DPP), an effective evidence-based strategy to reduce the incidence of type 2 diabetes, has been widely implemented in various locations, including workplaces. However, most people do not remain engaged in the program for the recommended full year. Limited qualitative research exists around participant engagement in the workplace DPP. Our study aimed to explore participant engagement in the DPP delivered through the employer-based clinic (EBC) at a large technology company.

Intervention Approach

The DPP was implemented through the EBC at a large technology company in Southern California, beginning in September 2019 by using in-person and virtual synchronous group classes before and during the COVID-19 pandemic.

Evaluation Methods

Virtual focus groups with DPP participants from 2 inaugural cohorts were conducted via Zoom from October 2020 to February 2021. Data were analyzed by using inductive thematic analysis.

Results

Five focus groups with 2 to 3 participants in each (total n = 12) were conducted, 2 focus groups per cohort and 1 focus group with the group instructors. Barriers and facilitators to engagement in the DPP were grouped into thematic domains: Individual Drivers, Small Group Community, Workplace Setting, Integrated EBC, and the COVID-19 Pandemic. Results showed that prepandemic workplace demands (ie, meetings, travel) affected DPP participation, yet the group setting provided social support in the workplace to engage in and maintain healthy habits. With the move to a virtual synchronous offering during the pandemic, participants valued the group setting but expressed a preference for in-person meetings. Collectively, participant engagement was bolstered by shared buy-in and collaboration between the employer and the EBC.

Implications for Public Health
Our findings suggest that engagement in a workplace DPP can be supported by addressing workplace-specific barriers and gaining buy-in from employers. Delivering the DPP, in person and virtually, through an EBC has the potential to engage employees who have prediabetes.

Introduction

The Diabetes Prevention Program (DPP) randomized clinical trial found that intensive lifestyle modification delivered in a year-long program reduced the incidence of type 2 diabetes by 58% among high-risk participants (1). The Centers for Disease Control and Prevention (CDC) created the National Diabetes Prevention Program in 2010 (2). Since then, the DPP has been widely implemented in approximately 1,500 different settings, including community centers, primary care clinics, churches, and worksites (3).

For people who enroll in the DPP to reap its full health benefits, they should ideally complete the full program. Recent studies had indicated that the degree of engagement, which prior authors defined as greater session attendance and more weekly physical activity minutes, predicted weight loss in community participants (4–7). In terms of longer-term benefits, the Diabetes Prevention Program Outcome Study, which followed participants from the original DPP trial for 15 years, found both lifestyle intervention and taking metformin reduced diabetes incidence by 27% ($P <$ .001) and 18% ($P =$ .001), respectively, compared with the control arm. In addition, in women (but not men), lifestyle intervention reduced microvascular disease by 21% (relative risk, 0.79) compared with placebo and by 22% (relative risk, 0.78) compared with metformin (8). However, evidence suggests that most people who enroll in DPP do not complete the course. Ely and colleagues explored high-intensity participation in the DPP, defined as completing 17 or more sessions (6). These authors found that among people enrolled from February 2012 to January 2016, only about 37% of enrollees met this threshold. Thus, better understanding of the barriers and facilitators of participant engagement is crucial to facilitate disseminating the DPP in ways that deliver its originally proven outcomes.

Recent evidence suggests that workplace DPPs are effective at preventing diabetes (4,9) and CDC has encouraged employers to play a critical role in helping employees prevent diabetes and cardiometabolic disease (10). Large employers are increasingly investing in employer-based clinics (EBCs) to enhance employee well-being, reduce health care costs, and improve productivity (11,12). According to the Business Group on Health, 53% of large employers invested in a worksite clinic in 2023; most are either occupational health clinics or primary care clinics (13,14). These clinics provide convenient access to primary care, preventive services, and occupational health services, reflecting a strategic focus on integrated health care management and employee health outcomes. Prior qualitative studies reporting on factors affecting attendance and engagement in DPP sessions are limited (11–14). Notably, a significant gap exists in the literature regarding qualitative studies reporting facilitators and barriers to participant engagement in a workplace DPP, particularly those delivered within an EBC. Our research aims to fill this gap.

Purpose and Objectives

The objective of our implementation study was to explore barriers and facilitators to participant engagement in a workplace DPP delivered through an EBC and to examine how converting from an in-person to virtual delivery mode during the COVID-19 pandemic affected engagement. We defined engagement as enrolling in the DPP, attending and participating in classes, and doing class activities, such as measuring one's weight, being physically active, and eating healthily. Our study aimed to explore participant engagement during the DPP, not after the program ends. We used qualitative methods to evaluate engagement in the DPP and to highlight key learnings for future implementation in similar settings.

Intervention Approach

An academic–corporate partnered EBC at a large technology company in Southern California implemented the DPP for its employees in September 2019. The EBC is located on the company's campus and provides comprehensive primary care services and on-site chiropractic care, physical therapy, optometry, and behavioral health services. The clinic is independently operated by Stanford Health Care, with physician staffing and leadership provided by the Stanford School of Medicine.

The DPP lifestyle change program consists of weekly classes for 2 months, semiweekly classes for 4 months, then monthly classes for 6 months for a total of 22 class sessions. Our first cohort (Cohort 1) started September 2019 and the second cohort (Cohort 2) started March 2020 (Figure). Cohort 1 classes began as in-person sessions, then moved to virtual synchronous sessions after 6 months at the start of the COVID-19 pandemic. Cohort 2 classes were exclusively virtual synchronous sessions because of the pandemic's shelter-in-place restrictions. Both cohorts were led by the same group instructors. One instructor was a registered dietitian, and one was a population health registered nurse. Employees of the technology company were eligible for the DPP if they had prediabetes and received care at the EBC. The DPP group instructors used the electronic health record patient portal to invite patients with a diagnosis of prediabetes to join the DPP. The instructors identified potential participants by running an automated report in the electronic medical record to find patients with HbA_{1c} levels in the prediabetes range (5.7%–6.4%) and sent them a bulk, nonpersonalized message about the program. Employees were made aware that there was no cost to participate in the DPP. They also learned about the DPP through their EBC primary care team, which made direct referrals to the program. The EBC physicians learned about the DPP through a presentation at their monthly staff meeting and individual outreach from the DPP group instructors.

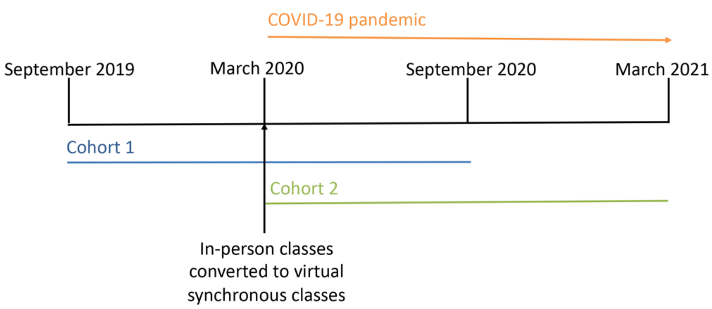

Figure. Timeline for the Diabetes Prevention Program, Cohort 1 and Cohort 2, implemented by an employer-based clinic. The first cohort (Cohort 1) started in September 2019 and the second cohort (Cohort 2) started in March 2020.

Evaluation Methods

Design

For our study, we invited DPP participants from the 2 inaugural cohorts and their group instructors to join focus groups to describe perceived barriers and facilitators to participant engagement. An exploratory qualitative study approach was used to explore themes (15), and the qualitative data were collected via virtual focus groups.

Selection and recruitment of participants

A convenience sampling technique was used to recruit focus group participants from the 2 cohorts who had recently completed or were about to complete the DPP. Cohort 1 had 14 participants (4 women) and Cohort 2 had 12 participants (2 women). An invitation to participate in a 1-hour focus group was sent via email to members of both cohorts, and a $25 DoorDash gift certificate was given to thank them for their participation.

Focus groups

We conducted 5 focus groups with a total of 12 participants (2–3 participants in each): 2 focus groups for cohort 1; 2 focus groups for cohort 2; and 1 focus group with the group instructors. Five members from each cohort participated in the focus groups along with 2 group instructors. Because of pandemic restrictions, the focus groups were video- and audio-recorded via Zoom with the permission of the participants and lasted from 45 to 60 minutes. The groups were led under the supervision of a PhD-trained qualitative researcher (C.B.J.) and conducted between October 2020 and February 2021, with the support of two MPH-trained colleagues, a doctoral student (A.B.) and a physician (S.T.), with participants who had recently completed or who were about to complete the DPP. All participants resided in California at the time of the focus group. Group discussion used a semistructured interview guide with open-ended questions relating to barriers and facilitators to engagement, which included outreach, enrollment, participation in the course activities, and meeting format. Two semistructured interview guides were use, 1 for group facilitators (Table 1) and one for DPP participants (Table 2).

Data analysis

Focus group discussions were transcribed from the Zoom recording and all transcripts were coded in NVivo 1.4.1 (Lumivero). Data were analyzed by using inductive thematic analysis (16). Three reviewers (C.B.J, S.T., A.B.C.) were involved in qualitative coding and analysis. Two reviewers double-coded 1 focus group transcript to develop a preliminary coding schema. Once a coding schema was developed, focus group transcripts were coded individually. Coding was reviewed by all 3 members by meeting regularly to reach consensus; changes were made to the codebook as necessary. The coded data were inductively examined for themes that represented perceived barriers and facilitators to participant engagement in the DPP. We found no thematic differences between the cohorts or group instructor focus groups, so data are presented in aggregate.

Results

The DPP participant focus group consisted of 10 people. Their average age was 45 years; 4 participants were female, which was higher than the number of females (23%) overall in the DPP, and were of the following races or ethnicities: 30% White, 50% Asian, and 20% Hispanic. The instructor focus group consisted of 2 White females with an average age of 55 years. We refer to each participant (P) by assigned numbers (eg, P1, P2) and instructors (I) by assigned number (I1 or I2).

Based on the inductive coding process, 5 themes emerged, and barriers and facilitators to participant engagement were identified for each. The 5 themes were individual drivers, small group community, workplace setting, integrated EBC, and COVID-19 pandemic. We described the detailed results for each domain and the barriers and facilitators to engagement of each theme (Table 3).

Theme 1. Individual drivers

Barrier: Limited bandwidth and motivation, especially during COVID-19. Participants said life was busy, which made engaging with the DPP difficult. DPP instructors observed that employees' significant work demands and stress could make finding time to make healthy lifestyle changes difficult. One instructor (I2) said that "workload and stress levels are very, very high." This then played into (I2) "their ability to find the time to exercise, to find the time to do meditation or relaxation." Participants echoed this, with one (P1) saying "sometimes it was just too many things to do."

During the COVID-19 pandemic, personal accountability became more important than external accountability because of social isolation. Participants said that being accountable to others could bring up feelings of shame if their lifestyle behaviors had not improved. They noted that making behavior change ultimately required having enough self-motivation.

> . . . the problem comes up if I am self-motivated enough to sustain it for a long time . . . I think my longest was about three months. But then, you know up and down . . . especially when there's a lot of work, just end up binge eating or something like that. (P9)

Facilitator: Knowing diabetes risk and the perceived benefits of the DPP. Learning about their risk for diabetes and how to prevent it motivated participants to engage in healthy changes. Increasing knowledge about a healthy diet, exercise, and weight maintenance supported participants in making practical lifestyle changes. For one participant (P4), knowing they could change the course of getting diabetes by making healthy changes made joining the DPP seem obvious: "I have to do everything that I can to stop this [diabetes] from occurring to me." Another participant said that their family history of diabetes pushed them to be proactive to avoid it.

Participants reported that the DPP's inclusion of tracking (ie, participant's food intake, physical activity, body weight) and regularly scheduled meetings helped to enhance their knowledge about how to put healthy behavior change into practice. Several participants mentioned the importance of this accountability, highlighting that the group acted, " . . . like a nudge to improve your activity numbers." (P6).

Knowing that others would learn about their progress encouraged participants to make behavior changes.

> Accountability, going to this meeting and saying, "Hey look I really worked on myself for the next four weeks, and this is where I stand," that was for me, the main reason [for making healthy behavior change]. (P8).

Theme 2. Small group community

Barrier: Challenge of virtual social support, compared with in-person meetings. Participants said community building was more difficult with virtual meetings than with in-person meetings. Participants from both Cohort 1 and Cohort 2 expressed a preference for in-person meetings because the social interaction was more intimate. One participant from Cohort 2 said that having only the option to meet virtually likely stymied the group sharing dynamic.

> . . . because everybody is kind of a little bit shy and doesn't know what to say and everybody stands on a different level for this class so I think it would have probably given some people more support and an exchange to be a little bit more open about you know where they come from and what they are struggling with. (P8)

For those participants who started with in-person meetings, shifting to virtual meetings was better than not meeting, but in-person meetings ultimately were preferred. Sharing was not as seamless on video.

> . . . we are on video and that is somewhat uncomfortable, but when we meet in person . . . it's like friendly and warm and we are able to share anything even in our normal day routine if it's something or we cannot do something, all those information which is like little bit restricted when we move to videos. (P2)

Facilitator: Effective instructors and sharing with others who have similar struggles. The group format of the DPP facilitated sharing and learning for both in-person and virtual settings. Participants talked about the importance of hearing about common struggles, using the group dynamic to solve problems, and the group becoming a supportive environment. Participants felt accountable to the group and believed the group could help push them to continue building healthy habits.

> [It] was just to get on track and being in a group, I think, is beneficial. You hear from other people having successes or is just pushing yourself a little bit (P1).

The group instructors were pleased to see the level of engagement of Cohort 1.

> But I really think the group was just especially [engaged] because we're all in-person and they really were just engaged . . . we were worried that nobody was going to show up and all of a sudden, we have this room full of people, and it was a party, and they were sharing . . . some of them getting teary (I1).

The group instructors also said creating group support and enhancing the group dynamic was important. One instructor said that as participants progressed with the group, they increased self-efficacy in adopting healthy behaviors and a positive mindset.

> [They] learned something along the way. So always looking at the positive and I think we've heard that from people: "I know I have the tools. I know what to do" (I1).

Participants uniformly agreed that their instructors were instrumental in program engagement.

> I think that we couldn't have picked two better teachers. I think they're very compassionate, they listen. They know where we're at, they know what we're trying to accomplish. They reinforce things. Yeah. So, it was a great class (P3).

Theme 3. Workplace setting

Barrier: Competing demands at work. Participants noted that a major barrier to attending the workplace DPP meetings was competing workplace demands, particularly overlapping meetings. Before the pandemic, the in-person classes were scheduled to meet at the worksite over lunch. This took place weekly for 4 months, biweekly for 2 months, then monthly for 6 months. Several participants said a demanding workload, which potentially could include significant travel, sometimes conflicted with the DPP meeting times. Work meetings overlapping with the DPP meeting was especially problematic for participants who did not proactively block off their work schedules for DPP.

> . . . [I] take measures such as blocking out [my calendar] and deliberately cutting [the] other meeting short to make room for it, but it worked out well that Thursday was somewhat less contested during the course (P7).

During the pandemic, the workload seemed to increase because the expectation from coworkers was that everyone would be online continuously without set breaks for lunch, which conflicted with the DPP meetings.

> I think just the norm that people expect, you know, "Hey, you're at home, you're available, you're just sitting there. We're going to do a lunch hour meeting," because everyone's available during lunch hours (P3).

Facilitator: On-site DPP meetings and resources. Prepandemic, workplace on-site meetings contributed to an increase in meeting attendance because of their close proximity and allowed people to participate during the workday even if their schedules became busy.

> I used to have some meetings right before [the DPP class] and that meeting was always running late . . . I decided that it's better to join even 10 minutes late than not join and that seemed to work for me (P1).

The workplace site for this DPP included a free on-site gym, and prepandemic, some participants took advantage of this convenience by exercising at work. The DPP group instructors organized personal training sessions at the on-site gym for participants. This relationship facilitated exercise (at least prepandemic).

> . . . everybody is very supportive of everybody's time and the ability and flexibility to take some time to walk over to [the gym] (P4).

One group instructor commented that the workplace environment was conducive to bringing employees together for a shared concern such as diabetes prevention, even when they did not know each other initially.

> We had never really started group programs because of the concern that they [employees] may not really . . . feel comfortable, like in a group setting talking about things . . . which is understandable right in a corporate environment anyway? But . . . what we've seen . . . bringing them together and facilitating it in the right way and having that commonality, it actually is just exactly what they want and then what they need (I2).

Theme 4. Integrated employer-based clinic

Barriers: None mentioned.

Facilitator: Ease of access to health care services. Because of the integration of the health care system into the workplace, employees could receive their primary care from the EBC and be referred by their primary care provider to the DPP, which was delivered through the EBC. Through the EBC, participants had annual check-ups and laboratory work that revealed prediabetes. This deemed them eligible to enroll in the DPP. Participants noted that when they learned they had prediabetes, it was motivating to be recommended to the DPP by their dietitian or primary care provider.

> And then we got my numbers back . . . I freaked out . . . [my primary care provider] gave me more information. And she says, I think you're a good candidate for this [DPP] program (P4).

> I'm just glad Stanford is there at our facility; it makes it so convenient (P3).

Furthermore, participants noted that receiving this information from their EBC clinician was motivating. One participant said that they "did not want to start any kind of medication and wanted to get it [the prediabetes] under control." (P8)

Theme 5. COVID-19 pandemic

Barrier: The pandemic magnified barriers to healthy behaviors. The COVID-19 pandemic acted as a multiplier to many of the previously described barriers. For instance, work hours increased, and work and home life became more stressful, leading to participants falling back into unhealthy habits.

In both Cohorts 1 and 2, the onset of the pandemic caused a rapid shift in participant priorities. Lockdown measures caused their daily environment to shift from the workplace to home. Additionally, concerns around infection and safety increased psychological distress. The focus on preventing diabetes became less important, with one participant noting that, "when the lockdown started somehow my priority shifted to other aspects. And it was a little bit more difficult." (P1)

Additionally, some participants said that at the beginning of the pandemic they exercised less, ate less healthily, and gained back their weight.

> When we started staying at home, and were not allowed to go out, I actually gained almost what I started [with] . . . we have restriction in what food items we can get online and all those things. So yeah, during that time I gained a lot of weight . . . (P2)

The challenges of adjusting to working from home and personal losses from COVID-19 increased stress among participants. Participants also said that because they were homebound, they were unable to get the daily exercise that they maintained at work and to stay consistent with their health goals.

> From a health perspective, it was not healthy. I was not as active. At work I bounced between the different buildings. So, I would walk to all my meetings. Whereas here, you know, you get out of bed, in your day pajamas and you're sitting, sitting there from 7 to 5. (P3)

Facilitator: Adjustment to pandemic life. Participants reported that they reverted at first to previous poor health habits, but as they adjusted to life in lockdown, many said that they were able to make the best of a bad situation. Because travel for work stopped, participants were able to focus on a continuous, healthy meal plan that was uninterrupted by air travel and constant meetings. They were able to readily visit with their primary care provider in a virtual setting that was less disruptive to their work schedule. Additionally, participants said that working from home afforded increased flexibility to find time to be physically active.

> When you're at work that prep time [to workout] has to be done somewhere. I can't be in a meeting and be changing or shampooing. So that's the reason it's tougher to do [workouts] at work. (P6)

Implications for Public Health

Understanding barriers and facilitators to participant engagement in the DPP is crucial for optimizing program efficacy and assisting participants in maximizing its benefits. Our study found that both the workplace setting and the integrated EBC health care system were strong facilitators for participant engagement, and the virtual synchronous class led by engaging group leaders supported group cohesion during the pandemic, However, participants expressed a preference to meet in person for their group class.

As in previous research, we found that the group instructors' interpersonal and facilitation skills were an integral piece of the group's cohesion and an important contributor to participant engagement in the DPP (17). Although the employees of this large technology company were unknown to each other at the start of the DPP, they had no trouble connecting. Furthermore, in alignment with existing DPP literature, group support from fellow employees was integral to participant engagement, accountability, and maintenance of behavior change (17,18). We found that this trend was maintained even when the course was delivered virtually. Additionally, our study points to the importance of individual motivation. We found that a participant's prediabetes status and a family history of diabetes were important motivational factors to engage in the DPP and support behavior change efforts. When individual motivation was low, such as when someone did not meet their weight loss goals, group support became ever more important.

We found specific facilitators and barriers related to the workplace setting that suggest that employers have a unique opportunity to play an integral role in participant engagement in a workplace DPP. Participants believed having their employer support the DPP by making it available to them without cost, having an on-site gym, and having on-site DPP meetings over the lunch hour were facilitators to engagement. Competing workplace demands (eg, meetings, travel) were barriers. Such barriers noted in prior qualitative research on community DPPs, including cost, location, meeting time, and conflicts with work schedule (19), could be removed by having an affordable workplace DPP. Prior research suggests that some workplace DPPs are less effective than others because of workplace characteristics, such as the social and physical environments (9). Thus, when considering the implementation of a workplace DPP, employers should consider how to integrate the program within the organizational infrastructure, such as scheduling meetings at a time when most employees can attend and coordinating with on-site or nearby fitness facilities. Modifying workplace demands can be challenging for employers, but prioritizing employee health warrants their diligent consideration throughout program implementation.

Our study also showed the advantage of delivering the DPP through an integrated EBC model, which facilitated communication among everyone involved. Because of the integrated model, DPP group instructors could reach out to primary care providers who learned the DPP was available to their patients. If a patient was interested in joining, the clinician could refer them to the DPP in the electronic health record and follow the patient's progress. Previous research on barriers to referral found lack of clinician knowledge about the DPP to be a common barrier (19). Because primary care providers can often motivate their patients to participate in the DPP, the EBC model underscores the benefit of implementing a DPP within an integrated employee health care model (18,20).

Having the option to participate virtually during the pandemic was a facilitator for engagement. Although the DPP was originally implemented as an in-person program, nearly 250 DPPs are exclusively distance learning (3). Virtually delivered DPPs are crucial because of the increasing prevalence of hybrid work models, which necessitate flexible and accessible health interventions that can accommodate employees working both remotely and on site. Virtual programs are important because they offer the potential to reach participants who cannot attend in-person classes; however, not all virtual DPPs successfully engage participants. A large multistate study exploring engagement in virtual versus in-person DPPs found that people referred to an online DPP were more likely to enroll, but less likely to remain engaged in the program (21). An online DPP may be convenient, but leaving it may be just as easy, which underscores the importance of developing strong group cohesion to motivate participants. Thus, workplace DPPs may have the advantage of creating a shared workplace identity among participants, which may bolster group cohesion and participant motivation.

Our study had several limitations. First, only those who enrolled in the DPP were eligible for the study, because its aim was to explore engagement during the DPP. Further examination of the barriers and facilitators to enrolling in the DPP for similar populations is warranted. Additionally, we collected limited demographic information to assure confidentiality in the workplace setting. Future studies may benefit from exploring barriers and facilitators to participant engagement based on demographic characteristics and identifying any similarities or differences. Finally, we did not collect data segmented on duration of participation in the DPP. Subsequent work would benefit from a deeper understanding of the various barriers and facilitators to participant engagement based on length of time in the program, as well as longer-term assessment of experience and sustained behavior changes of participants after completing the workplace DPP.

In summary, our qualitative study found that a workplace DPP delivered through an integrated EBC affected employee participant engagement. Participant engagement in turn was affected by competing workplace and life-directed demands, but personal motivation, group support, and accountability promoted program engagement. The virtual synchronous class option was important and appreciated during the pandemic, but incorporating in-person sessions during the year-long DPP may be needed for community building and group sharing. Delivering the DPP through an EBC fostered a sense of support from the employer, promoted an integrated approach to employee wellness, and reduced barriers to clinician referral to the DPP. Because our focus groups were conducted in only one EBC setting — a technology company with a largely young, majority Asian male population — our findings may not be applicable to other workplaces. Future research should explore the use of the DPP across diverse workplace settings with integrated primary care and examine how employers can support DPP implementation and employee engagement.

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Tables

Table 1. Instructor Semistructured Interview Guide, Diabetes Prevention Program (DPP) Group

Interview domains	Questions
Outreach	How did referred patients learn out about the DPP?
Outreach	What role has [company] played in making the DPP available to its employees?
Barriers to enrollment	For people who were referred to the program but not enrolled, why do you think they did not join the program?
Barriers to engagement	Throughout the program, what reasons prevented people from attending in-person classes? Video classes?
Facilitators of engagement	Throughout the program, what supported the participants' ability to change and sustain recommended behaviors?
Barriers to engagement	What factors made participants' ability to change and sustain recommended behaviors difficult?
Facilitators of engagement	What factors would have made participants' ability to report their physical activity, diet, and weight easier?
Barriers to engagement	What factors made participants' ability to report their physical activity, diet, or weight difficult?
Facilitators to engagement	Throughout the program, from recruitment to the end of the program, what factors motivated people to engage in the program?
Facilitators to engagement	What would you like to change to increase participant involvement and participation throughout the program, from recruitment to the end of the program?
Meeting format	How was the experience for the group and for the facilitators when the DPP went from in person to virtual?
Meeting format	What were the positives and negatives about doing the DPP in person versus virtual as it relates to participant involvement in attendance to sessions and behavior change?

Table 2. Participant Semistructured Interview Guide, Diabetes Prevention Program (DPP)

Interview domains	Question
Outreach	How did you learn about the Stanford DPP?
Outreach	What role has [company] played in your participation in the Stanford DPP?
Facilitators to enrollment	What motivated you to join the Stanford DPP?
Facilitator to engagement	How do you overcome factors that make it difficult for you to make it to class?
Barrier to engagement	What factors make it difficult for you to make it to class? (followup: Did this differ for in-person versus video?)
Facilitator to engagement	How do you overcome factors that make it difficult for you to make it to class?
Facilitators to engagement	What changes to the program would you recommend to make it easier to come to class?
Facilitator to engagement	What factors support your ability to change and sustain the behavior changes that you've learned in class?
Barriers to engagement	What factors most get in the way of your ability to change and sustain behaviors learned in class and to continue with the yearlong program?
Facilitator to engagement	What factors would make it easier to report your physical activity, diet, and weight?
Barrier to engagement	What, if any, factors made it difficult to report your physical activity, diet, or weight?
Meeting format	What do you like about meeting in person?
Meeting format	What would you change about meeting in person?
Meeting format	What do you like about meeting virtually?
Meeting format	What would you change about meeting virtually?
Meeting format	Thinking about the entire Stanford DPP program, what format would you prefer the classes be delivered in? For example, are there parts of the program/series of classes that would be better for one or the other?
Participation	What recommendations do you have to make this program more accessible to your peers who did not participate?
Participation	What would you tell a work colleague or friend who was considering the program?
Participation	What would you suggest change to increase recruitment and participation among your peers?

Table 3. Summary of Barriers and Facilitators to Participant Engagement in Diabetes Prevention Program, by Theme

Theme	Barrier	Facilitator
Individual drivers	Limited bandwidth and motivation, especially during COVID-19	Knowing their diabetes risk and the perceived benefits of the Diabetes Prevention Program
Small group community	Challenge of virtual social support, compared with in-person	Effective instructors and sharing with others who have similar struggles
Workplace setting	Competing demands at work	On-site DPP meetings and resources
Integrated employer-based clinic	None mentioned	Ease of access to health care services
COVID-19 Pandemic	Pandemic magnified barriers to healthy behaviors	Adjustment to pandemic life

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IMPLEMENTATION EVALUATION

A Communitywide Collaboration to Increase Enrollment, Retention, and Success in Evidence-Based Lifestyle-Change Programs in Racial and Ethnic Minority Populations

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PEER REVIEWED

Summary

What is already known on this topic?

Evidence-based lifestyle-change programs can reduce the burden of chronic disease. Unmet social needs disproportionately affect Black populations and the ability to enroll in and complete lifestyle-change programs.

What is added by this report?

We describe an example of how health care, public health, and community partners can work together to increase recruitment, enrollment, and success of Black people in evidence-based lifestyle-change programs.

What are the implications for public health practice?

Lessons learned from implementation and evaluation of lifestyle-change programs may be applied to other complex partnerships between clinical and community-based organizations to improve the health and well-being of people who are disproportionately affected by chronic disease.

Abstract

Purpose and Objectives

Chronic diseases (eg, diabetes, hypertension) are the leading causes of death in the US and disproportionally affect racial and ethnic minority populations. This disparity is partially due to the unequal burden of unmet social needs that stem from several factors, including racism.

Intervention Approach

The Alliance is a collaboration among health care, public health, and community organizations formed to improve referral, enrollment, and successful completion of evidence-based lifestyle-change programs, particularly among Black people. The Alliance built 1) a system to assess and address social barriers through the screening and referral process and 2) a training center for frontline staff (eg, community health workers).

Evaluation Methods

From January 2020 through September 2022, we conducted an evaluation that included both quantitative and qualitative methods. We developed an electronic database to make referrals and track key barriers to participation. Additionally, we conducted a focus group among frontline staff (N = 15) to understand the challenges in making referrals and discussing, documenting, and addressing barriers to participation. We used surveys that collected quantitative and open-ended qualitative responses to evaluate the training center and to understand perceptions of training modules as well as the skills gained.

Results

Frontline staff engaged with 6,036 people, of whom 847 (14%) were referred to a lifestyle-change program from January 2020 through September 2022. Of those referred, 257 (30%) were eligible and enrolled in a program. Food access and unreliable internet were the most common barriers to participation. Thirteen of 15 frontline staff participated in trainings, and, on average, trainees completed 4.2 trainings and gained several skills (eg, ability to

monitor personal bias, de-escalate a crisis, educate on mental health, understand community and environmental factors).

Implications for Public Health

The Alliance is an example of how health care, public health, and community partners can work together to increase enrollment in lifestyle-change programs of residents disproportionately affected by chronic diseases. Lessons learned from implementation and evaluation can inform other complex partnerships to improve public health.

Introduction

Chronic diseases such as diabetes, heart disease, hypertension, and stroke are the leading causes of illness, disability, and death in the US (1). Approximately half of the US population has a chronic disease, and these diseases account for 86% of all health care costs (2,3). More than 133 million Americans have diabetes (37.3 million) or prediabetes (96 million) (4). Diabetes and other chronic diseases disproportionally affect racial and ethnic minority groups. In 2018 in St. Louis City, the disparate burden of diabetes offered a stark example: the prevalence of diabetes was 13.4% among Black residents and 5.5% among non-Hispanic White residents, while diabetes mortality was 26.8 per 100,000 Black residents and 21.0 per 100,000 non-Hispanic White residents (5). Chronic diseases are affected by interdependent genetic, social, economic, cultural, and historical factors (6). The unequal burden of unmet social needs among Black people also contributes to chronic disease disparities (4,7).

The disparity in unmet social needs among Black people stems from racism, the unjust social, economic, and political oppression of non-Hispanic White people in the US. Racism occurs at multiple levels, including systemic racism, which creates structural barriers to health care access, and interpersonal racism, enacted by health care providers on their patients (7,8). Unmet social needs not only affect the risk of developing a chronic disease but also contribute to a disproportionate level of complications among non-Hispanic Black people (9,10). Despite the higher prevalence of chronic diseases and complications among Black people, they are less likely to receive recommended preventive care (9,11). The work described here focuses on addressing interpersonal racism, by training frontline staff who provide care for Black people, and structural racism, by providing resources to address unmet social needs that stem from inequitable environments and systems.

The Centers for Disease Control and Prevention (CDC) developed a suite of evidence-based lifestyle-change programs (LCPs) that provide preventive services through community organizations (eg, the YMCA). The Diabetes Prevention Program (DPP) was established in 2010 and is an evidenced-based LCP designed to prevent or delay the onset of type 2 diabetes (12). The CDC-approved curriculum — written at the 6th-grade reading level — is a year-long program instructed by lifestyle coaches with the goal of helping participants achieve a healthier lifestyle that encompasses nutrition changes, increased physical activity, and stress reduction (12). The DPP has demonstrated that lifestyle changes can be more effective than prescription medication to prevent or delay the onset of type 2 diabetes (13). The DPP Research Group found that 58% of people with prediabetes and 71% of people aged older than 60 years were able to meet the goal of decreasing body weight by 5% to 7% (14). Virtual DPP programs have helped people to meet weight-loss goals, especially people with low incomes and prediabetes who may not be able to attend in-person LCPs (13). The blood pressure self-monitoring program is a 4-month program developed by CDC to help participants measure their blood pressure correctly and consistently and educate them on healthy eating. Self-monitoring of blood pressure is supported by numerous national agencies (eg, American Heart Association) and can improve the management of hypertension (15).

Despite the evidence base for these programs, not everyone has an equal opportunity to access and succeed in these programs. Barriers to enrollment and participation exist, such as poor access to nutritious foods, few safe environments for physical activity, lack of transportation to programs, lack of reliable internet access or technology, and lack of childcare. Such barriers disproportionately affect Black people and families and may contribute to disparities in enrollment, retention, and success in LCPs (16). Screening for social needs allows providers to clearly identify barriers faced by program participants and determine how to effectively intervene. Interventions that alleviate unmet needs through screening, referral, and tracking of patients are imperative to increasing enrollment and success in LCPs (17).

Purpose and Objectives

The Alliance program was formed across multiple community-based health organizations in the St. Louis metropolitan area to design, test, and evaluate innovations that will optimize health status and advance racial equity. A major focus of the Alliance was to improve the reach of LCPs, particularly among Black residents living in the federally designated Promise Zone. Promise Zones are high-poverty, often medically underserved communities where the federal government partners with local leaders to enhance public health (18). These areas were formed by centuries of racial prejudice that resulted in migration patterns, both voluntary and forced, and territorial acquisition that led to the concentration of racial and ethnic minority groups (19). The largest of 22 Promise Zones in the US, the St. Louis regional Promise Zone comprises 25 zip codes in the northern region of the city and county, an area that is home primarily to Black residents.

The objective of this article is to describe the process and preliminary outcomes of the implementation and evaluation of the Alliance program. It will provide insight and describe lessons learned on addressing interpersonal and structural barriers to improving antiracist efforts in chronic disease prevention and summarize factors that affected the ability of the Alliance to refer and enroll members of a racial minority group, specifically low-income Black people, in LCPs.

Intervention Approach

The Alliance is a partnership among the Missouri Department of Health and Senior Services, the St. Louis County Department of Public Health, the City of St. Louis Department of Health, the Integrated Health Network, the Missouri Primary Care Association, the Missouri Pharmacy Association, Fit and Food Connection, and the Gateway Region YMCA (Figure). The partnership was funded by CDC's Division of Diabetes Translation DP18-1817 project, a 5-year cooperative agreement, which launched October 1, 2018, and ends September 30, 2023. The project funds health departments to develop new and innovative approaches to increase the reach and effectiveness of evidence-based public health strategies in populations and communities with a high burden of diabetes, heart disease, and stroke (20).

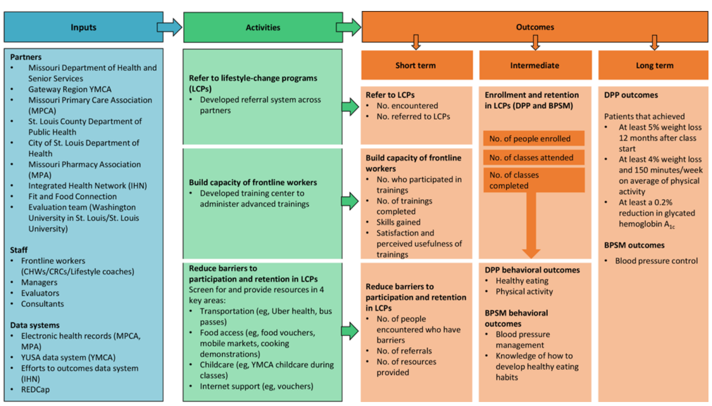

Figure. The Alliance logic model. Abbreviations: BPSM, blood pressure self-monitoring; CHW, community health worker; CRC, community resource coordinator; DPP, Diabetes Prevention Program; IHN, Integrated Health Network; LCP, lifestyle change programs; MPA, Missouri Pharmacy Association; MPCA, Missouri Primary Care Association; REDCap, Research Electronic Data Capture; YMCA, Young Men's Christian Association; YUSA, YMCA of the United States of America.

The main provider of the national DPP program and other LCPs (eg, the blood pressure self-monitoring program) in St. Louis is the Gateway Region YMCA. The Alliance supports community health workers and community resource coordinators, referred to as frontline workers, at partner organizations to screen patients for diabetes and hypertension risk and make referrals to LCPs. Lifestyle coaches, also considered frontline workers, facilitate programs and further support patients once they are enrolled in a program. Lifestyle coaches work with community health workers, community resource coordinators, and a community health navigator, who is embedded in the YMCA, to address social needs throughout the program with the goal of supporting people to complete the 12-month DPP.

Assessing and addressing social needs

The Alliance program developed a system to identify social barriers that may challenge full participation and success in LCPs. The system allows frontline staff at partner organizations to direct participants to other community programs and resources (eg, food assistance programs) that support health and well-being. For those who enroll in an LCP, the Alliance provides access to food vouchers, YMCA memberships, cooking and wellness-related classes, transportation subsidies, and onsite childcare to improve equity in enrollment, retention, and completion. Community health workers and partner organizations created a list of resources and a process for recommending, using, or accessing these resources to address patient barriers to participation.

Training center for frontline staff

The Alliance also built the capacity of frontline staff to interact with people disproportionately affected by chronic diseases, specifically Black residents, in community and clinical settings without the intention of inflicting interpersonal racism. To support a well-rounded and versatile workforce and offer high-quality training opportunities, the Alliance launched a training center in year 2.

Participation in training modules was not required of frontline staff but was strongly encouraged. Project staff created an online hub to notify frontline staff of training opportunities. A bootcamp-style training, including an introduction to relevant partners, resources, and procedures, was developed to orient frontline staff to the Alliance project. This training is now required of all new frontline staff and remains available for staff to take multiple times if needed.

Evaluation Methods

The Alliance used a strategic evaluation planning process for its evaluation. This process facilitates a transparent, logical, and participatory approach for assessing program and project-level outcomes (21). The strategic evaluation planning process involved 2 key groups throughout planning and evaluation: 1) program operators (eg, coalition partners, staff) and 2) primary users of the evaluation (eg, sponsors, collaborators, managers, partners). In year 1 (October 2018–September 2019), the Alliance evaluation team worked collaboratively with each partner to set up equitable data collection and reporting systems tailored to each organization while ensuring the collection of information needed for the overall evaluation. Outcomes were selected to align with 1) the goal of increasing the number of people, especially Black people, referred to, enrolled in, and successful in LCPs and 2) each organization's reporting systems and capacity to ensure that data collection and reporting were realistic and sustainable.

Quarterly data report. The team created a quarterly data report that aggregated information from each partner and communicated progress toward program goals. In this highly collaborative, multipartner program, consisting of many interrelated strategies, these data reports provided a mechanism for the Alliance leadership to manage risks and challenges that could impede successful implementation. Quarterly data reports were presented in all-partner meetings, distributed by email, and uploaded to a shared drive, which gave partners on-demand access to information on the progress and results of the evaluation project.

Referral system. The project team used REDCap (Research Electronic Data Capture) software hosted at Washington University in St. Louis. REDCap is a secure, web-based software platform designed to support data capture for research studies. We developed an electronic form and database in REDCap that launched in January 2020 and allowed all Alliance partners to make referrals to the YMCA through a common pathway. The referral form included information about the frontline staff member making the referral and their Alliance organization to allow for tracking at the organization level and allow the YMCA to communicate with the referring organization about the status of the person referred (eg, whether they enrolled, were actively engaged, or completed the program). The YMCA monitored referrals via REDCap in real time and used the system to track enrollment information and patient demographic data.

Addressing social needs and averting interpersonal racism. In addition to the referral system and quarterly data reports, the evaluation team used quantitative and qualitative approaches to examine 2 key strategies used by the Alliance: 1) accounting for social needs and barriers to participation and 2) building the capacity of frontline staff to interact with racial and ethnic minority populations in ways that do not inflict interpersonal racism. The referral system allowed frontline staff to document 4 barriers to participation identified by the Alliance partners as key to enrolling and being successful in LCPs: lack of transportation, food insecurity, lack of reliable internet, and childcare needs. Each organization had its own method for assessing social needs.

Focus group. Ten months after launching the referral system, the evaluation team conducted a focus group with frontline staff to understand the challenges of discussing, documenting, and addressing barriers to participation and making referrals to LCPs. The focus group was conducted virtually during the regular bimonthly meeting of frontline staff. Questions were developed to gain insight into the experiences of the frontline staff during their encounters with patients. Questions addressed social barriers that affect patients' ability to stay healthy, challenges in assessing unmet social needs, resources for patients' needs, and sustainability of assessing social needs after the Alliance project ends. The session was recorded and transcribed verbatim for analysis. Additionally, interactive all-partner activities were conducted throughout the project to refine processes across organizations. For example, frontline staff and managers from all partner organizations participated in mapping referral pathways and amending language on the referral form to better fit the needs of partners.

Training center. To evaluate the training center, project staff monitored participation in each training module and provided participants with a pre- and postsurvey to measure short-term changes in knowledge and frontline staff perception of training module effectiveness. Additionally, annual surveys were distributed to all participants to assess long-term maintenance and application of knowledge and skills. These annual surveys included open-ended questions to allow for qualitative responses. Data quality issues emerged with the pre- and postsurvey collection due to changes in the implementation platform. As a result, presurvey and postsurvey results are not reported. For this evaluation, we have results only for the annual survey conducted in September 2021, during year 3 (October 2020–September 2021). Year 4 (October 2021–September 2022) and year 5 (October 2022–September 2023) annual surveys had not been administered at the time of this writing. Barriers and facilitators of developing and implementing the training center were documented through informal discussions with relevant program staff and managers.

Evaluation framework

We used the Practical, Robust Implementation, and Sustainability Model (PRISM) to consider the dimensions of reach, effectiveness, adoption, and implementation and how they are influenced by multiple levels (ie, person, intervention, clinic or organization, and environment) (22). Year 1 of the 5-year project was used for hiring, planning, and establishing evaluation processes and systems for engaging the community and making referrals to LCPs.

Outcomes for all 5 years of the project were guided by the Reach, Effectiveness, Adoption, Implementation and Maintenance (RE-AIM) outcomes, which are part of the PRISM framework (Table 1). Reach was assessed as the absolute number of people encountered, defined as an interaction between an Alliance frontline staff member and a community member who could benefit from an LCP. A referral is a result of an encounter whereby a connection to LCPs is provided to the participant. The reach of the training center was examined as the number and proportion of frontline staff who participated in trainings. Effectiveness was defined as making referrals and enrolling people, especially those in the Promise Zone, in LCPs, and providing support for unmet social needs. The effectiveness of the training center was assessed as skills gained from trainings. Adoption was operationalized at the organizational level to understand which partners were participating in referrals and trainings. In the future, evaluation data will allow examination of retention and success (eg, improvements in health behaviors and outcomes) of program participants who received referrals (Figure). Additionally, the evaluation team will examine whether people who received the needed social support (through community resources, vouchers, etc) had better participation, retention, and success in the program than people who did not receive such support. As highlighted in PRISM, it was critical to realize the importance of context when examining the implementation of the Alliance project because it aimed to coalesce multiple organizations, each of which had its own resources, systems, cultures, and setting.

Data analysis

We used descriptive statistics and SAS version 9.4 software (SAS Institute Inc) to analyze all quantitative data. A single rater used rapid qualitative analysis methods (23) to analyze qualitative data (focus group, meetings, training center surveys); these methods were validated by other evaluation team members. The qualitative data from the focus group were analyzed by using a priori codes based on the interview guides. Two team members read through and coded the text from the discussion and then talked through discrepancies for reliability. Themes were derived from the coded text and summarized. Thematic summaries were aggregated into a brief and presented to Alliance partners.

Results

Referral and enrollment

The Alliance had 15 frontline staff members during the study period (January 2020–September 2022), with an average of 13 per year across partners. These staff members engaged with 6,036 people. Engagement increased as capacity (eg, number of frontline staff members, training, partnerships) increased (Table 2). On average, each frontline staff member engaged 234 people annually. Of the people encountered from January 2020 to September 2022, 847 (14%) were referred to the YMCA for an LCP (approximately 25 referrals per month). All 7 Alliance organizations referred community members to the YMCA. Referred people were aged on average 54.7 years (Table 3). Most (78%) were female and living in the Promise Zone (55%); 21% were food insecure, 15% had transportation needs, 3% needed childcare support, and 30% had unreliable internet.

Of those who were referred by Alliance frontline staff, 257 (30%) were eligible and enrolled in an LCP. Of these, 188 enrolled in the DPP and 76 enrolled in the blood pressure self-monitoring program; 7 people enrolled in both programs. On average, those who enrolled were aged 55.3 years. Most (92%) were female, 45% lived in the Promise Zone, 14% were food insecure, 9% had transportation needs, 1% had childcare needs, and 31% had unreliable internet (Table 3).

Focus group

Six of 15 Alliance frontline staff members participated in the focus group. Two main themes emerged from the data (Table 4). First was the importance of the frontline staff to the Alliance efforts. They described their work as "relationship-building" with patients and indicated they felt comfortable asking them about unmet social needs. They also reported serving as a resource person for many of their patients' needs, often joining forces with each other to find resources that fit. The frontline staff noted that a main responsibility is to help patients prioritize and address stressors such as immediate obstacles and identify resources in a scarce environment. They mentioned the importance of consistent updates with patients on progress for obtaining resources, so they can move to the point where they might consider an LCP. The second theme from the focus group was barriers to patient health. The frontline staff discussed how many of their patients are focused on survival and not on healthy eating or even disease prevention. They noted that patients without basic necessities "can't even see that as a goal," which makes it difficult to refer them to an LCP. These barriers to patient health were amplified by the impact of the COVID-19 pandemic. The frontline staff talked about creating a place where they could share information on resources to provide to their patients and develop a cohort among themselves to "share stories and information" that might make their job easier. In the end, they reported that this could help patients be able to address their unmet needs.

Training center

In year 3, a total of 13 frontline staff members participated in trainings offered by the training center (Table 5). Of the 13 participants, 6 worked for the Missouri Primary Care Association, 2 worked for the Integrated Health Network, 1 worked for the St. Louis County Department of Public Health, 2 worked for the Gateway Regional YMCA, and 2 worked for the City of St. Louis Department of Health. On average, trainees completed 4.2 training modules during year 1. Of the training modules offered in year 3, three addressed health equity, 1 addressed trauma-informed care, 2 addressed mental health, 3 addressed health literacy, and 3 addressed racial equity.

Trainees reported gaining several skills from the modules, including the ability to understand their role in the Alliance and monitor personal bias. Trainees also developed interpersonal and professional skills, including de-escalating crisis situations, fulfilling mandates for reporting, educating patients on mental health, and monitoring patients' exercise and health. Lastly, trainees developed skills to understand the influence of community and environmental factors on health equity. When asked how these skills would affect their ability to refer patients, trainees reflected on asking appropriate questions, understanding correct procedures, communicating their role to patients, and referring patients to appropriate LCPs and community resources. One trainee commented that the training modules helped them engage with patients in an "unconventional" way by considering their "interests, values, and culture."

Implications for Public Health

Lessons learned from implementation and evaluation can inform other complex partnerships between clinical and community-based organizations to reduce barriers stemming from interpersonal and structural racism and increase enrollment and retention in LCPs of people disproportionately affected by chronic diseases. This 5-year real-world intervention has several public health implications. Enrolling and retaining Black people in community- and evidence-based LCPs can reduce the unequal burden of chronic disease (24). The project provided an opportunity to document evaluation and implementation facilitators and barriers that may apply to future public health efforts. We have summarized lessons learned and potential strategies for improvement.

Understanding context and complexity

The Alliance is a partnership of multiple health organizations with various structures, systems, cultures, and priorities. Implementation science frameworks such as the Consolidated Framework for Implementation Research (CFIR) illustrate the multilevel factors within and outside an organization that affect implementation (25). The Alliance used an intentional, participatory implementation and evaluation planning approach to understand each partner's current systems and ensure that the intervention and evaluation fit the context of each organization. This fit also included gaining an understanding of each organization's workflow and employee responsibilities. The evaluation was planned in collaboration with our partners to leverage existing data and expand their capacity for systematic and rigorous data collection. Each organization had multiple people in 2 key roles for implementation: managers and frontline staff. Developing communication structures that ensured all implementers and evaluators had a common understanding of the Alliance goals, implementation processes, and requirements for data reporting was critical. For example, frontline staff members were encouraged to provide feedback immediately after each training module, which helped the project manager and evaluators amend topics and modalities for subsequent training modules and evaluations. Compounding the implementation and evaluation was the evolution of systems, processes, priorities, and people throughout the project period, which likely was heightened by the COVID-19 pandemic. Changes in data collection methods and platforms affected data consistency and quality (eg, pre- and post-survey data from the training center were not usable). Furthermore, COVID-19 placed unforeseen demands on Alliance partners that left staff stretched thin and unable to fully complete the planned project and evaluation activities within the intended time frame.

When working with racial and ethnic minority populations who are potential participants in LCPs, it is also critical to understand the context (eg, environments) and complexity (eg, life situations, competing demands, diverse needs) of their lived experience that translate into barriers to meeting their needs. Our frontline workers were valued members of the community; they understood and established trust in the community. Having nonjudgmental, truthful conversations about social needs allowed for meaningful intervention. On the other hand, the context of each encounter (eg, limited time, lack of privacy) was not always suitable for certain conversations or referral to an LCP.

Developing collective, multilevel buy-in and prioritization

Partnerships between community- and clinic-based organizations and researchers offer an opportunity to bring scientific and practice-based knowledge and experience together to improve the quality, value, and relevance of implementing interventions. To achieve meaningful public health impact, a diverse set of clinical and community programs and partners is needed (26). Residents must use multiple assistance and intervention resources to ensure their needs are met (27). To this end, the Alliance comprises various organizations (eg, clinics, health departments, community-based organizations, universities) and multiple partners with various roles (eg, implementers, managers, evaluators, funders). The effective delivery of interventions requires engagement and buy-in at multiple levels. The field of implementation science has emerged as a response to the challenges in translating evidence-based practices to real-world settings (28,29). Attention is paid to pre-implementation, which is the work necessary to effectively engage organizations and staff. Co-development of project goals, particularly with frontline staff, from inception may have generated stronger commitment and understanding of Alliance goals. Furthermore, clearly communicating implementation and evaluation expectations for each partner is vital to success. One facilitator of the Alliance's success in generating buy-in was the quarterly data report, which was disseminated via email and a shared drive and presented in all-partner meetings. These reports allowed partners to review collective progress and how this progress contributed to common goals. Additionally, the bootcamp-style training helped communicate project goals and structure to new Alliance members. Our intention was not to rigorously study these strategies; however, such a study could contribute to the field of implementation science by expanding the understanding of the mechanisms of change and the effectiveness of these discrete, multifaceted, and tailored strategies (30).

Being flexible and adapting

The Alliance evolved and responded to consequences of the COVID-19 pandemic in both engagement and service delivery. The COVID-19 pandemic started in year 2 (October 2019–September 2020) of this project, causing major shifts in priorities and resources as partners re-allocated staff to respond. Despite these shifts, engagement and enrollment in our programs increased, albeit slightly, each year. Although the main goal of the Alliance was maintained throughout the pandemic, flexibility was needed not only from partners but also from project funders, evaluators, and leadership. Some planned activities were delayed, while others sped up to support the community during the public health crisis. For example, an original program goal was to develop an online telehealth platform for DPP participants in year 4 (October 2021–September 2022). This goal was expedited. In year 3, we offered new remote classes, such as a lunchtime 30-minute exercise class and FitBit challenges, to all LCP enrollees. In addition to an online DPP course that was delivered by lifestyle coaches in a synchronous format, the Alliance piloted a self-paced online DPP program for 22 people. As a result of the effectiveness and acceptability among pilot participants, the Alliance opened referrals to anyone interested in this program. The community members' feedback was invaluable in developing this program.

Virtual LCPs became the only option for participating in an LCP during the COVID-19 pandemic. Virtual classes can improve access for people with transportation or time barriers or limited access to technology devices or reliable broadband internet. Frontline staff were primed with resources (eg, the Affordable Connectivity Program offered by the Federal Communication Commission, library hotspots) to support people without internet access or in places with poor connectivity. Enrollees were further supported by lifestyle coaches. Infrastructure changes and additional resources are needed to fully support these people and improve digital literacy among populations who may not be comfortable using technology (eg, older persons).

Another example of the impact of the COVID-19 pandemic was flexibility in recruitment methods. Before the pandemic, community members were encountered primarily through in-person clinic visits, community events, and health fairs. During the pandemic, the Alliance shifted strategies to reach people remotely (eg, via telehealth, telephone) and launched a marketing campaign that promoted LCPs at transit stops and via social media. The Alliance leveraged increases in drive-through food distributions by including flyers about the Alliance program and the DPP in food boxes. The Alliance also increased community awareness of food resources by building a website that provides details of mobile grocery vendors and other food access opportunities.

Another adaptation to the COVID-19 pandemic was to change frontline staff trainings to a flexible, self-paced format and add COVID-19–related material (eg, a training titled "Understanding Health Disparities in Heart Disease in these Unsettling Times"). The Alliance also pivoted to support the needs of communities and partners. For example, frontline staff in clinical settings received training in a COVID-19 vaccine module to assist community members who were not vaccinated and had questions about the vaccine. To maintain project goals, vaccine appointments were leveraged as an opportunity to screen and assist with unmet social needs, particularly because these needs had increased during the pandemic among racial and ethnic minority groups.

Evaluating a constantly adapting project was a challenge. These adaptations required bidirectional communication with implementers and project managers to ensure progress toward intended goals. Annual documentation of progress was also required by the funder. Collaborative relationships between the Alliance evaluation team and partners were key to overcoming this challenge.

Keeping an eye to the future

To fully realize public health impact, we should broadly and equitably sustain effective public health programs and partnerships; this sustainment requires active and early planning (31). The Alliance evaluation will use a participatory design approach for developing a sustainability plan and generating capacity for sustainability. Sustainability capacity, defined as the ability to maintain systems and their benefits over time, may be influenced by 8 domains outlined in the sustainability framework: environmental support, funding stability, partnerships, organizational capacity, program evaluation, program adaptation, communications, and environmental support (32,33). To build capacity, it is necessary to systematically assess and understand factors affecting a program's sustainability capacity and develop a sustainability plan with actionable strategies. The Alliance will use a mixed-methods, partner-engaged approach involving quantitative surveys and qualitative interviews. We first want to understand perceived barriers (eg, resources, time) and facilitators within these 8 domains to continue the Alliance partnership and referral system. The use of such an approach to ensuring sustainability is essential to public health impact and is required by many public health agencies and foundations (eg, CDC, Robert Wood Johnson Foundation, Kaiser Permanente).

Conclusion

Responding to complex health inequities in communities requires collaborative partnerships. The Alliance is an example of how health care, public health, and community partners work together to increase recruitment and enrollment of racial and ethnic minority populations who are disproportionately affected by chronic diseases into evidence-based LCPs. Solely increasing access to these programs may not achieve the desired effect. The Alliance also aims to address interpersonal and structural racism that may generates barriers (eg, structural barriers to food access, physical activity facilities, childcare, and transportation) that impede equitable health improvements. The Alliance evaluation shows that strong collaborative relationships among partners and the co-development of systems and priorities can achieve positive outcomes.

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Tables

Table 1. Outcomes Guided by the Reach, Effectiveness, Adoption, Implementation, and Maintenance (RE-AIM) Framework in an Evaluation of a Project to Increase Participation of Black People in Evidence-Based Lifestyle-Change Programs, St. Louis, 2018–2023[a]

RE-AIM construct	Outcomes	Data sources
Reach	The absolute number of community members who were encountered (years 2–4)	Quarterly data reports; REDCap referral system
	The absolute number and proportion of frontline staff who participated in trainings (year 3)	REDCap Training Center survey
Effectiveness	The absolute number, proportion, and representativeness of community members referred and enrolled (years 2–4)	REDCap referral system
	Skills gained from trainings (year 3)	REDCap Training Center survey
Adoption	The absolute number and proportion of Alliance organizations that made referrals and participated in trainings (years 2–4)	REDCap referral system; REDCap Training Center survey
Implementation	Barriers and facilitators to implementing and evaluating the Alliance programs (eg, making referrals, addressing social needs, training frontline staff) (years 1–4)	Process data; focus groups

[a] The study period was January 2020–September 2022. The project was funded by the Centers for Disease and Control's Division of Diabetes Translation DP18-1817 project, a 5-year cooperative agreement, which launched October 1, 2018, and ends September 30, 2023.

Table 2. Engagement in a Project to Increase Participation of Black People in Evidence-Based Lifestyle-Change Programs, St. Louis, 2018–2023[a]

Phase	Year 2 (October 2018–September 2019)	Year 3 (October 2019–September 2020)	Year 4 (October 2020–September 2021)	Total
Engaged	1,917	1,915	2,204	6,036
Referred	317	230	300	847
Enrolled	50	99	108	257

[a] The study period was January 2020–September 2022. The project was funded by the Centers for Disease and Control's Division of Diabetes Translation DP18-1817 project, a 5-year cooperative agreement, which launched October 1, 2018, and ends September 30, 2023.

Table 3. Representativeness of Participants in Lifestyle-Change Programs, St. Louis, 2018–2023[a]

Characteristic	Total referred (n = 847)[b]	Total enrolled (n = 257)[b]
Age		
Respondents to question	798 (94.2)	257 (100.0)
Mean (SD), y	54.7 (13.2)[c]	55.3 (13.1)[c]
Missing data	49 (5.8)	0
Sex		
Respondents to question	837 (98.8)	257 (100.0)
Male	179 (21.4)[c]	20 (7.8)[c]
Female	655 (78.3)[c]	237 (92.2)[c]
Unspecified	3 (0.4)[b]	0
Missing data	10 (1.2)	0
Reside in the Promise Zone[d]		
Respondents to question	799 (94.3)	257 (100.0)
Respondents who reside in Promise Zone	440 (55.1)[c]	115 (44.7)
Missing data	48 (5.7)	0
Social barriers to participation		
Lack of food access		
Respondents to question	568 (67.1)	228 (88.7)
Respondents with lack of food access	119 (21.0)[c]	33 (14.5)[c]
Missing data	279 (32.9)	29 (11.3)
Transportation needs		
Respondents to question	564 (66.6)	226 (87.9)
Respondents with transportation needs	83 (14.7)[c]	21 (9.3)[c]
Missing data	283 (33.4)	31 (12.1)
Childcare needs		
Respondents to question	564 (66.6)	227 (88.3)
Respondents with childcare needs	16 (2.8)[c]	3 (1.3)[c]
Missing data	283 (33.4)	30 (11.7)
Unreliable internet		
Respondents to question	482 (56.9)	227 (88.3)
No. (%) of respondents	144 (29.9)[c]	71 (31.3)[c]
Missing data	365 (43.1)	30 (11.7)

[a] The study period was January 2020–September 2022. The project was funded by the Centers for Disease and Control's Division of Diabetes Translation DP18-1817 project, a 5-year cooperative agreement, which launched October 1, 2018, and ends September 30, 2023.
[b] Unless otherwise indicated, values are number (percentage).
[c] Percentages are based on number of respondents who answered question.
[d] Promise Zones are high-poverty, often medically underserved communities where the federal government partners with local leaders to enhance public health (18).

Table 4. Themes and Example Quotes From Focus Groups With Alliance Frontline Staff in a Project to Increase Participation of Black People in Evidence-Based Lifestyle-Change Programs, St. Louis, 2018–2023[a]

Theme	Example quotes
Theme 1: Importance of frontline staff to Alliance efforts	I think one of the benefits of having community health workers screen for social determinants of health is that they are experts in developing that relationship and that rapport to be able to access information.
	It depends on that rapport that that CHW [community health worker] or CRC [community resource coordinators] or whoever originally builds with the patient. That carries a long ways. If you come off like you know everything, you will not get answers. You will get just what they want to tell you. You have to be a person to them.
	A lot of these things really affect people in ways that you might not think about unless you're really, really working with them every day.
Theme 2: Barriers to patient health	Our patients certainly struggle with transportation, food and childcare, but to me it's sometimes just the tip of the iceberg. There's all of the different adverse community experiences they've had. Discrimination, poverty. A lot of different traumatic events that they've experienced. And so, then that's just another layer we have to consider when we're helping them to work through transportation, food, childcare and other social determinants. Because there's always layers of social and structural determinants of health that we have to address.
	We have patients who don't have electric or gas, they don't have a refrigerator, they don't have some things that some people might consider basic. That's their starting point. So, we have to start at their starting point, which sometimes is not necessarily focusing on healthy eating. So, we try to help them get those needs met so we can get them to a starting point of focusing on health.

[a] The study period was January 2020–September 2022. The project was funded by the Centers for Disease and Control's Division of Diabetes Translation DP18-1817 project, a 5-year cooperative agreement, which launched October 1, 2018, and ends September 30, 2023.

Table 5. Summary of Trainings Completed, by Domain, in a Project to Increase Participation of Black People in Evidence-Based Lifestyle-Change Programs, St. Louis, 2018–2023[a]

Training name	Domain (no. of modules)					No. of participants per training module
	Health equity (n = 3)	Trauma-informed care (n = 1)	Mental health (n = 2)	Health literacy (n = 3)	Racial equity (n = 3)	
Unequal Treatment: Disparities in Access, Quality, and Care	X				X	7
No Safety, No Health: A Conversation about Race, Place and Preventing Violence		X			X	8
Let's Live Healthy! High Blood Pressure in Pregnancy				X		5
Mental Health and Wellness: Positive Psychology and Psychiatry in Uncertain Times			X			9
Understanding Health Disparities in Heart Disease in these Unsettling Times	X				X	7
The Importance of Measuring Blood Pressure Accurately				X		4
Understanding the Intersection of Diabetes and Addiction	X		X			7
Use of Social Media and Peer Support in Diabetes Care: A Panel from AADE Project Leaders				X		7

Abbreviation: AADE, Association of Diabetes Care & Education Specialists.
[a] The study period was January 2020–September 2022. The project was funded by the Centers for Disease and Control's Division of Diabetes Translation DP18-1817 project, a 5-year cooperative agreement, which launched October 1, 2018, and ends September 30, 2023.

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ORIGINAL RESEARCH

Interests and Preferences in Programs to Improve Health Among Men With or at Risk for Type 2 Diabetes in Racial and Ethnic Minority Groups, 2019

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PEER REVIEWED

Summary

What is already known on this topic?

Men in racial and ethnic minority groups are less likely than non-Hispanic White men to participate in diabetes prevention and management programs, despite having a higher prevalence of type 2 diabetes. Research is limited on men's perceptions of lifestyle modification programs.

What is added by this report?

We identified characteristics and programmatic elements that might encourage men in racial and ethnic minority groups to participate in programs designed to improve their health.

What are the implications for public health practice?

Tailoring a program to the interests and preferences of men in racial and ethnic minority groups — with or at risk for type 2 diabetes — could lead to their increased participation in diabetes prevention and management programs.

Abstract

Introduction

Men in racial and ethnic minority groups are less likely than non-Hispanic White men to participate in programs designed to improve health, despite having a higher prevalence of type 2 diabetes. We sought to understand 1) the interests and preferences of racial and ethnic minority men, with or at risk for type 2 diabetes, in programs designed to improve health and 2) factors that influence participation and health practices.

Methods

We designed a 43-question web-based survey on facilitators and barriers to participation in a healthy living program. The survey was administered from August 27, 2019, through September 3, 2019. Our analytic sample consisted of 1,506 men at risk for or diagnosed with type 2 diabetes in racial and ethnic minority groups. We conducted descriptive and regression analyses of survey data.

Results

Most men (59%) were interested in participating in a healthy living program and/or program elements such as incentives (67%), male-specific health topics (57%), and the inclusion of family (63%). Flexibility was important, since "exercising when it is convenient for me" was the most frequently selected facilitator of physical activity and "the hours were inconvenient" was identified as a challenge in previous programs. Men in this survey were significantly more likely to be interested in participating in a health improvement program for several reasons, including if they were physically active 150 minutes or more per week (vs not) (adjusted odds ratio [AOR] = 2.2; 95% CI, 1.6–3.0) and had previously been in a healthy living program (vs not) (AOR = 1.5; 95% CI, 1.1–2.1).

Conclusion

Our findings can be useful for recruiting and retaining racial and ethnic minority men with or at risk for type 2 diabetes in programs designed to improve health and ultimately reduce disparities in the prevalence of diabetes.

Introduction

Racial and ethnic disparities exist in the prevalence of diabetes in the US: The prevalence is higher among American Indian or Alaska Native men (13.4%), Asian men (10.6%), Black or African American men (11.5%), and Hispanic men (12.2%) than among non-Hispanic White men (7.7%) (1).

For people who have diabetes, diabetes self-management education and support services provide skills training, education, and support (2). For people at risk for type 2 diabetes, the National Diabetes Prevention Program (National DPP) lifestyle change program (LCP) is a year-long intervention designed to prevent or delay the onset of type 2 diabetes through moderate weight loss, healthy eating, physical activity, and stress management (3). However, men infrequently participate in diabetes education and prevention interventions (4,5). Likely contributors to men's infrequent participation include financial challenges, a lack of access to quality care, lack of access to transportation, and a lack of social support, all of which have been reported as barriers to healthy living for men (6,7).

To encourage men's participation in programs to improve health, studies have proposed enrolling all-male cohorts, developing programmatic content that is relevant and appealing to men, and recruiting male facilitators (8–10). Nevertheless, few studies have captured data from a diverse group of men regarding their interests and preferences in programs to improve their health (11,12). To help fill these gaps, we conducted a survey to capture interests and preferences in various elements of a healthy living program as well as health practices of racial and ethnic minority men at risk for or diagnosed with type 2 diabetes.

Methods

Survey development

The Centers for Disease Control and Prevention partnered with the National Association of Chronic Disease Directors to develop and distribute a 43-question survey on a priori knowledge of potential facilitators and barriers to participation in a program designed to improve health. The web-based survey was administered from August 27, 2019, through September 3, 2019.

The survey protocol, informed consent, sampling design, and questionnaire were approved by Sterling Institutional Review Board (IRB ID-7292). We used a nonprobability quota sample drawn from an opt-in consumer panel provided by Dynata, a market research firm. The sampling frame included 3,000 men in the US from various regions and education and income levels and reached 1,506 men. Participants consented to the study when signing up and could exit the survey at any time. The final data set was postweighted to reflect the 2019 US adult male population per race and ethnicity (13).

Survey sample

Participants were invited to take the survey if they self-identified as adult males (aged ≥18 y) living in the US, at risk for or diagnosed with type 2 diabetes, and members of the following racial or ethnic minority groups: American Indian or Alaska Native, Asian, Black or African American, Hispanic, Native Hawaiian or Pacific Islander, or multiple races. Participants were considered at risk for type 2 diabetes if they reported 1 or more of the following: diagnosed hypertension or prediabetes, a family history of type 2 diabetes, physical inactivity (<150 minutes of moderate-vigorous physical activity per week), aged 45 years or older, or a body mass index (BMI) of 23.0 or more for self-reported Asian race and a BMI of 25.0 or more for all other races and ethnicities. The unweighted sample consisted of 1,506 men. Participants received a monetary incentive for participation.

Measures

Using the 2019 Behavioral Risk Factor Surveillance System (BRFSS) survey as a guide, we adapted validated measures, including time since the last doctor visit, health history, employment status, marital status, ethnicity, race, annual household income, and education level (14). We also used BRFSS measures to capture data on height and weight (to calculate BMI as weight in kilograms divided by height in meters squared), health history, and physical activity status. We developed survey items to capture data on location of primary residence and language spoken at home by consulting with subject matter experts and census data. We developed questions about interests and preferences for healthy living programs and piloted the full instrument with a small group (n = 5) from the respondent population.

We recoded age into 4 categories: 18 to 24, 25 to 44, 45 to 64, and 65 years or older. Annual household income was classified in 4 categories: less than $20,000, $20,000 to $49,999, $50,000 to $99,999, and $100,000 or more. We recoded the variable on last doctor visit in 5 categories: within the last 3 months, more than 3 months ago but less than 6 months ago, more than 6 months ago but less than 12 months ago, 12 months ago or longer, and "I don't know." To capture data on ethnicity, participants were asked, "Are you of Hispanic, Latino, or Spanish origin?" and answers were yes or no. Participants who said yes were included as Hispanic, regardless of race. To capture data on race, participants were asked "What is your race?" and answers included American Indian or

Alaska Native, Asian, Black or African American, Native Hawaiian or Pacific Islander, or White. For those who selected more than 1 race we used the variable "multiple races." We excluded from the survey participants who identified as non-Hispanic White.

Interest in healthy living program elements. Six questions assessed interest in elements of a healthy living program. These questions were prefaced by, "Would you be interested in participating in . . ." Responses consisted of a 5-answer Likert-type scale: "yes, definitely," "yes, probably," "I'm not sure," "no, probably not," and "no, definitely not." We recoded these into 3 categories (yes, "I'm not sure," and no).

Facilitators to participation in healthy living programs. Questions to determine whether certain elements would increase the likelihood of program participation were prefaced by, "Would you be more likely to participate . . . " For men who indicated they spoke a language other than English at home (n = 616), we included an additional question about using program materials in the language spoken at home. We recoded the 5-answer Likert-type scale ("yes, definitely," "yes, probably," "I'm not sure," "no, probably not," and "no, definitely not") into 3 categories (yes, "I'm not sure," and no).

Healthy living program design preferences. Participants who answered "yes, definitely" or "yes, probably" to the question "Would you be interested in participating in a group session on healthy living?" were asked 4 questions about program design preferences (n = 897). These questions asked about preferred frequency of sessions, distance willing to travel, structure (structured vs informal), and setting (eg, classroom vs barber shop). The question, "What is the farthest you would be willing to travel to attend a group session on healthy living? (Assume the program is free and offered at a time when you are available)" was recoded from 6 answer choices to 5 by combining "between 20 to 60 miles" with "more than 60 miles."

Health practices. Participants were asked, "Do you usually engage in physical activity for at least 150 minutes (2.5 hours) per week? Physical activity is any activity that speeds up your heart rate and breathing, such as walking at a brisk pace, running, cycling, playing basketball, swimming, etc." Those who responded yes were asked to select what helped them maintain that level of physical activity. Those who answered no or "I don't know" were asked to select what limited them from reaching the recommended physical activity level.

Previous experience in formal programs to improve health. The men who had previously participated in a health improvement program (n = 460) were asked to identify challenges they encountered in those programs. They were asked, "Thinking of the formal programs you have previously participated in that have to do with improving your health, what problems or issues did you encounter with these programs?"

Data analysis

We used cross-tabulations to produce a descriptive analysis of the participants, their interests and preferences in a healthy living program, and their health practices. We used χ^2 tests to identify differences in interests and preferences among racial and ethnic groups; $P < .05$ was considered significant.

We used multiple logistic regression to determine the association between the characteristics of the men and their health practices with the outcome: interest in participating in a healthy living program. We recoded the outcome variable, "Would you be interested in participating in a group session on healthy living?" into a dichotomous response (yes/no) to conduct the analysis. We included variables such as age, race and ethnicity, education level, and physical activity status to determine any interaction between them and the outcome. We used SPSS Statistics Subscription version 1.0.0.1406 (IBM Corp) to conduct the analysis in 2023.

Results

Survey participants (N = 1,506) more frequently were aged 45 to 64 years (42.9%), were Hispanic (44.4%), had a BMI of 30.0 or more (48.8%), visited a doctor within the last 3 months (45.5%), were college graduates (48.0%), and reported an annual household income of $50,000 to $99,999 (34.5%) (Table 1). By design, approximately half of the sample had been diagnosed with type 2 diabetes (49.7%), and the rest were at risk for type 2 diabetes (50.3%). Most participants reported engaging in physical activity for at least 150 minutes per week (65.2%), receiving their health information from a doctor or doctor's office (54.2%), and living in small cities, suburban areas, or large towns (53.8%). Combining responses from the men diagnosed with type 2 diabetes and those at risk for type 2 diabetes did not meaningfully change the results.

Interest in healthy living program elements

Many men indicated interest in participating in a group session on healthy living (59.3%) (Table 2), despite 69.4% having never participated in a formal health improvement program (Table 1). A slightly smaller percentage of men were interested if the sessions were held online (55.7%). The men showed more interest in program elements such as incentives for losing or maintaining weight (67.3%) and programs that include families (63.3%) (Table 2). Working with a personal health coach (58.5%) and male-centered topics such as erectile dysfunction and diabetes (57.1%) were also of interest. Among men (n = 1,340) who had a BMI of 25.0 or more (or ≥23.0 for Asian men), approximately half (51.4%) showed interest in a program in which they could compete on a team to lose weight.

Facilitators to participation in healthy living programs

Approximately 43% said they would be more likely to participate in a healthy living program if the group was led by a man or by someone from their racial and ethnic group (Table 2). Nearly half (47.3%) said they would be more likely to participate if the program used materials with examples and images of people from their racial and ethnic group. For participants who indicated that they spoke a language other than English at home (n = 616), 64.2% agreed that if the program materials were in the language they spoke at home, they would be more likely to participate.

Healthy living program design preferences

A program that held sessions up to once a week was preferred (58.6%), compared with sessions held up to twice monthly (26.3%) or up to once monthly (9.9%) (Table 3). Almost one-quarter of men (23.3%) were willing to travel no more than 3 miles for a program, 36.1% were willing to travel no more than 5 miles, and 28.2% were willing to travel 5 to 20 miles. Men had a slight preference for informal and discussion-based sessions (41.7%) over those structured as a class (36.6%). Sessions held in an existing gathering space (eg, a community center, barbershop, coffee shop) were slightly preferrable (39.1%) to a classroom setup (27.6%), but one-third of the men had no preference for session location (33.3%).

Some of the variables were significantly different across racial and ethnic groups (Table 2 and Table 3). However, the absolute differences in percentages were usually minor (<10%).

Challenges in previous healthy living programs

Some men (n = 462) faced challenges in previous healthy living programs (Figure 1). The 3 most frequently noted challenges were inconvenient hours (23.7%), lack of motivation (22.5%), and program expense (18.3%).

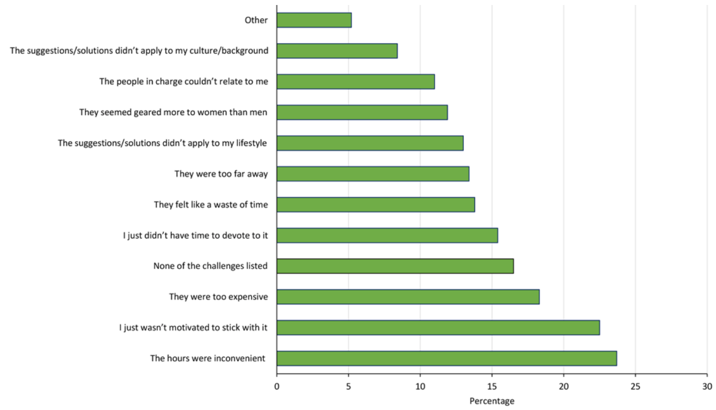

Figure 1. Challenges encountered in previous healthy living programs reported in a survey of men in racial and ethnic minority groups at risk for or diagnosed with type 2 diabetes (n = 462). "Other" challenges included distance (too far), program ended, problem with staff, cost and insurance issues, illness, and life circumstances. Participants could select multiple answers; percentages were weighted. Data source: 43-question survey developed and distributed (August 27, 2019–September 3, 2019) by the Centers for Disease Control and Prevention and the National Association of Chronic Disease Directors.

Facilitators and barriers to a physical activity routine

Among men who reported engaging in physical activity for at least 150 minutes weekly (n = 981), the most frequently selected facilitators for maintaining a physical activity routine were "Being able to exercise when it is convenient for me" (42.3%), "I have fitness or weight loss goals that I am trying to achieve" (37.7%), and "I don't have to pay anything to exercise" (36.4%) (Figure 2A). The most frequently selected (n = 525) barriers to physical activity were "I don't feel motivated" (44.3%), "I don't like to do it" (27.4%), and "I am not physically able to exercise regularly, due to an injury or other limitations" (26.4%) (Figure 2B).

PREVENTING CHRONIC DISEASE
PUBLIC HEALTH RESEARCH, PRACTICE, AND POLICY
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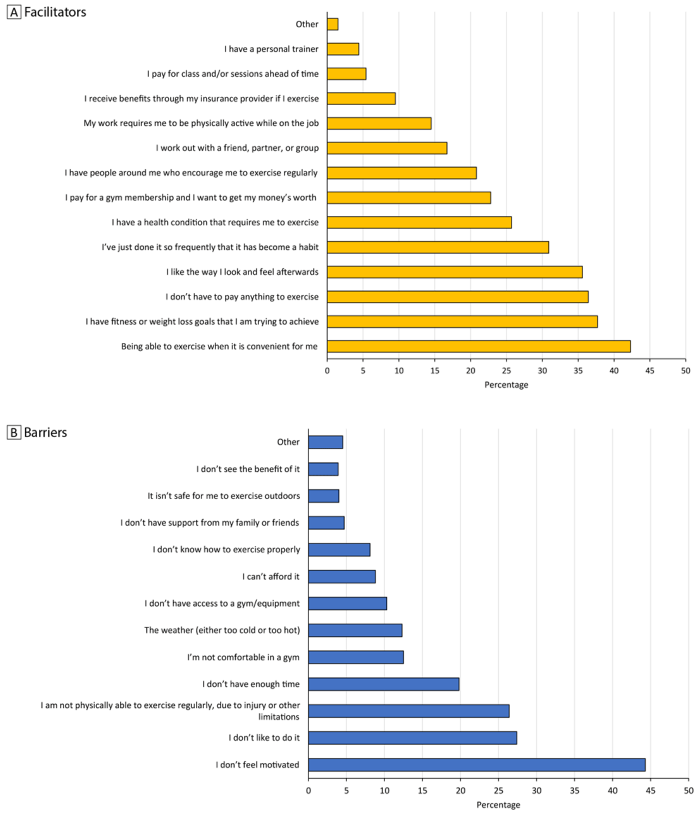

Figure 2. Facilitators and barriers to maintaining a physical activity routine reported in survey of men at risk for or diagnosed with type 2 diabetes in racial and ethnic minority groups. A. Facilitators to maintaining a physical activity routine among men (n = 981) who indicated that they engaged in physical activity for at least 150 minutes per week. "Other" facilitators included personal exercise equipment, pets, habit/lifestyle, and requirement of physical therapy. B. Barriers to maintaining a physical activity routine among men (n = 525) who indicated they do not or do not know if they engage in physical activity for at least 150 minutes per week. "Other" barriers were health, work conditions and/or schedule, lack of motivation, no babysitter, no reason given. Participants could select multiple answers; percentages were weighted. Data source: 43-question survey developed and distributed (August 27, 2019–September 3, 2019) by the Centers for Disease Control and Prevention and the National Association of Chronic Disease Directors.

Factors associated with interest in healthy living programs

The adjusted multivariate model (Table 4) showed that participants were significantly more likely to be interested in participating in a group session on healthy living if they 1) were aged 25 to 44 years (adjusted odds ratio [AOR] = 2.0; 95% CI, 1.2–3.3) or 45 to 64 years (AOR = 1.5; 95% CI, 1.0–2.3) compared with participants aged 65 years or older, and 2) had an annual household income of $50,000 to $99,999 (AOR = 1.5; 95% CI, 1.0–2.1) compared with participants with an annual household income of $100,000 or more. Men who were physically active at least 150 minutes weekly (AOR = 2.2; 95% CI, 1.6–3.0) and had previously participated in a program designed to improve their health (AOR = 1.5; 95% CI, 1.1–2.1) were also significantly more likely to be interested. Compared with the men who were employed, those who were unemployed (AOR = 0.4; 95% CI, 0.2–0.8), retired (AOR = 0.5; 95% CI, 0.3–0.7), and unable to work (AOR = 0.4; 95% CI, 0.2–0.8) were significantly less likely to be interested in program participation. Those men who had their last doctor visit more than 3 months but less than 6 months ago (AOR = 0.7; 95% CI, 0.5–1.0) and more than 12 months ago (AOR = 0.5; 95% CI, 0.3–0.8) were also significantly less likely to be interested compared with men who had seen a doctor within the last 3 months.

Discussion

To our knowledge, this is the first large survey of men — with or at risk for type 2 diabetes in racial and ethnic minority groups — reporting their interests, preferences, and previous challenges in a program designed to improve their health.

Many men surveyed were interested in participating in a group session on healthy living, although most had never participated in one. This finding stands in contrast to the gap in the uptake of programs such as the National DPP LCP (15) and diabetes self-management education and support services (16). The men surveyed also expressed interest in participating in healthy living programs online, which highlights the importance of flexibility in program delivery and an opportunity to overcome transportation challenges. This finding is timely since, after the survey was administered, the COVID-19 pandemic occurred and most health promotion activities relied on virtual delivery (17,18). Several program elements were appealing to the men surveyed, such as the inclusion of family and incentives. This finding provides some evidence for including or bolstering these program elements — especially since chronic disease prevention and management programs that have participant incentives demonstrate greater reductions in bodyweight and BMI compared with programs that omit incentives (19). Additionally, some men were interested in a program that includes information on how to prevent or delay erectile dysfunction. To our knowledge this finding has not been reported in the literature.

We found that healthy living program sessions led by a man or someone from participants' racial or ethnic group, and program materials that featured examples of people from their racial or ethnic group, were likely facilitators to program participation. This finding supports research showing that using male-centered topics (20,21) and the inclusion of culture (21–23) can motivate men in chronic disease prevention and management programs. Also, providing program materials in the language participants speak at home was preferred — which is promising since both diabetes prevention and management programs are offered in English and Spanish (2,15).

A program with more frequent (ie, weekly) versus less frequent sessions appealed to the men; frequent sessions are associated with success for participants in both the National DPP LCP (24) and diabetes self-management education and support services (25). Respondents preferred a short travel distance to the program site over a program that was farther away, a key factor in increasing the likelihood of engaging in physical activity (26). Finally, because survey participants slightly favored an informal and discussion-based session over a structured class, consulting men about format and location preferences may be beneficial since social and environmental challenges may inhibit motivation or ability to participate. These program design preferences point to a desire to participate in a program that men perceive as having a convenient and comfortable space, which is especially important since people in racial and ethnic minority groups are more likely than other population groups to live in neighborhoods that might be unsafe or not conducive to healthy living (11,27).

Inconvenient hours was the most frequently reported challenge in previous healthy living programs, which is imperative to consider since timing is a major motivator for male participation in lifestyle change programs (28). The second most frequently reported challenge, lack of motivation, could be mitigated by including more appealing program elements for men and by identifying healthy coping strategies that support lifestyle change. Health coaching that emphasizes accountability and motivation can encourage men's participation in diabetes management programs (11) and is a key component of lifestyle change programs (2). The program being too costly was the third most frequently reported challenge, which is known to be a hindrance to adopting a healthy lifestyle (6,23,29). Offering diabetes prevention and management programs for free or at reduced cost could potentially eliminate this barrier for many men.

For the men who exercised consistently, having fitness goals and a convenient low-cost routine were key facilitators. This finding points to a need for flexible, relevant, and affordable options that can help men overcome barriers to maintaining healthy habits. More than 40% of the men surveyed in our study cited lack of motivation as a barrier to maintaining a physical activity routine. Since lack of motivation was also mentioned as a challenge in previous healthy living programs, it is important to consider the adverse effect of factors such as psychosocial stress on managing the requirements for healthy lifestyle change (30). Support for such stress could be tailored to address male-specific challenges, like chronic stress related to male gender-role strain (31,32) — which might help men initiate and maintain physical activity. Adequate social support is an important facilitator for the ability to manage one's health in addition to overcoming extenuating circumstances that might make healthy living challenging.

In the multivariate model, one of the strongest predictors of interest in a program was being physically active; physically active men were twice as likely to be interested in program participation compared with men who were not. Surprisingly, men aged 25 to 44 years were significantly more interested in participating in a healthy living program than those aged 65 years or older. This finding contrasts with the reported lower likelihood of enrollment and retention in the National DPP LCP for people in this age range (24). Innovative strategies to recruit younger and physically active men could increase their enrollment and participation in lifestyle change programs. Another unique finding was that men were more likely to be interested in participating in a healthy living program if they had previously participated in one. These men were motivated to return to a health improvement program, which might suggest the benefit of a trial period, wherein participants can try a program before fully committing. Additionally, such men could be ideal candidates for program champions. Program champions are trusted community members who have successfully made changes and overcome barriers and thereby champion the program for others (33).

Strengths and limitations

Our study has several strengths. It was a large survey that included a range of responses from men in racial and ethnic minority groups who have historically been underrepresented in and/or excluded from the literature. We captured data on the interests of men on various programmatic elements as well as their health practices, findings that have practical implications for designing and implementing programs to improve men's health. Through our multivariate model, we identified characteristics of men who are more likely to have interest in participating in a health improvement program. This information will be beneficial for future recruitment, marketing, and retention efforts that focus on improving the health of men in racial/ethnic minority groups.

Our study also has several limitations. The data were self-reported, which could have led to recall or social desirability bias. For example, a higher proportion of the survey respondents reported being physically active (>50%) compared with the national average (31%) (34), so they may have been inclined to respond positively to participating in a healthy living program. Also, the survey population had higher educational attainment than the national average; and since higher educational attainment and health literacy are associated with program participation, the responses of men in this survey may not reflect men with lower educational attainment

(35). The interpretation of our cross-tabulation data was limited by the small sample sizes for some of the groups in the survey. Since the study was not designed to test cross-group differences, further interpretation is beyond the scope of this study. Programs and future research could consider other factors (eg, socioeconomic) that might also affect participation, which was beyond the scope of this work. Although we surveyed a large group of men in racial and ethnic minority groups, we acknowledge the limitations of a nonprobability sample and that our sample was not nationally representative or representative of the diversity among these populations.

Conclusion

Men in racial and ethnic minority groups, who had or were at risk for type 2 diabetes, expressed interest in a program to improve their health and indicated a preference for specific programmatic characteristics in this survey. Programs that add, bolster, or market some of the elements highlighted in our findings could lead to increased numbers of men in racial and ethnic minority groups who participate in programs to improve their health and adopt healthy lifestyle habits. This ultimately could lead to a reduction in the racial and ethnic disparities in the prevalence of diabetes among men.

Acknowledgments

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Tables

Table 1. Demographic Characteristics of Participants (N = 1,506) in a Survey of Men at Risk for or Diagnosed With Type 2 Diabetes in Racial and Ethnic Minority Groups[a]

Characteristic	No. (%)[b]
Age, y	
18–24	53 (3.5)
25–44	448 (30.3)
45–64	650 (42.9)
≥65	355 (23.4)
Race and ethnicity	
American Indian or Alaska Native	27 (1.7)
Asian	236 (15.2)
Hispanic	581 (44.4)
Native Hawaiian or Pacific Islander	16 (1.0)
Non-Hispanic Black or African American	577 (32.0)
Multiple races	70 (5.6)
Diabetes status	
Diagnosed with type 2 diabetes	750 (49.7)
At risk for type 2 diabetes	756 (50.3)
Do you engage in physical activity for at least 150 minutes per week?[c]	
Yes	981 (65.2)
No/don't know	525 (34.8)
Body mass index (BMI)[d]	
Underweight (<18.5)	9 (0.6)
Normal weight (18.5–24.9)	178 (11.7)
Overweight (25.0–29.9)	585 (38.9)
Obese (≥30)	734 (48.8)
About how long has it been since you last visited a doctor for a routine check-up?	
Within the last 3 months	692 (45.5)
More than 3 months but less than 6 months ago	327 (22.0)
More than 6 months ago but less than 1 year ago	312 (20.8)
12 months ago or longer	144 (9.7)
I don't know	31 (2.0)

Abbreviation: GED, General Educational Development.
[a] Data source: The Centers for Disease Control and Prevention partnered with the National Association of Chronic Disease Directors to develop and distribute a 43-question survey from August 27, 2019, through September 3, 2019. Percentages may not add to 100 because of rounding.
[b] Weighted percentage.
[c] Physical activity is any activity that speeds up your heart rate and breathing, such as walking at a brisk pace, running, cycling, playing basketball, swimming, etc.
[d] Calculated by using self-reported height and weight data.
[e] Some school includes kindergarten through grade 11.
[f] A formal program could include a group education course, one-on-one sessions with a health coach, a team weight-loss competition, or another similar program.
[g] Adds to >100% because >1 answer could be selected; answers are not mutually exclusive.

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Table 1. Demographic Characteristics of Participants (N = 1,506) in a Survey of Men at Risk for or Diagnosed With Type 2 Diabetes in Racial and Ethnic Minority Groups[a]

Characteristic	No. (%)[b]
What is the highest grade or year of school you completed?	
Some school[e] or never attended school	58 (3.9)
High school graduate or GED	251 (16.4)
Some college or technical school	486 (31.8)
College, 4 years or more (graduate)	711 (48.0)
Employment status	
Employed for wages	860 (57.3)
Unemployed	99 (6.6)
Other (including student, homemaker)	38 (2.5)
Retired	414 (27.5)
Unable to work	95 (6.1)
Marital status	
Married	827 (55.5)
Never married	401 (26.2)
Member of an unmarried couple	75 (5.0)
Other (widowed, divorced, separated)	203 (13.3)
Which of the following best describes the location of your primary residence?	
Large city	557 (36.7)
Small city, suburban area, or large town	809 (53.8)
Village or rural	134 (9.1)
A reservation	6 (0.4)
Annual household income, $	
<20,000	201 (13.1)
20,000–49,999	361 (23.6)
50,000–99,999	511 (34.5)
≥100,000	433 (28.9)
Do you speak a language other than English at home?	
Yes	616 (43.8)
No	890 (56.2)
Have you ever participated in any formal programs aimed at improving your health?[f]	
Yes	462 (30.6)

Abbreviation: GED, General Educational Development.
[a] Data source: The Centers for Disease Control and Prevention partnered with the National Association of Chronic Disease Directors to develop and distribute a 43-question survey from August 27, 2019, through September 3, 2019. Percentages may not add to 100 because of rounding.
[b] Weighted percentage.
[c] Physical activity is any activity that speeds up your heart rate and breathing, such as walking at a brisk pace, running, cycling, playing basketball, swimming, etc.
[d] Calculated by using self-reported height and weight data.
[e] Some school includes kindergarten through grade 11.
[f] A formal program could include a group education course, one-on-one sessions with a health coach, a team weight-loss competition, or another similar program.
[g] Adds to >100% because >1 answer could be selected; answers are not mutually exclusive.

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Table 1. Demographic Characteristics of Participants (N = 1,506) in a Survey of Men at Risk for or Diagnosed With Type 2 Diabetes in Racial and Ethnic Minority Groups[a]

Characteristic	No. (%)[b]
No	1,044 (69.4)
Where do you get information about health-related activities? (Select all that apply)[g]	
Doctor or doctor's office	817 (54.2)
The internet or social media	607 (40.2)
Television	482 (31.3)
A friend, family member, or relative	450 (29.8)
Gym or health club	290 (19.0)
Pharmacy or pharmacist	198 (13.1)
Somewhere else	128 (8.6)
Radio or podcasts	124 (8.2)
A community organization	113 (7.5)
Local government	77 (5.1)
Church	76 (4.9)
School	63 (4.2)
Medicine men	60 (4.0)
Barbershop or hair salon	42 (2.7)
Sweat lodges	22 (1.6)
None of the above	115 (7.7)

Abbreviation: GED, General Educational Development.
[a] Data source: The Centers for Disease Control and Prevention partnered with the National Association of Chronic Disease Directors to develop and distribute a 43-question survey from August 27, 2019, through September 3, 2019. Percentages may not add to 100 because of rounding.
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[e] Some school includes kindergarten through grade 11.
[f] A formal program could include a group education course, one-on-one sessions with a health coach, a team weight-loss competition, or another similar program.
[g] Adds to >100% because >1 answer could be selected; answers are not mutually exclusive.

Table 2. Interest in Program Elements and Facilitators to Participation in a Program Designed to Improve Health for Men at Risk for or Diagnosed With Type 2 Diabetes in Racial and Ethnic Minority Groups[a,b]

Survey item	Total (N = 1,506)	AI/AN (n = 27)	Asian (n = 236)	Black (n = 577)	Hispanic (n = 581)	NH/PI (n = 16)	Multiple races (n = 69)	*P* value[c]
Would you be interested in participating in a group session on healthy living?								
Yes, definitely	426 (28.0)	2 (7.4)	47 (20.0)	193 (33.4)	170 (29.3)	3 (18.7)	11 (16.5)	<.001
Yes, probably	471 (31.3)	10 (37.0)	80 (33.9)	176 (30.5)	173 (29.8)	7 (43.7)	25 (36.5)	
I'm not sure	328 (22.0)	8 (29.6)	58 (24.3)	110 (19.1)	137 (23.6)	1 (6.3)	14 (20.0)	
No, probably not	172 (11.3)	4 (14.8)	35 (14.8)	69 (12.0)	53 (9.1)	2 (12.5)	9 (12.9)	
No, definitely not	109 (7.5)	3 (11.1)	16 (7.0)	29 (5.0)	48 (8.2)	3 (18.8)	10 (14.1)	
Would you be interested in participating in a group session on healthy living that is held online?								
Yes	844 (55.7)	15 (55.6)	113 (48.0)	350 (60.6)	322 (55.4)	10 (62.5)	34 (49.4)	.10
I'm not sure	322 (21.4)	4 (14.8)	57 (24.0)	117 (20.3)	128 (22.0)	2 (12.5)	14 (20.0)	
No	340 (22.9)	8 (29.6)	66 (27.9)	110 (19.1)	131 (22.6)	4 (25.0)	21 (30.6)	
Would you be interested in participating in a group session on healthy living that provides information about ways to prevent or delay erectile dysfunction? (Assume the sessions are free and held at a time when you are available.)[d]								
Yes	866 (57.1)	12 (44.4)	117 (49.8)	364 (63.1)	332 (57.1)	8 (50.0)	33 (48.8)	.003
I'm not sure	301 (20.2)	9 (33.3)	60 (25.3)	93 (16.2)	125 (21.5)	2 (12.5)	12 (16.7)	
No	339 (22.6)	6 (22.2)	59 (24.9)	120 (20.7)	124 (21.4)	6 (37.5)	24 (34.5)	
Would you be interested in participating in a program that offers incentives (nonfinancial or financial) for losing and/or maintaining your weight?								
Yes	1,018 (67.3)	19 (69.2)	149 (63.0)	408 (70.7)	389 (67.0)	13 (81.3)	40 (58.8)	.22
I'm not sure	251 (16.7)	3 (11.5)	38 (16.1)	95 (16.4)	99 (17.0)	1 (6.3)	15 (21.2)	
No	237 (16.0)	5 (19.2)	49 (20.9)	74 (12.9)	93 (16.0)	2 (12.5)	14 (20.0)	
Would you be interested in participating in a program where you compete in a team to lose weight? (Assume this program is free to participate and held at a time when you are available.)[e]								
Yes	691 (51.4)	12 (44.4)	103 (47.6)	273 (54.3)	270 (52.7)	9 (64.3)	24 (36.6)	.11
I'm not sure	269 (20.1)	4 (14.8)	49 (22.9)	97 (19.3)	103 (20.0)	1 (7.1)	15 (22.0)	
No	380 (28.5)	11 (40.7)	64 (29.5)	133 (26.4)	140 (27.3)	4 (28.6)	28 (41.5)	
Would you be interested in participating in a healthy eating program with your family, children, and/or those who live with you?								
Yes	960 (63.3)	14 (51.9)	139 (59.0)	397 (68.9)	361 (62.1)	10 (62.5)	39 (56.5)	.008
I'm not sure	273 (18.5)	7 (25.9)	54 (22.7)	78 (13.5)	120 (20.7)	0	14 (20.0)	
No	273 (18.2)	6 (22.2)	43 (18.3)	102 (17.6)	100 (17.2)	6 (37.5)	16 (23.5)	

Abbreviations: AI/AN, American Indian or Alaska Native; NH/PI, Native Hawaiian or Pacific Islander.
[a] Data source: The Centers for Disease Control and Prevention partnered with the National Association of Chronic Disease Directors to develop and distribute a 43-question survey from August 27, 2019, through September 3, 2019. Percentages may not add to 100 because of rounding.
[b] Weighted percentage.
[c] χ^2 tests were used for each variable to examine differences across categories; $P < .05$ is considered significant.
[d] The question asked was the following: "Men with diabetes are three times more likely to have erectile dysfunction (ED). Knowing this, would you be interested in participating in a group session on healthy living that provides information about ways to prevent or delay ED? (Assume the sessions are free and held at a time when you are available.)"
[e] Includes only participants with a BMI ≥23 for Asians and BMI ≥25 for all other races, ie, participants who are overweight. N's for this question were the following: total (N = 1,340); AI/AN (n = 27); Asian (n = 216); Black (n = 503); Hispanic (n = 513); NH/PI (n = 14); multiple races (n = 67).
[f] Includes only participants who selected yes to the question, "Do you speak a language other than English at home?" N's for this question were the following: total (n = 616); AI/AN (n = 2); Asian (n = 117); Black (n = 88); Hispanic (n = 389); NH/PI (n = 4); multiple races (n = 16).

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Table 2. Interest in Program Elements and Facilitators to Participation in a Program Designed to Improve Health for Men at Risk for or Diagnosed With Type 2 Diabetes in Racial and Ethnic Minority Groups[a,b]

Survey item	Total (N = 1,506)	AI/AN (n = 27)	Asian (n = 236)	Black (n = 577)	Hispanic (n = 581)	NH/PI (n = 16)	Multiple races (n = 69)	*P* value[c]
Would you be interested in working with a personal health coach, that is, someone who can help you identify ways to incorporate healthy living in your life? (Assume the health coach is free.)								
Yes	884 (58.5)	15 (55.6)	132 (55.9)	355 (61.5)	336 (57.9)	9 (56.3)	37 (54.1)	
I'm not sure	294 (19.7)	4 (14.8)	47 (20.1)	105 (18.2)	123 (21.1)	3 (18.8)	12 (17.6)	.74
No	328 (21.8)	8 (29.6)	57 (24.0)	117 (20.3)	122 (21.0)	4 (25.0)	20 (28.2)	
Facilitators to participation								
Would you be more likely to participate in a group session on healthy living if the group was led by a man?								
Yes	654 (43.1)	9 (33.3)	96 (40.6)	268 (46.5)	257 (44.2)	6 (37.5)	18 (25.9)	
I'm not sure	497 (33.2)	12 (44.4)	92 (38.9)	175 (30.3)	186 (32.0)	4 (25.0)	28 (41.2)	.02
No	355 (23.7)	6 (20.5)	48 (20.5)	134 (23.2)	138 (23.8)	6 (37.5)	23 (32.9)	
Would you be more likely to participate in a group session on healthy living if the group was led by someone from your racial/ethnic group?								
Yes	659 (43.2)	8 (29.6)	96 (40.6)	286 (49.6)	245 (42.2)	4 (25.0)	20 (29.4)	
I'm not sure	481 (32.0)	10 (37.0)	84 (35.8)	175 (30.3)	185 (31.8)	6 (37.5)	21 (30.6)	.002
No	366 (24.8)	9 (33.3)	56 (23.6)	116 (20.1)	151 (26.0)	6 (37.5)	28 (40.0)	
Would you be more likely to participate in a program to improve your health if the program materials, such as flyers or videos, used examples and images of people from your racial/ethnic group?								
Yes	725 (47.3)	9 (33.3)	100 (42.4)	328 (56.8)	263 (45.3)	5 (31.3)	20 (29.4)	
I'm not sure	409 (27.2)	8 (29.6)	82 (34.9)	144 (24.9)	147 (25.3)	4 (25.0)	24 (34.1)	<.001
No	372 (25.5)	10 (37.0)	54 (22.7)	105 (18.3)	171 (29.4)	7 (43.8)	25 (36.5)	
Would you be more likely to participate in a program to improve your health if the program materials, such as flyers or videos, were provided in the language you speak at home?[f]								
Yes	398 (64.2)	1 (50.0)	65 (55.8)	70 (78.4)	251 (64.5)	1 (25.0)	10 (63.2)	
I'm not sure	110 (18.0)	1 (50.0)	28 (23.9)	9 (10.8)	66 (17.0)	3 (75.0)	3 (21.1)	.02
No	108 (17.7)	0	24 (20.4)	9 (10.8)	72 (18.5)	0	3 (15.8)	

Abbreviations: AI/AN, American Indian or Alaska Native; NH/PI, Native Hawaiian or Pacific Islander.
[a] Data source: The Centers for Disease Control and Prevention partnered with the National Association of Chronic Disease Directors to develop and distribute a 43-question survey from August 27, 2019, through September 3, 2019. Percentages may not add to 100 because of rounding.
[b] Weighted percentage.
[c] χ^2 tests were used for each variable to examine differences across categories; $P < .05$ is considered significant.
[d] The question asked was the following: "Men with diabetes are three times more likely to have erectile dysfunction (ED). Knowing this, would you be interested in participating in a group session on healthy living that provides information about ways to prevent or delay ED? (Assume the sessions are free and held at a time when you are available.)"
[e] Includes only participants with a BMI ≥23 for Asians and BMI ≥25 for all other races, ie, participants who are overweight. N's for this question were the following: total (N = 1,340); AI/AN (n = 27); Asian (n = 216); Black (n = 503); Hispanic (n = 513); NH/PI (n = 14); multiple races (n = 67).
[f] Includes only participants who selected yes to the question, "Do you speak a language other than English at home?" N's for this question were the following: total (n = 616); AI/AN (n = 2); Asian (n = 117); Black (n = 88); Hispanic (n = 389); NH/PI (n = 4); multiple races (n = 16).

Table 3. Preferences for the Design of a Healthy Living Program for Men at Risk for and Diagnosed With Type 2 Diabetes in Racial and Ethnic Minority Groups[a,b,c]

Survey item	Total (N = 897)	AI/AN (n = 12)	Asian (n = 127)	Black (n = 369)	Hispanic (n = 343)	NH/PI (n = 10)	Multiple races (n = 36)	*P* value[d]
Convenience (frequency and distance)								
How often would you be willing to participate in a group session on healthy living?								
Up to once a week	525 (58.6)	9 (75.0)	72 (56.5)	215 (58.3)	201 (58.8)	8 (80.0)	20 (55.6)	.94
Up to twice a month	238 (26.3)	2 (16.7)	37 (29.0)	102 (27.5)	88 (25.7)	0	9 (24.4)	
Up to once a month	87 (9.9)	1 (8.3)	11 (8.9)	33 (9.1)	36 (10.4)	2 (20.0)	4 (11.1)	
Less than once a month	7 (0.8)	0	2 (1.6)	2 (0.6)	3 (0.8)	0	0	
No preference	40 (4.5)	0	5 (4.0)	17 (4.5)	15 (4.3)	0	3 (8.9)	
What is the farthest you would be willing to travel to attend a group session on healthy living? (Assume the program is free and held at a time when you are available.)								
NA (not willing to travel at all)	65 (7.0)	0	6 (4.9)	34 (9.1)	22 (6.3)	0	3 (8.7)	.003
No more than 3 miles	203 (23.3)	0	30 (23.6)	68 (18.5)	90 (26.3)	4 (40.0)	11 (30.4)	
No more than 5 miles	328 (36.1)	9 (75.0)	58 (45.5)	140 (38.0)	110 (32.2)	1 (10.0)	10 (28.3)	
Between 5 and 20 miles	250 (28.2)	3 (25.0)	30 (23.6)	96 (26.0)	105 (30.6)	5 (50.0)	11 (30.4)	
20 miles or greater	51 (5.4)	0	3 (2.4)	31 (8.4)	16 (4.6)	0	1 (2.2)	
Structure (format and location)								
Would you prefer to participate in a group session on healthy living that is structured and set up like a class, or informal and discussion based?								
Structured and set up like a class	327 (36.6)	3 (25.0)	46 (36.6)	133 (36.0)	131 (38.2)	2 (20.0)	12 (33.3)	.98
Informal and discussion based	374 (41.7)	6 (50.0)	55 (43.1)	152 (41.2)	141 (41.0)	5 (50.0)	15 (42.2)	
No preference	196 (21.7)	3 (25.0)	26 (20.3)	84 (22.7)	71 (20.8)	3 (30.0)	9 (24.4)	
Held in a classroom or another gathering space such as a community center, barbershop, or coffee shop? (Assume you are able to easily access any of these options.)								
Held in a classroom	247 (27.6)	4 (33.3)	34 (26.8)	101 (27.3)	97 (28.4)	2 (20.0)	9 (25.0)	.81
Held in an existing gathering space (a community center, a barbershop, a coffee shop, etc.)	351 (39.1)	5 (41.7)	59 (46.3)	138 (37.3)	138 (38.7)	4 (40.0)	12 (34.1)	
No preference	299 (33.3)	3 (25.0)	34 (26.8)	130 (35.4)	130 (32.9)	4 (40.0)	15 (40.9)	

Abbreviations: AI/AN, American Indian or Alaska Native; NA, not applicable; NH/PI, Native Hawaiian or Pacific Islander.
[a] Data source: The Centers for Disease Control and Prevention partnered with the National Association of Chronic Disease Directors to develop and distribute a 43-question survey from August 27, 2019, through September 3, 2019. Percentages may not add to 100 because of rounding.
[b] Includes only participants who selected "yes, definitely" or "yes, probably" to the question, "Would you be interested in participating in a group session on healthy living?"
[c] Weighted percentage.
[d] χ^2 tests were used for each variable to examine differences across categories; $P < .05$ considered significant.

Table 4. Predictors of Interest in Participating in a Healthy Living Program for Men at Risk for or Diagnosed With Type 2 Diabetes in Racial and Ethnic Minority Groups[a]

Variable	No. (%)[b]	Unadjusted OR (95% CI) [P value[c]]	Adjusted OR (95% CI) [P value[c]]
Age, y			
≥65	249 (69.6)	1 [Reference]	1 [Reference]
45–64	538 (82.7)	1.1 (0.9–1.5) [.21]	1.5 (1.0–2.3) [.04]
25–44	391 (87.5)	1.8 (1.3–2.5) [<.001]	2.0 (1.2–3.3) [.01]
18–24	47 (88.5)	1.8 (0.7–4.2) [.18]	1.8 (0.6–5.5) [.28]
Race and ethnicity			
American Indian or Alaska Native	20 (73.1)	0.6 (0.2–1.5) [.35]	0.7 (0.3–1.9) [.54]
Asian	185 (78.6)	0.8 (0.5–1.1) [.23]	0.8 (0.5–1.3) [.41]
Black	479 (83.0)	1.1 (0.8–1.5) [.23]	1.1 (0.8–1.5) [.61]
Hispanic	480 (82.6)	1 [Reference]	1 [Reference]
Native Hawaiian or Pacific Islander	11 (68.8)	0.5 (0.1–1.4) [.21]	0.5 (0.1–1.5) [.20]
Multiple races	50 (72.9)	0.5 (0.3–0.9) [.04]	0.7 (0.4–1.3) [.26]
Education			
College, 4 years or more (graduate)	578 (81.2)	1 [Reference]	1 [Reference]
Some college or technical school	391 (80.8)	0.9 (0.7–1.2) [.71]	0.9 (0.6–1.2) [.56]
High school graduate or GED	209 (82.6)	1.1 (0.7–1.6) [.52]	1.1 (0.7–1.8) [.61]
Some school[d] or never attended school	47 (81.0)	0.9 (0.5–1.9) [.94]	0.7 (0.3–1.6) [.48]
Employment			
Employed for wages	751 (87.3)	1 [Reference]	1 [Reference]
Unemployed	75 (76.8)	0.7 (0.4–1.2) [.24]	0.4 (0.2–0.8) [.008]
Other (including student, homemaker)	34 (89.5)	1.8 (0.6–5.1) [.23]	1.2 (0.4–3.8) [.73]
Retired	292 (70.3)	0.4 (0.3–0.5) [<.001]	0.5 (0.3–0.7) [<.001]
Unable to work	73 (76.1)	0.7 (0.4–1.1) [.16]	0.4 (0.2–0.8) [.006]
Annual household income, $			
≥100,000	347 (79.8)	1 [Reference]	1 [Reference]
50,000–99,999	424 (83.0)	1.1 (0.9–1.5) [.21]	1.5 (1.0–2.1) [.04]
20,000–49,999	291 (80.8)	0.9 (0.7–1.3) [.81]	1.2 (0.8–1.9) [.31]
<20,000	163 (80.7)	0.9 (0.6–1.3) [.80]	1.5 (0.9–2.7) [.15]
Primary residence			
Large city	465 (83.5)	1 [Reference]	1 [Reference]
Small city, suburban area, or large town	656 (81.0)	0.9 (0.7–1.2) [.84]	1.0 (0.7–1.3) [.83]
Village or rural	99 (73.0)	0.6 (0.4–0.8) [.01]	0.7 (0.4–1.0) [.10]
A reservation	5 (83.3)	1.1 (0.1–9.8) [.93]	1.0 (0.8–12.5) [.99]

Abbreviation: GED, General Educational Development.
[a] Data source: The Centers for Disease Control and Prevention partnered with the National Association of Chronic Disease Directors to develop and distribute a 43-question survey from August 27, 2019, through September 3, 2019.
[b] Weighted percentage.
[c] *P* value calculated by using SPSS software multivariate logistic regression; $P < .05$ considered significant.
[d] Some school includes kindergarten through grade 11.
[e] Includes up to 5 years ago.

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Table 4. Predictors of Interest in Participating in a Healthy Living Program for Men at Risk for or Diagnosed With Type 2 Diabetes in Racial and Ethnic Minority Groups[a]

Variable	No. (%)[b]	Unadjusted OR (95% CI) [*P* value[c]]	Adjusted OR (95% CI) [*P* value[c]]
Marital status			
Married	666 (80.5)	1 [Reference]	1 [Reference]
Never married	333 (83.0)	1.1 (0.8–1.6) [.28]	0.9 (0.6–1.3) [.47]
Member of an unmarried couple	62 (82.7)	1.0 (0.5–1.9) [.80]	1.1 (0.6–2.2) [.76]
Other (widowed, divorced, separated)	164 (80.8)	1.0 (0.6–1.4) [.95]	1.1 (0.7–1.7) [.73]
Last doctor visit			
Within the last 3 months	572 (82.7)	1 [Reference]	1 [Reference]
More than 3 months but less than 6 months ago	262 (80.1)	0.8 (0.6–1.1) [.40]	0.7 (0.5–1.0) [.04]
More than 6 months ago but less than 1 year ago	259 (83.0)	1.2 (0.8–1.6) [.28]	0.8 (0.5–1.2) [.33]
12 months ago or longer[e]	107 (74.3)	0.6 (0.4–0.9) [.03]	0.5 (0.3–0.8) [.002]
I don't know	25 (80.6)	1.0 (0.4–2.5) [.96]	1.0 (0.3–2.7) [.96]
Physically active ≥150 min per week			
No/I don't know	378 (71.9)	1 [Reference]	1 [Reference]
Yes	847 (86.3)	2.4 (1.8–3.1) [<.001]	2.2 (1.6–3.0) [<.001]
Body mass index			
Normal weight (18.5–24.9)	152 (85.2)	1 [Reference]	1 [Reference]
Underweight (<18.5)	8 (88.9)	2.1 (0.2–20.3) [.52]	1.0 (0.8–11.3) [.98]
Overweight (25.0–29.9)	471 (80.7)	0.9 (0.7–1.2) [.64]	0.8 (0.5–1.4) [.49]
Obese (≥30)	594 (80.7)	0.9 (0.7–1.1) [.56]	0.8 (0.5–1.3) [.35]
Previous participation in a health program			
No	822 (78.7)	1 [Reference]	1 [Reference]
Yes	403 (87.2)	1.8 (1.3–2.4) [<.001]	1.5 (1.1–2.1) [.01]

Abbreviation: GED, General Educational Development.
[a] Data source: The Centers for Disease Control and Prevention partnered with the National Association of Chronic Disease Directors to develop and distribute a 43-question survey from August 27, 2019, through September 3, 2019.
[b] Weighted percentage.
[c] *P* value calculated by using SPSS software multivariate logistic regression; $P < .05$ considered significant.
[d] Some school includes kindergarten through grade 11.
[e] Includes up to 5 years ago.

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IMPLEMENTATION EVALUATION

Leveraging Technology and Theory to Change Health Behaviors, Close Gaps in Health-Related Social Needs, and Increase Enrollment in the National Diabetes Prevention Program

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PEER REVIEWED

Summary

What is already known on this topic?

Innovative strategies are needed to increase engagement with the National Diabetes Prevention Program (National DPP) lifestyle change program (LCP).

What is added by this report?

We conducted a systematic evaluation of an interactive, tailored text-messaging program to address the awareness and engagement continuum for the National DPP (ie, identify risk for prediabetes, address health-related social needs that present barriers, tailor messages to increase readiness to participate, and facilitate referral).

What are the implications for public health practice?

Text messaging represents a promising approach to increasing readiness for and reducing barriers to patients' engagement with the National DPP.

Abstract

Purpose and Objectives

Although progress has been made in scaling up the National Diabetes Prevention Program Lifestyle Change Program (National DPP LCP), innovative engagement strategies are needed.

Intervention Approach

This implementation evaluation leveraged and combined technology, behavior change theory, and community-based participatory design approaches to develop, deploy, and evaluate a 6-month, bilingual, tailored text message–delivered program (*bRIght communities*) to increase 1) readiness to engage in key behaviors for diabetes prevention, 2) engagement in services that address health-related social needs to reduce barriers to participation, and 3) readiness to enroll in the National DPP LCP.

Evaluation Methods

We implemented a statewide, multichannel recruitment strategy from May through October 2022 and recruited 432 community members (62.3% White, 26.0% Hispanic, 6.2% Black) who received up to 6 months of tailored text messages. Six months postenrollment, 273 participants completed an online follow-up survey. Among those who did not complete the survey, responses from the last texting session were used for pre/post comparisons.

Results

Matched pre/post analyses (using *t* tests and McNemar tests) indicated that *bRIght communities* had a significant impact on daily consumption of fruits and vegetables (d = 0.43); weekly physical activity minutes (d = 0.48); resilience (d = 0.26); food insecurity ($P < .001$); transportation concerns ($P < .001$); and perceptions of feeling unsafe exercising in one's neighborhood ($P < .001$). Nearly 68% of participants with or at risk for prediabetes were in the precontemplation stage for enrolling in the National DPP. Overall, 30.3% of participants in *bRIght communities* moved forward at least 1 stage of change.

Implications for Public Health

Interactive, theoretically driven tailored text messaging represents a promising approach to increasing awareness of prediabetes risk, readiness to enroll in the National DPP LCP, participant engage-

ment, and health behavior change. Providing links to existing geographically matched community resources reduced health-related social needs that can present barriers to participating in the National DPP LCP. The results also provide insights to inform the design and development of other population-based tailored text-delivered interventions.

Introduction

More than 1 in 3 US adults have prediabetes (1), and more than 80% of those who have prediabetes don't know that they do (2). Having prediabetes increases the risk of developing diabetes and cardiovascular disease, as well as the risk of death due to cardiovascular disease (3). One of the Healthy People 2030 objectives is to reduce the proportion of Americans who are unaware that they have prediabetes (4). To increase public awareness, the Centers for Disease Control and Prevention (CDC), in collaboration with other national organizations, launched the National Prediabetes Awareness Campaign (5) to make Americans aware of the risk factors and symptoms of prediabetes, connect people with the Diabetes Risk Screening Test, and link people who have prediabetes with the National Diabetes Prevention Program (National DPP).

The National DPP provides a structured, evidence-based lifestyle change program (LCP) designed to prevent or delay onset of type 2 diabetes (6). Although progress has been made scaling the National DPP LCP nationally, enrollment remains a challenge (7); only 3% of adults with prediabetes have engaged (3). Innovative methods and strategies are needed to enroll a higher proportion of at-risk people, which is particularly relevant for underserved populations who are at high risk for developing diabetes and its complications (8,9).

Frequently cited and real barriers to participating in the National DPP LCP include those related to social determinants of health (SDOH), including lack of knowledge of the program, cost to participate, and lack of time and transportation (10–12). Although addressing health-related social needs can reduce barriers to participation (eg, transportation barriers are mitigated by the increasing availability of online and distance learning National DPP LCP classes), additional critical barriers to enrollment remain. Those barriers include lack of readiness to engage in the key behaviors targeted by the National DPP LCP (ie, physical activity, healthy eating, and stress management) and differing levels of readiness to engage with the program.

Providing dynamically tailored, population-based behavior change messages appropriate for all adults via a widely used communication channel (13) has the potential to raise awareness of prediabetes and to advance readiness to engage in key health behaviors for diabetes prevention, as well as — among those who are eligible — increase readiness to enroll in the National DPP LCP. An estimated 97% of people in the US text daily; the open rate of texts is 98% and 90% of texts are read within 3 minutes of being delivered (14). Text messaging therefore represents a promising and powerful communication channel through which interventions can boost confidence and provide personalized reminders. The emergence of text-message interventions for health behavior change (15) has largely been uninformed by rigorous behavior change science. For their potential to be realized, behavior change theory must be at the foundation of these communications to tailor the behavior-change strategies based on recipients' readiness to change and levels of self-efficacy. Deploying effective text-messaging campaigns requires a systematic approach to integrating best practices of behavior change science (eg, stages of change from the Transtheoretical Model [16]; social cognitive theory), as well as reliance on other robust communication frameworks (eg, principles of "pre-suasion" [17]). Pairing ongoing tailored behavior change micro-communications with screening for health-related social needs and localized referrals also has the potential to be particularly effective.

Although text messaging has been explored as an adjunct to the National DPP LCP (18,19) or as a delivery mechanism (20) for historically low-resourced communities, no systematic evaluations of efforts to use interactive text messaging to address the awareness and engagement continuum for the National DPP LCP appear to exist. To our knowledge, no studies have evaluated the effectiveness of a theoretically grounded short-message service (SMS)–delivered behavior change intervention that simultaneously enables identifying risk for prediabetes, addressing health-related social needs that present barriers to participating, tailored behavior-change reminders to increase readiness to participate, and geographically matched referrals to available recognized entities. This article addresses that gap by presenting the results of a 24-month initiative that involved 5 months of formative research, 5 months of intervention development, a 12-month demonstration project, and 2 months of data analyses.

Purpose and Objectives

We leveraged technology, behavior change theories, and community-based participatory design approaches to develop, deploy, and conduct a statewide evaluation of a text message–delivered, bilingual, tailored behavior change program. This implementation evaluation examined whether this type of interactive, theory-driven technology solution could increase 1) readiness to engage in key behaviors for diabetes prevention, as indicated by forward stage progress from one stage of readiness to the next; 2) engagement in community services and resources that address health-related social needs to reduce barriers to participating in the National DPP LCP; 3) readiness and self-efficacy for enrolling in the National DPP LCP; and 4) enrollment in the National DPP LCP.

Intervention Approach

In keeping with the Achieving Health Equity and Systems Transformation through the Meaningful Community Engagement Model (21), a community-based participatory design process was used to ensure maximum potential for engagement, successful implementation, and impact on health equity. Formative research was conducted from late 2021 through early 2022. Extensive formative input was obtained from 16 English- and Spanish-speaking participants from Rhode Island communities with high social vulnerability indices (SVI) through a series of three 1.5-hour interviews. Potential interview participants were invited via word-of-mouth referrals from community health workers and partners from community-based organizations serving communities with high SVI (eg, Providence, Pawtucket). Their feedback was combined with insights from 8 community health experts (eg, representatives of agencies from Rhode Island Health Equity Zones and federally qualified health centers, Master National DPP Trainers) who participated in five 2-hour meetings. In addition to the 8 community experts, 2 members from the Rhode Island Department of Health participated in key advisory meetings (ie, the interim Diabetes Prevention Program coordinator for the state and the Community Health Network manager). Community health experts were invited via word-of-mouth invitations following introductions through the statewide National DPP Stakeholder network or the state's Health Equity Zones. Key participants and community members provided feedback on all aspects of program design, content development and promotional strategies, and resources available to help users with health-related social needs. One key contribution was the naming of the program. With the intention of having a program name that was tied to a superordinate goal with broad appeal, the name initially proposed to community members and community health experts was thRIve. Their input, that the program name should evoke a sense of connection and community to generate interest and still be localized, transformed the program name to *bRIght communities*. The updated name addressed participants' concern that thRIve was too focused on individual versus community well-being and that bRIght had a Spanish cognate (*comunidades bRIllantes*) that maintained the local reference to Rhode Island.

The insights gleaned were combined with the feedback of 15 additional English- and Spanish-speaking community members who participated in a 10-day usability test of *bRIght communities* to inform the intervention development. Usability testers participated in a 30-minute video meeting, during which they were asked to enroll in the SMS program to ensure that they understood that enrollment required texting the keyword to the designated phone number. Usability testers then completed the first *bRIght communities* session. They were asked to think out loud about their user experience. Ten days later, a 1.5-hour follow-up meeting enabled usability testers to give feedback on the texts they received, the reminders to do their next assessment, the study landing page, a selection of recruitment posters, and their likelihood of recommending it to a friend. Usability testers were given a $50 gift card for their time. Revisions to the program based on usability testing feedback included adding images to the program (eg, animated gifs to illustrate what a cup of fruit and veggies looks like), clarifying questions and intervention messages, and encouraging participants to save the study telephone number as a contact.

Three of the main factors considered in intervention development were how to ensure that *bRIght communities* was engaging a broad sample of adults in a conversation about maximizing their health and well-being; could reduce barriers to improving health; and would increase awareness of prediabetes risk. Enrolling any adult created 1) an opportunity to deliver individually tailored feedback to increase readiness to engage in key diabetes prevention behaviors (ie, healthy eating and exercise), 2) a mechanism to identify and address unmet health-related social needs; and 3) an avenue of communication with people who may not be aware of having prediabetes.

Another equally crucial factor was ensuring that *bRIght communities* could personalize both the assessment and the intervention messaging to meet the needs of each person. The foundation for the tailoring technology driving the interactive text messaging was the Transtheoretical Model of behavior change (TTM) (22,23). The TTM is a model that frames readiness to change as a continuum of 5 stages of change: 1) Precontemplation = not yet ready; 2) Contemplation = getting ready; 3) Preparation = ready; 4) Action = recently adopted a new behavior; and 5) Maintenance = adopted a behavior more than 6 months ago and is feeling more confident about sustaining it (16,24). More than 35 years of research on the TTM have identified specific principles and processes (ie, strategies) of change that work best in each stage to facilitate progress (24–27). This evidence-based framework informs tailored feedback that is more likely to be remembered, considered personally relevant and credible, and to change behavior. Meta-analyses found that health interventions tailored to stage of change produced significantly greater effects than those not tailored to stage (24,25). Thus, the TTM was used as the key unifying theoretical framework for *bRIght communities* (Figure 1).

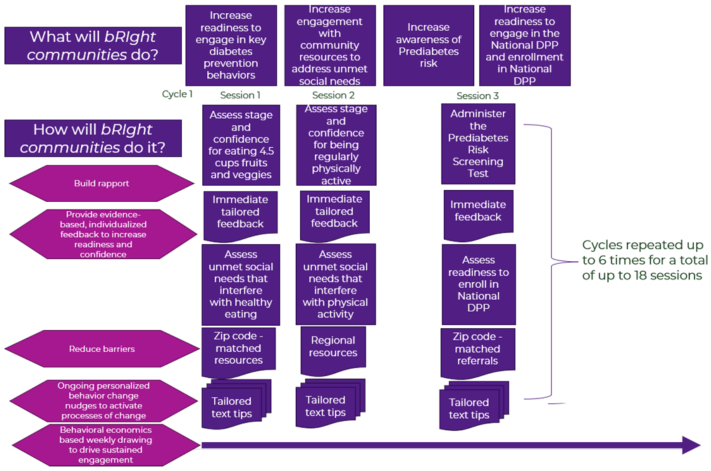

Figure 1. Range of objectives and strategies of *bRIght communities*.

bRIght communities is a customized and individually tailored user journey in a fully automated SMS-delivered experience based on each participant's readiness to engage in various health behaviors, level of self-efficacy for each, health-related social needs, risk for prediabetes, and readiness to enroll in the National DPP LCP. Users were invited to text a keyword (ie, "bright") to a local number to complete a brief screening to confirm eligibility. Through a series of interactive text messaging sessions, preprogrammed decision rules operated to dynamically present the appropriate questions and personalized feedback for each user based on their responses. The immediate tailored feedback users were given was supplemented by customized text messages. Intervention delivery from an automated text messaging delivery platform was standardized, ensuring high treatment fidelity, as well as being cost-effective and easily accessible among anyone regardless of their device type (eg, flip phone).

bRIght communities was split into 10-day sessions that included assessment questions related to the focus of that session. During the initial onboarding session, which lasted approximately 5 to 7 minutes, users were asked to report their zip code and their current daily consumption of fruit and vegetables. Based on responses, users were then assessed on their stage of readiness and self-efficacy for consuming 4.5 cups of fruits and vegetables daily (the recommendation from the Dietary Guidelines for Americans). Users then received tailored feedback. Users in Precontemplation, Contemplation, or Preparation were asked about social needs related to fruit and vegetable intake. Users who confirmed food insecurity or transportation barriers were provided with immediate zip code–matched community resources to help close gaps. Users' responses were used to queue 30 days of tailored text message tips that were matched to their level of readiness to consume sufficient fruits and vegetables and to their specific constellation of health-related social needs (if any). The schedule for delivery of those texts was also variable and dependent on the user's stage of change.

To maintain engagement, participants completing Session 1 became eligible for a "regret style" contest for the duration of the study. The weekly drawing used multiple principles of behavioral economics (eg, loss aversion, tendency to overestimate small probabilities). Every 10 days, anyone who had responded to at least 1 text was eligible to win one of ten $10 gift cards or one $100 gift card based on a random drawing. In past studies, adding a "regret contest" increased enrollment, adherence, and long-term engagement (28–31).

During Session 2, users were asked to report their weekly minutes of physical activity. Users were then asked about their readiness and confidence to engage in regular physical activity (ie, 150 minutes of moderate physical activity per week). They received immediate tailored feedback. Any user who confirmed concerns about perceived neighborhood safety or that childcare presented a barrier to being physically active were given feedback and regional resources to address those concerns. Up to 30 days of tailored text messages were then queued to be sent based on a cadence that was determined by their stage of change.

During Session 3, the Prediabetes Risk Test (32) was administered. People with or at risk for prediabetes were provided with information about the National DPP LCP and asked about their past or current participation. People who had never participated or who had previously dropped out were then asked about their readiness and confidence to participate in the National DPP LCP. Immediate feedback based on stage of change and confidence was presented in conjunction with a zip code–matched referral to the geographically closest National DPP LCP and the state Community Health Network. Tailored messages based on readiness to participate were then queued up for 30 days and delivered based on stage.

The logic and decision rules allowed the cycles of 3 sessions to recur every 30 days. Stage of change for each respective behavior was reassessed in each session to allow feedback to be dynamically retailored over time. People with persistent health-related social needs received new resources at subsequent sessions.

A 12-month statewide demonstration project was conducted in Rhode Island to evaluate the feasibility, acceptability, and effectiveness of *bRIght communities*. Recruitment began in May 2022 and continued on a rolling basis for 6 months. Multichannel, grassroots promotional strategies (ie, radio, online, email, flyers, and in-person) were used to recruit participants. These methods included the dissemination of promotional materials statewide via community partnerships, direct community outreach, and community events. Rhode Island residents were eligible to participate if they were aged at least 18 years, were not pregnant, and had not been diagnosed with diabetes. Users who were screened out based on 1 or more of the exclusion criteria were provided with local resources. Although recruitment efforts and materials were disseminated in every town and city in the state, they were most heavily focused in cities with the highest social vulnerability. Identifying a variety of nontraditional community channels such as churches and car washes allowed *bRIght communities* to reach traditionally underserved and hard-to-reach populations. Various community partnerships were developed and cultivated to facilitate and strengthen the association of *bRIght communities* with existing community-based organizations with whom residents already had a trusted relationship.

Evaluation Methods

Self-efficacy (ie, confidence) to enroll in the National DPP LCP was the primary outcome measure used to evaluate the effectiveness of *bRIght communities* texting program, as it is among the measures recommended in the Centers for Disease Control and Prevention's (CDC's) health communication and marketing toolkit (33). Participants were asked to respond to the question "How confident are you that you will take part in a DPP?" on a 5-point Likert scale ranging from 1 being "not at all confident" to 5 being "extremely confident." Based on an initial power calculation assuming a small effect (d = 0.3) on confidence and a 75% retention rate, the minimum recruitment goal was 416 participants. Secondary outcomes included readiness to engage in the health behaviors addressed in the National DPP LCP (ie, healthy eating and physical activity) and rates of health-related social needs. Increasing readiness to engage in these health behaviors is crucial to promote overall health and well-being and to prevent chronic illnesses among people not at risk for prediabetes. Furthermore, increasing readiness for these behavior changes and addressing health-related social needs could play an important role in increasing sustained engagement and success in the National DPP LCP.

Participants interacted in their preferred language and received up to 6 months of tailored text messages. On day 180, each user (regardless of number of sessions completed during the intervention) received an SMS message to complete the final follow-up survey and a link to a secure online platform. Participants received a $25 grocery store or Amazon gift card for completing the onboarding assessment and another $25 gift card for completing the final assessment 6 months later. The research protocol was reviewed and approved by the Pro-Change Behavior Systems Institutional Review Board, which has federal-wide assurance. All data were stored on secure servers that were regularly audited to ensure compliance with rigorous data privacy standards.

A robust evaluation was conducted in the context of a single group, pre/post comparison over a 6-month period. Paired *t* test and McNemar tests were used to compare baseline data (ie, responses at onboarding) to the last available data for each participant. The McNemar test is a nonparametric test used to analyze paired nominal data (34). For some participants (n = 273), the "last" available data was the 24-week final follow-up evaluation. For others, the "last" available observation was a response within a session of *bRIght communities*. Consideration was given to reporting the pre-to-post comparison of onboarding to final follow-up assessment data, but sample sizes were larger when all available data were used, and results were remarkably similar. Thus, to maximize power, all available data were used. The last value carried forward was used for any participants who had postbaseline data but no final follow-up assessment data. Analyses were conducted by using SPSS (SPSS Inc). When reporting paired *t* tests, estimates of effect size are presented in Cohen's d, with d = 0.2 representing a small effect, d = 0.5 representing a medium effect, and d = 0.8 representing a large effect (35). Although this study was not powered to do subgroup analyses by race or ethnicity, the proportion of White participants who were enrolled in the National DPP LCP at onboarding versus the last session was compared with that of non-White participants.

Results

A total of 432 participants enrolled in the study. During the study period, 35 participants had a mobile number that went out of service. Thus, 397 participants were invited to complete the 6-month follow-up assessment. A total of 273 did so, representing a 68.7% retention rate (Figure 2).

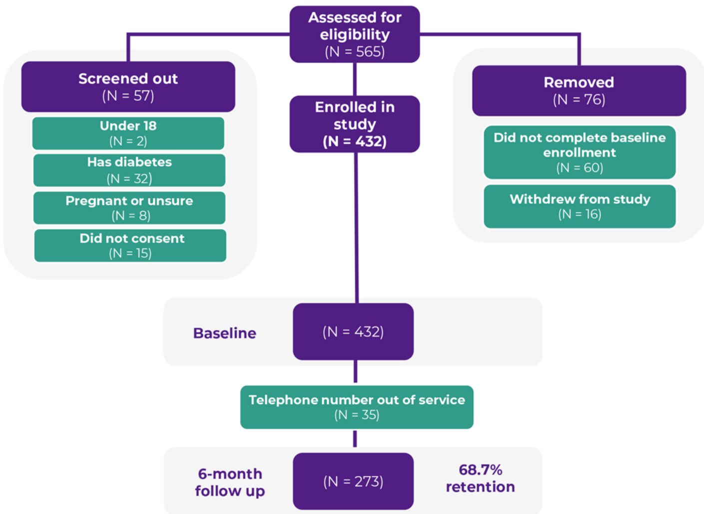

Figure 2. Eligibility and participation of *bRIght communities* participants.

The average age of participants was 40.1 years (SD, 13.4 y), 78.2% were female, and 70.3% had a body mass index in the overweight or obese range. Race and ethnicity were assessed only at the follow-up assessment. Among the 273 respondents, 62.3% were White, 26.0% were Hispanic, 6.2% were Black, and 5.5% reported another race.

Users could complete as many as 18 sessions over 6 cycles (ie, 6 months). A total of 119 users (27.5%) initiated the sixth cycle (ie, Session 16). On average, users completed 8.6 sessions of *bRIght communities*.

Primary outcome: readiness and self-efficacy to enroll in the National DPP LCP

A total of 300 participants completed the Prediabetes Risk Screening Test at the outset of Session 3 in Cycle 1. Approximately 31% (n = 93) had or were identified as being at risk for prediabetes based on the Prediabetes Risk Test. *bRIght communities* identified 58% of those at risk for prediabetes (n = 54) who were not aware they were at risk. The stage of change distribution for enrolling in the National DPP among individuals who had or were at high risk for prediabetes is depicted in Table 1.

The increase in confidence to enroll in the National DPP LCP from first to last session was not statistically significant ($t = 1.33$, $P = .19$, d = 0.15). Among people who were not extremely confident at the onboarding session and therefore had an opportunity to increase their confidence (ie, answered 1–4 on a 5-point scale), 29.5% had higher self-efficacy at their last session, with scores increasing from 1.9 to 2.1 points.

Enrollment in the National DPP LCP

Significantly more participants had enrolled or asked to enroll at the last session than at the first session ($P = .01$). At onboarding (first session), 7.2% of participants reported already being enrolled in a National DPP LCP, and 2.4% reported being on a waiting list for a National DPP LCP. At the last session, those numbers had increased: 15.4% reported being enrolled in a National DPP LCP, and 4.8% reported being on a waiting list for a National DPP LCP.

Among White participants, 5.3% were enrolled in the National DPP LCP at onboarding and 15.8% reported being enrolled or on a waiting list at the final time point. Among non-White participants, 21.1% were enrolled in the National DPP LCP at onboarding and 36.8% were enrolled or on a waiting list at the last time point.

Secondary outcomes: readiness to engage in health behaviors for diabetes prevention

Fruit and vegetable consumption

More than 92% of participants were not consuming 4.5 cups of fruit and vegetables each day at their first (onboarding) session. Among them, 7.5% were in Precontemplation, 2.5% were in Contemplation, and 82.1% were in Preparation. The proportion of participants in Action and Maintenance (consuming adequate fruits and vegetables) at onboarding was compared with the proportion in Action and Maintenance at the last session. Significantly more participants were in Action and Maintenance at their last session (23.8%) compared with at onboarding (7.8%, $P < .001$).

Daily cups of fruits and vegetables consumed increased significantly from first to last session. At onboarding, participants consumed an average of 2.43 cups per day (SD, 1.63). At the last session, the average had increased to 3.21 (SD, 1.70; $t = 7.76$; $P < .001$; d = 0.43). Overall, 60% of participants had some increase in their daily consumption of fruit and vegetables.

Similar findings were seen among people with or at risk for prediabetes. From first session to last session, average daily cups of fruit and vegetables increased significantly from 2.17 cups to 3.00 cups ($t = 4.42$, $P < .001$, d = 0.47) among people with or at risk for prediabetes. Among those not at risk, average daily cups increased from 2.58 to 3.44 ($t = 6.69$, $P < .001$, d = 0.48). The increase in daily cups of fruit and vegetables was higher (mean increase = 0.86 cups, $t = 5.42$, $P < .001$, d = 0.53) for non-White participants than for White participants (mean increase = 0.73 cups, $t = 5.05$, $P < .001$, d = 0.39).

Physical Activity

At onboarding, 50% of the participants were engaging in at least 150 minutes of physical activity each week (ie, they were in Action and Maintenance). There was a small, nonsignificant increase (to 53.5%) in the proportion in Action and Maintenance at the last session (P = .30). Substantial improvements were noted among people who were not regularly physically active at the first session (ie, the participants in Precontemplation, Contemplation, or Preparation). More than one-third (34.3%) of them moved forward at least 1 stage of change.

A small, nonsignificant increase was found in self-efficacy for physical activity among people in the pre-Action stage from first (mean 3.20 [SD, 0.88]) to last session (mean = 3.37 [SD, 1.01], d = 0.15). A substantial increase was found in weekly minutes of physical activity among this group, with 59.4% of participants reporting an increase. Weekly minutes increased from 58.31 to 113.34 from first to last session (t = 5.77, P < .001, d = 0.48).

Among people who were at risk for or who had prediabetes and were in a pre-Action stage at onboarding, weekly minutes of physical activity increased significantly from an average of 46.88 to 89.02 (t = 3.48, P < .001, d = 0.52). The increase in weekly minutes of physical activity was higher (mean increase = 74.30 min, t = 4.29, P < .001, d = 0.67) for non-White participants than for White participants (mean increase = 43.03 min, t = 3.73, P < .001, d = 0.40). Overall, 56% of White participants increased their weekly minutes of physical activity, and 66% of non-White participants did so.

Secondary outcomes: health-related social needs

McNemar tests showed significant reductions in food insecurity (P < .001), transportation concerns that make it difficult to obtain healthy food (P < .001), and perceptions of feeling unsafe exercising in one's neighborhood (P < .001) from first to last session among participants. A reduction in the proportion of participants endorsing that problems with childcare make it difficult to exercise (P = .06) was seen from first to last session (Figure 3).

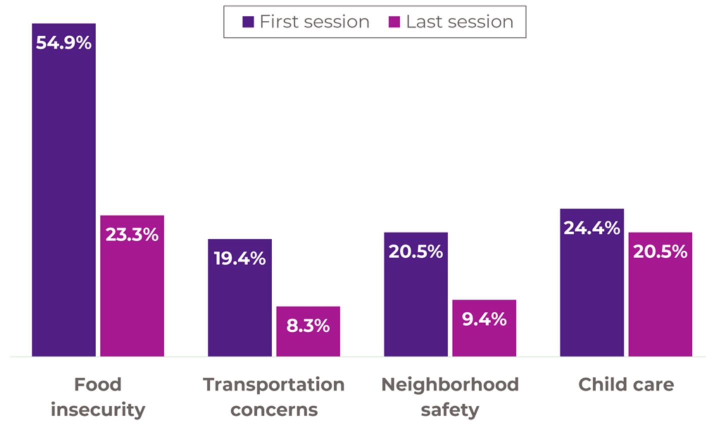

Figure 3. Comparison of proportion of *bRIght communities* participants reporting health-related social needs from first to last session.

People with prediabetes had similar meaningful reductions in health-related social needs to those who did not report having or being at risk for prediabetes (Table 2). The proportion of those with health-related social needs was also compared between participants who reported being White versus participants who reported any other race or ethnicity. Gaps in health-related social needs were closed for all participants, but non-White participants were more likely to endorse health-related social needs (Table 2).

Acceptability data

Participants rated *bRIght communities* with an average star rating of 4.2 (of 5), with 79.2% giving 4 or 5 stars. More than 89% reported that they read most or all of the texts, and 76.6% reported that the program gave them "new things to think about." Nearly 62% reported that the texts they received were personalized for them, and 71.8% reported that the program could help them be healthier.

In response to what participants liked best about *bRIght communities*, common themes were that it provided helpful, informative tips and reminders. The texts reminded users to engage with the program but also acted as a gentle, continual reminder of the importance of their daily health behaviors (eg, one participant said, "Gentle reminders to eat healthy!"). Another common theme was the interactive tailoring (eg, "personalized information and positive feedback").

Implications for Public Health

The data confirm that using theoretically driven, interactive, tailored text messaging can increase awareness of prediabetes risk, readiness to enroll in the National DPP LCP, and engagement.

Overall, 30.3% of participants in *bRIght communities* moved forward at least 1 stage of change for enrolling in the National DPP LCP.

The stage of change distribution for readiness to enroll in the National DPP LCP among people who are eligible (ie, 90.5% in a pre-Action stage and nearly 70% of participants in the Precontemplation stage) underscores how critical it is to provide tailored health behavior change communications about the National DPP LCP to increase readiness. Action-oriented messages are not well-matched to individuals in the Precontemplation stage of change. The goal for people in Precontemplation is to promote forward stage progress to Contemplation (16). *bRIght communities* had an effect on progression out of the stable Precontemplation stage: nearly 25% of those in Precontemplation at the onboarding session moved forward at least 1 stage of change or took action to enroll in the National DPP LCP. Forward stage movement is a positive intermediate success metric; moving forward at least 1 stage can as much as double the probability that a person will move to the Action stage within the following 6 months (36).

The results also affirm and are consistent with past studies that speak to the ability of health communications based on the TTM to create behavior change on key diabetes prevention behaviors (23,27). Here, however, the delivery channel was brief, interactive texting, a novel intervention channel for a tailored, behavior-change intervention for multiple behaviors. The proportion of participants who increased their daily consumption of fruit and vegetables and the medium effect size of the increase from 2.4 to 3.2 compare favorably to a meta-analysis of 19 studies on e-health interventions to improve fruit and vegetable consumption in which the overall effect size was small (d = 0.26) (37). Similarly, the medium effect on weekly minutes of physical activity (with an increase of 55 minutes per week) compares favorably to previous research on physical activity interventions. One systematic review and meta-analysis (n = 16,476) reported an average increase of 14.2 minutes for interactive online physical activity interventions (38), and another systematic review and meta-analysis of 46 randomized trials including more than 16,000 participants reported that physical activity interventions delivered by health care providers in primary care resulted in an increase of 14 to 24 minutes of moderate physical activity a week (39).

One of the key objectives of *bRIght communities* was to close gaps in health-related social needs by providing localized referrals to community health services. Providing links to existing geographically matched community resources reduced critical health-related social needs that can present barriers to participating in the National DPP LCP. Our results emphasize the importance of navigation and support services (eg, community health workers) in communities experiencing more health-related social needs.

Intervention dose is an important consideration worth mentioning. Program users can benefit from variable user experiences. Although users could engage in up to 18 sessions over the 6 months, some elected to participate in fewer sessions of *bRIght communities*. The users who engaged in fewer sessions, however, need not be considered "dropouts," in that some achieved the same outcomes as those who engaged in more sessions. One user, for example, interacted for 5 sessions and progressed from Precontemplation to Preparation for taking part in the National DPP — the same outcome achieved by another user who engaged in 16 sessions. Future research should explore dose response in more depth.

The strengths of this approach include the heavy reliance on participatory design and robust theoretical frameworks, as well as the number and robustness of partnerships with an array of community-based organizations and boots-on-the-ground recruitment efforts. This approach is repeatable, scalable, and generalizable to other communities and can inform the design and development of other population-based tailored SMS-delivered interventions. The automation of the decision rules and SMS delivery ensures that disseminating the tailored behavior change feedback to larger communities is easily achieved. The effort required to adapt *bRIght communities* to different contexts or populations is identifying and matching the recognized entities offering the National DPP and the resources for health-related social needs to the region and additional language translations as needed. Future research could also explore additional strategies for maintaining engagement to supplement the regret contest.

These results also highlight opportunities for improving the design of SMS programs, such as adding even more refined tailoring; more images; more links to resources; links to recipes and cooking demonstrations; reminders to users at onboarding and on the landing page of the importance of reconnecting with us if their number changes or they get a new mobile number; and a more spaced series of reminders at a less frequent interval to re-engage users. Another potential enhancement that warrants further exploration would be to enable users to set the desired frequency for text messaging from the outset or to allow the selection of a less-frequent cadence among users who have not yet returned for a follow-up session as a mechanism for re-engaging.

Limitations of this implementation evaluation include the self-selection bias operating on who initially elected to enroll and who completed a follow-up assessment. The wide-ranging recruitment efforts and extensive efforts to capture follow-up mitigate these concerns to a certain degree. The reliance on a single-group design is also a limitation in that we could not eliminate questions about the role of confounding factors that could have influenced the outcomes. Future studies should conduct randomized trials to address questions about the potential influence of secular trends.

Given the cost effectiveness of text messaging and high acceptability ratings given to *bRIght communities*, interactive tailored texting rooted in behavior change science represents a promising approach to improving population health and increasing enrollment in the National DPP LCP. This approach offers the opportunity to increase awareness of risk, as well as awareness of and, ultimately enrollment in, the National DPP LCP, particularly among underserved people living with prediabetes.

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Tables

Table 1. Readiness of People with Prediabetes (N = 93) to Participate in the National Diabetes Prevention Program (DPP) Lifestyle Change Program

Stage of change for enrolling in the National DPP	% of Participants
Precontemplation	67.9
Dropped out of a previous national DPP	3.6
Contemplation	8.3
Preparation	10.7
Waiting list for the National DPP	2.4
Action	3.6
Maintenance	3.6

Table 2. Comparison of Proportion of *bRIght communities* Participants Reporting Health-Related Social Needs, From First to Last Session, by Prediabetes Status and Race and Ethnicity

Unmet social need	Participants with prediabetes, %		Participants without prediabetes, %		White participants, %		Non-White participants, %	
	Onboarding	Final session	Onboarding	Final session	Onboarding	Final session	Onboarding	Final session
Food insecurity	50.0	27.5	57.2	21.4	36.7	12.2	77.8	30.6
Transportation	15.0	7.5	21.4	8.7	10.1	5.0	30.6	8.3
Neighborhood safety	24.4	13.3	18.3	7.3	16.3	7.5	30.3	12.1
Childcare	17.8	13.3	28.0	24.4	18.8	15.0	42.4	36.4

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ESSAY

Advancing Practices to Increase Access to Diabetes Self-Management Education and Support Through State Health Departments

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PEER REVIEWED

Currently, 38 million Americans have diabetes, a complex and chronic condition that is the leading cause of adult kidney failure, adult blindness, and lower-limb amputations (1). Learning how to manage this condition is a crucial skill for people with diabetes (PWD). The cornerstone of diabetes management is diabetes self-management education and support, or DSMES, which aims to provide PWD with the “knowledge, skills, and confidence” needed for good self-care (2). The benefits of DSMES are vast and include clinical outcomes such as improved hemoglobin A1c levels and behavioral outcomes including enhanced self-efficacy and problem-solving skills to manage diabetes. Despite these advantages, DSMES remains widely underused (2).

In 2018, the Centers for Disease Control and Prevention (CDC)’s Division of Diabetes Translation and the Division for Heart Disease and Stroke Prevention launched DP18–1815 (1815), *Improving the Health of Americans Through Prevention and Management of Diabetes and Heart Disease and Stroke.* This 5-year cooperative agreement focused on diabetes management and type 2 diabetes prevention, as well as heart disease and stroke prevention, and was awarded to the state health departments (SHDs) of each of the 50 states and the District of Columbia, to run from June 29, 2018, to June 30, 2023 (3).

One of the initiatives encouraged in 1815 was to improve access to and participation in American Diabetes Association (ADA)–recognized or Association of Diabetes Care and Education Specialists (ADCES)–accredited DSMES services in underserved areas. All 51 recipients worked on this initiative, and in this essay we reflect on several activities related to engaging the pharmacy sector, establishing umbrella organizations, and engaging in continuous quality improvement (Table). These activities were identified through 1815 deliverables, such as recipient progress reports. Detailed descriptions of work related to DSMES were extracted from the deliverables and coded for analysis.

Engaging the Pharmacy Sector

During 1815, SHDs played a significant role in supporting pharmacies in advancing DSMES offerings nationwide. Approximately 73% of SHDs engaged with community- and ambulatory care–based pharmacists in their respective jurisdictions to provide DSMES start-up information, training, and ongoing technical assistance to establish pharmacy-based DSMES services. Given the treatment complexities related to successfully managing diabetes, pharmacists were recognized as valuable partners of the health care delivery team based on their medication expertise, ease of access when questions from PWD arise, and presence in nearly every US community (4). The ADA endorses pharmacists as integral providers of DSMES services, leading many SHDs to pursue strategic partnerships with the pharmacy sector (2).

As the partnerships progressed, barriers to successfully sustaining DSMES in pharmacy practice locations became evident. A lack of experience with DSMES billing in pharmacies and low participation rates due to the nontraditional DSMES setting posed challenges to a sustainable pharmacy-based DSMES model (5). Recipients responded as follows to address barriers and improve sustainability: 1) developed promotional materials to increase awareness of DSMES among PWD and health care providers (74%); 2) strengthened referral pathways for health care providers to refer PWD to pharmacy-based DSMES programs (16%); 3) provided tailored technical assistance for pharmacists at DSMES sites (16%); and 4) aided in the establishment of a DSMES billing infrastructure, such as implementing pharmacy billing support mechanisms (10%). Additional support from SHDs included integrating community health workers to promote pharmacy-based DSMES programs (10%) and aiding in exploring and developing a multi-site network of pharmacy-based DSMES programs (2%).

Support from SHDs provided pharmacists with the necessary tools to lead innovations and lay the groundwork for potential improvements in delivering DSMES. Innovative opportunities that use the pharmacy infrastructure in a turn-key manner to efficiently scale DSMES services within pharmacy networks and chains would be of great value. SHDs have a vested interest in increasing the capacity of the pharmacy sector to succeed by not only increasing the availability of DSMES within communities but also by helping to strengthen and sustain quality DSMES services.

Umbrella Organizations

Recipients of 1815 regularly cited administrative challenges as a key barrier to increasing DSMES access. The umbrella organization approach is a successful method for alleviating several of these challenges and establishing sustainable reimbursement. It allows a sponsor organization to become ADA-recognized or ADCES-accredited and then help subsites become certified under their umbrella certification. The umbrella sponsor can support the subsites with administrative components such as completing the accreditation or recognition process, reporting requirements for the certifying body, and helping with billing and reimbursement.

Throughout the 1815 funding period, 25% of recipients pursued a DSMES umbrella organization approach. Some recipients worked on a model where the SHD served as the umbrella sponsor to establish a centralized system that allowed them to provide support to DSMES partners (22%). Support included submitting applications and data for certification and providing technical assistance to DSMES services on an array of services ranging from billing to curriculum usage. States that applied this approach were able to establish subsites at locations ranging from local health departments to health care practices to community pharmacies.

Two states pursued the umbrella organization approach by establishing sponsor organizations at universities or regional health care institutions. This format enabled the sponsors to offer many of the same benefits as an SHD-based sponsor but within a smaller jurisdiction.

Continuous Quality Improvement

Continuous quality improvement (CQI) efforts in health care may be critical to advancing and adapting in an ever-changing environment. Defined as a “progressive incremental improvement of processes, safety, and patient care,” CQI is generally considered a successful tool in improving health care (6). Under the 1815 cooperative agreement, 55% of recipients leveraged CQI approaches to advance DSMES efforts. Common CQI efforts involved increasing awareness and referrals to DSMES services by health care providers (60%) as well as advancing patient awareness of DSMES and improving enrollment (66%). CQI efforts were implemented in various settings, including health care systems, pharmacies, and local health departments, using common methods such as “plan–do–study–act,” process maps, workflow analyses, and decision trees. The most successful CQI efforts among recipients spanned multiple years, allowing for multiple CQI cycles. They targeted specific processes, including diabetes diagnosis, referral form completion, follow-up notifications, laboratory referral workflow, and educational opportunities.

States’ CQI activities identified several key findings, including:

1. PWD referred to DSMES services regularly cited transportation as the most significant barrier to DSMES attendance, prompting 17% of DSMES providers to explore telehealth platforms;
2. PWD needed to be contacted up to 4 times via multiple modes of communication (eg, text, phone calls, electronic health record [EHR] platforms) to begin the DSMES intake process, resulting in 33% of health care systems reformatting their referral process and incorporating multiple outreach efforts; and
3. There was a lack of familiarity of both DSMES and how to make referrals, prompting SHDs to provide ongoing training for health care providers on the benefits of DSMES and successfully navigating the referral system using existing EHR systems (31%).

Future Implications

SHDs can be essential in coordinating chronic disease prevention and management efforts at the population level. This is evident in CDC’s continued investment in a new cooperative agreement, DP23–0020 (2320), *A Strategic Approach to Advancing Health Equity for Priority Populations with or at Risk for Diabetes.* This cooperative agreement will extend from June 30, 2023, to June 29, 2028, and funds the 50 SHDs, the District of Columbia, and 26 local and national organizations to implement diabetes management and type 2 diabetes prevention strategies with a focus on priority populations (7). Under 2320, more than 84% of recipients (n = 65) have selected to work on a strategy to improve access, appropriateness, and feasibility of DSMES services through a health equity lens.

Engaging the pharmacy sector has been a key approach for 2320 recipients to advance DSMES access and participation. As highly accessible and trusted health care professionals, pharmacists can play a pivotal role in ensuring that diabetes programming, including DSMES, is both accessible and appropriate for priority populations. SHDs can further support the pharmacy sector in strengthening screening processes and community referrals for identified social determinants of health (8).

Recipients of 2320 are also working to establish and sustain new DSMES umbrella organizations in regions lacking DSMES. By strategically locating newly established sponsors or subsites in areas accessible to priority populations, such as within a network or pharmacy chain, these umbrella organizations can help bridge gaps and improve participation in DSMES among communities that need it most. Additionally, umbrella organizations strengthen the individual DSMES site by enhancing service offerings, sharing resources, and supporting long-term sustainability.

Those interested in scaling these approaches can apply them within many geographic and health care settings. Umbrella organizations can also exist in nontraditional health care settings, such as health departments. Throughout 1815, the effectiveness of these approaches was gauged by the number of DSMES sites within a state and the number of PWD that attended DSMES. A more robust evaluation should be tailored to the approach and incorporate additional data points, such as rates of DSMES referrals and enrollment and successful billing encounters.

Although the approaches in this essay are described in relation to diabetes management, they may also be applicable to other chronic disease programs. For example, the umbrella approach can be seen in the emergence of community care hubs, which support and provide a range of evidence-based chronic disease management and prevention programs hosted by community-based organizations and that feature a centralized hub for joint administrative and operational functions (9). The unique structure of the umbrella and community care hub model allows staff and organizations to have specialized roles. For example, staff within the sponsor entity may serve as billing specialists, increasing the likelihood of reimbursement, while staff at the subsites are able to allocate more effort to program referrals and delivery. Recipients of 2320 are also exploring this tailored version of the umbrella model.

Ultimately, applying the 3 approaches described in this essay may help ensure PWD have equitable access to DSMES and an opportunity for improved diabetes-related outcomes.

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Table

Table. Examples of Activities Implemented by State Health Departments to Increase Access to Diabetes Self-Management Education and Support, 2018–2023

State health department	Example activities
Texas	The Texas Department of State Health Services worked with the University of Texas College of Pharmacy to develop a "Pharmacy-Led DSMES Guide" to aid in the delivery and sustainability of DSMES in pharmacy settings.
Oklahoma	The Oklahoma State Department of Health supported amendments to include pharmacists as reimbursable providers of DSMES by Oklahoma State Medicaid.
North Carolina	The North Carolina Department of Health and Human Services became a DSMES umbrella sponsor before 1815. Under 1815, they scaled up the number of subsites and provided technical assistance on an array of topics.
Maryland	The Maryland Department of Health partnered with the School of Pharmacy at Notre Dame of Maryland University to establish DSMES umbrella organizations to increase the region's access to DSMES services.
Michigan	The Michigan Department of Health and Human Services collaborated with a large health care system in metro Detroit to pilot a social needs screener for persons with diabetes referred to DSMES services.
Colorado	The Colorado Department of Public Health and Environment worked with health systems to identify people with diabetes, restructuring electronic health record systems and workflows for efficient scheduling, screening, and documentation, with referrals primarily between clinics and DSMES providers.

Abbreviation: DSMES, diabetes self-management education and support.

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RESEARCH BRIEF

Diabetes Distress Among US Adults With Diagnosed Diabetes, 2021

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PEER REVIEWED

Summary

What is already known on this topic?

Diabetes distress can negatively affect diabetes care and management.

What is added by this report?

In 2021, more than half of US adults with diabetes had diabetes distress, including 7% with severe diabetes distress and 24% with moderate diabetes distress. Diabetes distress was higher among people aged 18 to 64 years, women, and those with lower income.

What are the implications for public health practice?

Researchers can assess the prevalence of diabetes distress and examine economic and social factors that contribute to differences. Interventions including diabetes distress screening, behavioral therapy (such as stress management and psychoeducation), and family support may improve diabetes management and services.

Abstract

National prevalence of diabetes distress is unknown among US adults. This cross-sectional study examined the prevalence among US adults with diabetes using 2021 National Health Interview Survey data. Multivariable multinomial logistic regressions were used to estimate adjusted prevalence and prevalence ratios for diabetes distress. Adjusted prevalence of moderate and severe diabetes distress was 24.3% (95% CI, 22.5%–26.1%) and 6.6% (95% CI, 5.6%–7.8%), respectively. Prevalence was higher among people aged 18 to 64 years, women, and those with lower incomes. Findings highlight the importance of examining economic and social factors and integrating diabetes distress screening into diabetes management and services.

Objective

Diabetes prevalence has increased among US adults aged 18 years or older, and in 2021, 29.7 million people were diagnosed with the disease (1). People living with diabetes are more likely to experience adverse mental, social, and physical health effects that result in diabetes distress (DD). DD refers to the emotional and psychological difficulty among people with diabetes when they manage their condition (2). Approximately 18% to 40% of people with diabetes experience significant DD, with 18-month cumulative incidence ranging from 38% to 48% (2). DD is associated with lower glycemic control, decreased self-glucose monitoring, and poor medication management (3). Study findings have illustrated that people with high self-efficacy (ie, a person's confidence in their ability to achieve a goal) have lower DD compared with those with low self-efficacy (4). Thus, prior findings (3,4) demonstrate the importance of assessing DD among people living with diabetes to support behavioral change by implementing multilevel, culturally tailored interventions. We aimed to examine the prevalence and associated distress factors — including sociodemographic, treatment, and health status — among US adults diagnosed with diabetes by using National Health Interview Survey (NHIS) data (5).

Research Design and Methods

This cross-sectional analysis used self-reported data from the 2021 NHIS, a national representative survey of the US civilian noninstitutionalized population conducted by the Centers for Disease Control and Prevention's National Center for Health Statistics (5). The 2021 NHIS introduced 2 supplemental questions based on a modified version of a question on the Diabetes Distress Scale that assesses whether someone is "feeling overwhelmed by the demands of living with diabetes" (6). Respondents aged 18 years or older self-reported diagnosed diabetes based on the question, "Have you ever been told by a doctor or health professional (other than during pregnancy, if female) that you have diabetes?" We used the question, "During the past month, how often have you felt overwhelmed by the demands of living with diabetes? Would you say always, usually, sometimes, rarely, or never?" to classify DD as severe (always), moderate (usually or sometimes), mild (rarely), and none (never). We also assessed how overwhelmed respondents were currently compared with before the COVID-19 pandemic, by DD level. Covariates included age, sex, race and ethnicity, education, imputed family poverty-to-income ratio (PIR; variable RATCAT_A), living alone, cost-related medication/insulin underuse, diabetes duration, self-reported health, diagnosed depression, and diagnosed anxiety. The analytic sample included 3,096 respondents, excluding those with missing data (n = 38).

To calculate estimates representing the US population with diagnosed diabetes and accounting for the complex design and weights of the NHIS, we used SAS-callable SUDAAN version 11.0.3 (Research Triangle Institute). We compared differences in characteristic distributions by DD level using Pearson χ^2 tests. Multivariable multinomial logistic regressions with predictive margins were used to estimate adjusted prevalence and prevalence ratios with 95% CIs for DD by subgroup, adjusting for covariates. All estimates met National Center for Health Statistics data presentation standards for proportions (7). Significance was evaluated using $P < .05$ Pearson or 95% CI (prevalence, prevalence ratios).

Results

Among US adults with diabetes, an estimated 1.6 million (6.6%) had severe DD, 5.8 million (24.3%) had moderate DD, 4.8 million (19.9%) had mild DD, and 11.8 million (49.3%) had no DD (Table 1). Characteristics of adults with diabetes varied by level of DD. Specifically, age, sex, race and ethnicity, PIR, cost-related medication/insulin underuse, self-reported health, diagnosed depression, and diagnosed anxiety were significantly associated with DD ($P < .05$). Compared with their counterparts, adjusted prevalence of severe DD was higher in adults aged 18 to 49 and 50 to 64 years, Hispanic and non-Hispanic Black adults, adults with a PIR of less than 3.00, adults who reported cost-related insulin underuse, adults with fair/poor self-reported health, and adults with diagnosed depression or anxiety (Table 2). We observed similar but attenuated patterns for adjusted prevalence of moderate DD, except that estimates were also higher among women and not significantly different across race and ethnicity groups. In contrast, adjusted prevalence of mild DD was similar among most subgroups, apart from lower prevalence among adults with less than high school education and those with the lowest income compared with their counterparts. The adjusted percentages of adults reporting no DD was higher among those aged 65 years or older, male respondents, those with a PIR of 3.00 or higher (compared with those with a PIR of 1.00–2.99), those who did not report cost-related medication/insulin underuse, those diagnosed with diabetes of less than 15 years, those with excellent/very good/good self-reported health, and those with no diagnosed depression or anxiety (Table 2). Compared with 3.6% (95% CI, 2.6%–5.0%) of US adults with diabetes without DD, 37.6% (95% CI, 29.8%–46.2%) of those with severe DD, 25.2% (95% CI, 21.6%–29.2%) of those with moderate DD, and 9.4% (95% CI, 7.0%–12.5%) of those with mild DD reported being more overwhelmed living with diabetes now than before the COVID-19 pandemic (Figure).

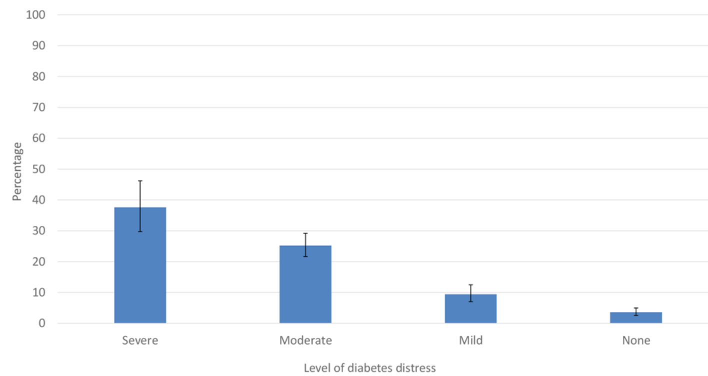

Figure. Percentage of US adults with diabetes who reported currently feeling more overwhelmed than before the COVID-19 pandemic. Responses based on the survey question, "Compared with the time before the coronavirus pandemic, would you say that you now feel more overwhelmed by the demands of living with diabetes, less overwhelmed, or about the same as before the pandemic?"

Discussion

We found that among US adults with diagnosed diabetes, 12.2 million (half of those with diabetes) are estimated to have severe, mild, or moderate DD. Our findings are consistent with previously reported point estimates of DD among US adults ranging from moderate to severe in various settings (8). We found that women were less likely than men to have no DD, showing that sex is a major demographic factor associated with DD (9). Although the cause is unknown, different coping strategies and stress management among the sexes may play a role in diabetes distress. Whereas Gahlan et al (10) found that lower level of education was associated with DD, we did not observe a significant association of educational attainment and DD. Our findings demonstrated that adults aged 65 years or older were less likely to have severe DD. This finding was consistent with prior research that postulated that older adults with type 2 diabetes experience DD but that they practice emotional regulation strategies (eg, reappraisal) (11).

This study is subject to limitations. First, results were based on a single-item definition of DD limited to the past month, which may misclassify some individuals; however, our estimates are similar to other studies in various populations and settings. Second, we did not have information on duration of DD, only on perceived severity of DD. Third, small sample sizes limited reliable estimation of DD prevalence among certain subgroups, such as by disaggregated race and ethnicity and by diabetes type.

This study provides the first national estimates of DD prevalence and highlights the importance of associated factors, such as sex, income, age, and race and ethnicity. Continued investment in DD data collection may be warranted to monitor changes in DD over time and examine additional economic and social factors contributing to DD-related disparities. Assessing the differences and impact of DD by diabetes type to guide individualized and population-level interventions is also needed. Program interventions integrating DD screening, behavioral therapy (eg, stress management, psychoeducation [ie, cognitive–behavioral, individual, and group-based therapy]), and family support (12) may improve diabetes management and services.

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Tables

Table 1. Characteristics of US Adults With Diabetes (N = 3,096), by Level of Diabetes Distress, National Health Interview Survey, 2021[a]

Characteristic	Severe diabetes distress	Moderate diabetes distress	Mild diabetes distress	No diabetes distress	*P* value[b]
Unweighted no.	200	723	634	1,539	—
Represented population size, no. in millions (%)	1.6 (6.6)	5.8 (24.3)	4.8 (19.9)	11.8 (49.3)	—
Age, y					
18–49	23.6 (3.7)	26.6 (2.1)	14.1 (1.9)	13.9 (1.1)	<.001
50–64	48.5 (4.2)	37.7 (2.2)	37.3 (2.4)	36.4 (1.6)	
≥65	28.0 (3.4)	35.7 (2.0)	48.6 (2.4)	49.7 (1.6)	
Mean age, y	57.6 (1.0)	58.2 (0.7)	62.8 (0.7)	63.4 (0.5)	<.001
Sex					
Female	50.9 (4.1)	56.6 (2.2)	50.2 (2.3)	43.1 (1.5)	<.001
Male	49.1 (4.1)	43.4 (2.2)	49.8 (2.3)	56.9 (1.5)	
Race and ethnicity					
Hispanic	30.2 (4.5)	22.0 (2.1)	16.7 (2.1)	16.5 (1.4)	<.001
NH Black	23.0 (3.6)	17.3 (1.7)	13.4 (1.7)	15.3 (1.2)	
NH White	37.2 (4.1)	49.6 (2.4)	62.5 (2.4)	60.0 (1.7)	
NH Other	9.7 (2.8)	11.1 (1.7)	7.5 (1.3)	8.2 (0.9)	
Education					
Less than high school	27.5 (4.2)	18.1 (1.6)	13.0 (1.7)	17.0 (1.2)	.01
High school/GED	36.0 (4.2)	34.1 (2.3)	34.4 (2.4)	32.3 (1.4)	
Some college or higher	36.5 (4.1)	47.8 (2.2)	52.6 (2.4)	50.7 (1.5)	
Family poverty-to-income ratio					
<1.00	25.9 (3.7)	14.3 (1.3)	9.5 (1.5)	12.0 (1.1)	<.001
1.00–2.99	51.7 (4.2)	47.2 (2.2)	44.9 (2.4)	39.3 (1.5)	
≥3.00	22.4 (3.3)	38.5 (2.1)	45.6 (2.4)	48.6 (1.5)	
Living alone					
Yes	24.3 (3.0)	19.1 (1.4)	21.9 (1.5)	22.2 (1.0)	.25
No	75.7 (3.0)	80.9 (1.4)	78.2 (1.5)	77.8 (1.0)	
Cost-related medication/insulin underuse[c]					
Yes	31.1 (3.8)	23.8 (1.8)	13.7 (1.8)	9.1 (1.0)	<.001
No	69.0 (3.8)	76.2 (1.8)	86.3 (1.8)	91.0 (1.0)	
Duration of diabetes, y					
<15	50.4 (4.1)	57.8 (2.2)	59.6 (2.2)	61.5 (1.5)	.05
≥15	47.0 (4.0)	39.3 (2.1)	38.2 (2.2)	34.9 (1.4)	
Self-reported health					

Abbreviations: —, not applicable; GED, general educational development; NH, non-Hispanic.
[a] Estimates are weighted percentage (SE) unless otherwise noted.
[b] Pearson χ^2 tests were performed to assess whether differences existed in the distribution of characteristics by diabetes distress level.
[c] Based on a positive response to survey questions asking about having to take less medication/insulin, delay in getting medication/insulin, or skipping medication/insulin to save money.

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Table 1. Characteristics of US Adults With Diabetes (N = 3,096), by Level of Diabetes Distress, National Health Interview Survey, 2021[a]

Characteristic	Severe diabetes distress	Moderate diabetes distress	Mild diabetes distress	No diabetes distress	*P* value[b]
Excellent/very good/good	28.1 (3.8)	48.2 (2.2)	64.1 (2.3)	71.6 (1.4)	<.001
Fair/poor	71.9 (3.8)	51.8 (2.2)	35.9 (2.3)	28.4 (1.4)	
Depression diagnosis					
Yes	50.7 (4.2)	34.2 (2.0)	23.4 (1.9)	17.1 (1.3)	<.001
No	49.3 (4.2)	65.8 (2.0)	76.6 (1.9)	82.9 (1.3)	
Anxiety diagnosis					
Yes	50.3 (4.0)	26.6 (1.9)	19.9 (1.9)	13.7 (1.1)	<.001
No	49.7 (4.0)	73.4 (1.9)	80.1 (1.9)	86.3 (1.1)	

Abbreviations: —, not applicable; GED, general educational development; NH, non-Hispanic.
[a] Estimates are weighted percentage (SE) unless otherwise noted.
[b] Pearson χ^2 tests were performed to assess whether differences existed in the distribution of characteristics by diabetes distress level.
[c] Based on a positive response to survey questions asking about having to take less medication/insulin, delay in getting medication/insulin, or skipping medication/insulin to save money.

Table 2. Adjusted Prevalence and Prevalence Ratios of Diabetes Distress Among US Adults With Diabetes (N = 3,096), National Health Interview Survey, 2021[a]

Characteristic	Severe diabetes distress		Moderate diabetes distress		Mild diabetes distress		No diabetes distress	
	% (95% CI)	aPR (95% CI)	% (95% CI)	aPR (95% CI)	% (95% CI)	aPR (95% CI)	% (95% CI)	aPR (95% CI)
Overall	6.6 (5.6–7.8)	—	24.3 (22.5–26.1)	—	19.8 (18.2–21.5)	—	49.3 (47.2–51.5)	—
Age, y								
18–49	8.0 (5.7–11.3)	1.89 (1.20–2.97)[b]	35.5 (30.2–41.2)	1.83 (1.50–2.24)[b]	16.4 (12.6–21.0)	0.76 (0.58–1.01)	40.1 (34.7–45.7)	0.73 (0.63–0.84)[b]
50–64	8.6 (6.7–11.0)	2.03 (1.44–2.87)[b]	24.8 (22.0–27.9)	1.28 (1.07–1.53)[b]	19.7 (17.1–22.7)	0.92 (0.77–1.11)	46.8 (43.6–50.1)	0.85 (0.78–0.93)[b]
≥65	4.2 (3.2–5.5)	1 [Ref]	19.4 (17.0–22.0)	1 [Ref]	21.4 (19.0–24.0)	1 [Ref]	55.0 (51.9–58.1)	1 [Ref]
Sex								
Female	6.5 (5.3–8.0)	0.97 (0.71–1.31)	27.9 (25.5–30.5)	1.34 (1.16–1.56)[b]	20.8 (18.7–23.2)	1.10 (0.94–1.29)	44.8 (41.9–47.6)	0.84 (0.77–0.91)[b]
Male	6.7 (5.3–8.5)	1 [Ref]	20.8 (18.5–23.4)	1 [Ref]	18.9 (16.7–21.4)	1 [Ref]	53.5 (50.5–56.6)	1 [Ref]
Race and ethnicity								
Hispanic	8.6 (6.1–12.1)	1.75 (1.13–2.69)[b]	26.0 (21.4–31.1)	1.14 (0.92–1.42)	18.4 (14.3–23.4)	0.85 (0.65–1.11)	47.0 (41.4–52.6)	0.93 (0.81–1.06)
NH Black	8.5 (6.2–11.6)	1.73 (1.15–2.58)[b]	24.6 (20.6–29.0)	1.08 (0.88–1.33)	17.0 (13.4–21.4)	0.78 (0.61–1.00)	49.9 (44.6–55.1)	0.99 (0.88–1.11)
NH White	4.9 (3.9–6.3)	1 [Ref]	22.8 (20.5–25.2)	1 [Ref]	21.7 (19.6–24.0)	1 [Ref]	50.6 (47.8–53.4)	1 [Ref]
Education								
Less than high school	7.8 (5.3–11.2)	1.35 (0.82–2.20)	23.7 (19.4–28.5)	0.96 (0.77–1.21)	14.7 (11.3–18.9)	0.69 (0.52–0.92)[b]	53.9 (48.5–59.2)	1.11 (0.99–1.25)
High school/GED	6.9 (5.2–8.9)	1.19 (0.81–1.74)	24.4 (21.1–27.9)	0.99 (0.83–1.19)	20.3 (17.4–23.6)	0.96 (0.79–1.16)	48.5 (44.7–52.3)	1.00 (0.91–1.10)
Some college or higher	5.8 (4.4–7.6)	1 [Ref]	24.5 (22.0–27.3)	1 [Ref]	21.2 (18.9–23.7)	1 [Ref]	48.5 (45.6–51.4)	1 [Ref]
Family poverty-to-income ratio								
<1.00	11.2 (8.1–15.2)	3.06 (1.93–4.86)[b]	24.3 (20.0–29.2)	1.09 (0.87–1.37)	14.4 (10.9–18.8)	0.70 (0.52–0.95)[b]	50.1 (44.4–55.8)	0.93 (0.82–1.06)
1.00–2.99	7.8 (6.1–9.8)	2.13 (1.45–3.12)[b]	26.5 (23.8–29.4)	1.19 (1.02–1.40)[b]	20.7 (18.2–23.5)	1.01 (0.84–1.21)	45.0 (41.9–48.3)	0.84 (0.77–0.92)[b]
≥3.00	3.7 (2.7–5.0)	Ref	22.2 (19.7–25.0)	1 [Ref]	20.6 (18.1–23.2)	1 [Ref]	53.6 (50.3–56.8)	1 [Ref]
Living alone								
Yes	7.5 (5.8–9.6)	1.18 (0.86–1.61)	22.4 (19.6–25.6)	0.90 (0.77–1.07)	19.6 (17.2–22.3)	0.99 (0.84–1.16)	50.5 (46.9–54.0)	1.03 (0.94–1.12)
No	6.4 (5.2–7.8)	1 [Ref]	24.8 (22.7–27.0)	1 [Ref]	19.9 (18.0–21.9)	1 [Ref]	49.0 (46.5–51.6)	1 [Ref]

Abbreviations: aPR, adjusted prevalence ratio; GED, general educational diploma; NH, non-Hispanic.
[a] Estimates are adjusted prevalences and prevalence ratios with their respective 95% CI calculated from multinomial logistic regression adjusted for continuous age, sex, race and ethnicity, and continuous family poverty to income ratio.
[b] Significant at $P < .05$.
[c] Based on a positive response to survey questions asking about having to take less medication/insulin, delay in getting medication/insulin, or skipping medication/insulin to save money.

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Table 2. Adjusted Prevalence and Prevalence Ratios of Diabetes Distress Among US Adults With Diabetes (N = 3,096), National Health Interview Survey, 2021[a]

Characteristic	Severe diabetes distress		Moderate diabetes distress		Mild diabetes distress		No diabetes distress	
	% (95% CI)	aPR (95% CI)	% (95% CI)	aPR (95% CI)	% (95% CI)	aPR (95% CI)	% (95% CI)	aPR (95% CI)
Cost-related medication/insulin underuse[c]								
Yes	11.8 (8.8–15.5)	2.12 (1.51–2.98)[b]	35.6 (30.4–41.3)	1.60 (1.34–1.91)[b]	19.5 (15.4–24.5)	0.98 (0.75–1.27)	33.1 (27.7–39.0)	0.63 (0.53–0.76)[b]
No	5.6 (4.5–6.8)	1 [Ref]	22.3 (20.4–24.2)	1 [Ref]	20.0 (18.2–22.0)	1 [Ref]	52.2 (49.8–54.6)	1 [Ref]
Duration of diabetes, y								
<15	5.3 (4.1–6.7)	0.59 (0.42–0.82)[b]	22.6 (20.4–25.0)	0.84 (0.72–0.98)[b]	20.2 (18.2–22.4)	1.02 (0.86–1.21)	51.9 (49.1–54.7)	1.17 (1.07–1.28)[b]
≥15	9.0 (7.2–11.1)	1 [Ref]	27.0 (24.0–30.3)	1 [Ref]	19.8 (17.2–22.6)	1 [Ref]	44.3 (41.1–47.5)	1 [Ref]
Self-reported health								
Excellent/very good/good	3.2 (2.4–4.4)	1 [Ref]	19.5 (17.5–21.8)	1 [Ref]	20.6 (18.5–22.9)	1 [Ref]	56.6 (53.8–59.4)	1 [Ref]
Fair/poor	11.2 (9.2–13.7)	3.44 (2.35–5.03)[b]	32.0 (28.8–35.3)	1.64 (1.41–1.92)[b]	18.8 (16.3–21.7)	0.93 (0.77–1.11)	38.0 (34.8–41.2)	0.66 (0.60–0.73)[b]
Depression diagnosis								
Yes	12.9 (10.2–16.1)	2.91 (2.10–4.02)[b]	31.5 (27.9–35.3)	1.44 (1.24–1.68)[b]	18.6 (15.6–22.0)	0.92 (0.75–1.11)	37.0 (32.9–41.3)	0.69 (0.61–0.79)[b]
No	4.4 (3.5–5.6)	1 [Ref]	21.9 (19.8–24.0)	1 [Ref]	20.3 (18.5–22.4)	1 [Ref]	53.4 (50.8–56.0)	1 [Ref]
Anxiety diagnosis								
Yes	15.3 (12.1–19.2)	3.63 (2.69–4.89)[b]	28.5 (24.6–32.6)	1.23 (1.04–1.45)[b]	19.9 (16.4–23.9)	1.00 (0.81–1.23)	36.3 (31.9–41.0)	0.69 (0.60–0.79)[b]
No	4.2 (3.4–5.2)	1 [Ref]	23.2 (21.3–25.3)	1 [Ref]	19.9 (18.1–21.9)	1 [Ref]	52.6 (50.2–55.0)	1 [Ref]

Abbreviations: aPR, adjusted prevalence ratio; GED, general educational diploma; NH, non-Hispanic.
[a] Estimates are adjusted prevalences and prevalence ratios with their respective 95% CI calculated from multinomial logistic regression adjusted for continuous age, sex, race and ethnicity, and continuous family poverty to income ratio.
[b] Significant at $P < .05$.
[c] Based on a positive response to survey questions asking about having to take less medication/insulin, delay in getting medication/insulin, or skipping medication/insulin to save money.

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ORIGINAL RESEARCH

Rural–Urban Disparities in State-Level Diabetes Prevalence Among US Adults, 2021

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PEER REVIEWED

SUMMARY

What is already known on this topic?

Prevalence of diabetes is 9% to 17% higher in rural areas than in urban areas. Common risk factors of diabetes, such as age, race, ethnicity, income, and obesity may explain the rural–urban disparities.

What is added by this report?

This study examines rural–urban disparities in diabetes prevalence across states, providing a better understanding of the geographic distribution and underlying attributes associated with higher diabetes prevalence among people who live in rural areas.

What are the implications for public health practice?

Identifying drivers of rural–urban disparities in diabetes prevalence by state underscores the need for planned interventions and resources to address diabetes in rural communities.

Abstract

Introduction

We assessed state-level disparities in diabetes prevalence among adults in rural and urban areas in the United States.

Methods

We estimated state-specific diabetes prevalence in rural and urban areas in 41 states with applicable data from the 2021 Behavioral Risk Factor Surveillance System. Rural areas were defined based on the 2013 National Center for Health Statistics Urban–Rural Classification Scheme. We estimated diabetes odds ratios (ORs) in rural versus urban areas in each state by using logistic regressions adjusted for sociodemographic characteristics and obesity status. Analyses were conducted in 2023.

Results

In rural areas, diabetes prevalence was 14.3%, ranging from 8.4% in Colorado to 21.3% in North Carolina. In urban areas, the prevalence was 11.2%, ranging from 6.9% in Colorado to 15.5% in West Virginia. Unadjusted diabetes ORs in rural versus urban areas were significant ($P < .05$) and greater than 1 for 19 states. After adjusting for age, sex, race, and ethnicity, the ORs were significant and greater than 1 for 7 states (Florida, Illinois, Kentucky, Maryland, North Carolina, Oregon, and Virginia). With additional adjustment for education, income, and obesity status, diabetes ORs in rural versus urban areas remained significant and greater than 1 for 2 states (North Carolina and Oregon).

Conclusion

Our findings reveal significant geographic disparities in diabetes prevalence between rural and urban areas in 19 states. The differences in most states may have been explained by rural–urban differences in sociodemographic characteristics and obesity rates. Our findings could inform decision makers to identify effective ways to reduce rural–urban disparities within states.

Introduction

Diabetes is a serious chronic health condition and is a major contributor to heart disease, kidney failure, stroke, vascular disorders, and vision loss (1). In 2021, the Centers for Disease Control and Prevention (CDC) reported that more than 38 million adults were living with diabetes (2). Diabetes has been identified as one of the top 10 Healthy People 2030 priorities for the rural United States (3,4). Public health practitioners, researchers, and policymakers deemed diabetes an important health priority to address in the coming decade to close the rural–urban divide (4).

Prevalence of diabetes has been reported from 9% to 17% higher in rural areas than in urban areas (5,6). Demographic characteristics, socioeconomic status, neighborhood characteristics, physical environment, food environment, prevalence of health behavior risk factors, and chronic disease prevention efforts are potential factors that explain rural–urban differences in prevalence of diabetes (7,8). Specifically, O'Connor and Wellenius examined rural–urban disparities in diabetes prevalence at the national level and found that age, sex, race, ethnicity, income, and obesity were factors that contributed to the differences (6). However, to our knowledge, the rural–urban disparities in diabetes prevalence by state have not been examined systematically.

In 2016, CDC released the Diabetes State Burden Toolkit, reporting data on the health, economic, and mortality burden of diabetes in each state and the District of Columbia (DC). In 2024, the toolkit was updated with more recently available data and expanded to report diabetes outcomes by urbanicity status (https://nccd.cdc.gov/Toolkit/DiabetesBurden). The goal of the update to the toolkit was to meet information needs of state health officials and other organizations. The objectives of our study were to 1) assess the magnitude of rural–urban differences in diabetes prevalence by state as reported in the toolkit, and 2) identify the underlying factors that may be contributing to the rural–urban disparities at the state level.

Methods

Source of data

We used data from the 2021 Behavioral Risk Factor Surveillance System (BRFSS) to estimate diabetes prevalence in each state. BRFSS is a yearly, state-based, cross-sectional telephone interview survey sponsored by CDC and conducted by state health departments. It covers the civilian noninstitutionalized adult population aged 18 years or older in each of the 50 states and the District of Columbia (DC). BRFSS collects prevalence data regarding health-related risk behaviors, chronic health conditions, and preventive health care practices among US adults. Response rates for the BRFSS vary by state. The median survey response rate in the 2021 BRFSS for states included in this analysis was 46.4% and ranged from 23.5% to 60.5% (9).

We downloaded the 2021 BRFSS data file that included all states, except Florida, directly from the BRFSS website. The 2021 Florida BRFSS data set was requested and obtained from the Florida Department of Health.

Study population

We identified people with diabetes as those who answered yes to the survey question, "Has a doctor, nurse, or other health professional ever told you that you had diabetes?" The estimates reported in this analysis are for both type 1 and type 2 diabetes combined because of data limitations. We excluded survey responses with missing diabetes status (n = 989). We applied the BRFSS sample weights and calculated the weighted percentage of adults with self-reported diagnosed diabetes in each state.

In BRFSS, rural or urban status of the county where the respondent resides is defined by using the 2013 National Center for Health Statistics (NCHS) Urban–Rural Classification Scheme for US counties. The scheme states that urban counties include large central metropolitan, large fringe metropolitan, medium metropolitan, small metropolitan, and micropolitan counties (10). Rural counties include noncore counties (ie, nonmetropolitan counties that do not qualify as micropolitan). In BRFSS, the rural or urban status is assigned based on the county Federal Information Processing Standards codes rather than respondent self-reported information on whether they reside in a rural or urban county.

Seven states (Connecticut, Delaware, Hawaii, Massachusetts, New Hampshire, New Jersey, and Rhode Island) and DC did not have any respondents from rural counties in the 2021 BRFSS. In 2 other states (California and Nevada), 2021 BRFSS data for diabetes prevalence in rural counties did not meet the NCHS data presentation standard of the minimum relative confidence interval width (11,12). Thus, we excluded these 9 states and DC from this analysis (n = 60,233). The final BRFSS analysis sample included 378,504 observations.

Analysis methods

We calculated prevalence of diabetes in 41 states where data were available for both rural and urban areas. To compare diabetes prevalence between rural and urban areas, we calculated the odds ratios (ORs) of diabetes in rural versus urban areas to help understand the likelihood of diabetes occurring in one area compared with the other. Specifically, we ran separate logistic regressions for each state and for 41 states combined to estimate the ORs of having diabetes for people residing in rural versus urban counties. An OR greater than 1 indicates a higher likelihood of diabetes in rural areas than in urban areas. An OR less than 1 indicates a lower likelihood of diabetes in rural areas than in urban areas.

We ran a series of models controlling for different factors. The first set of regressions produced unadjusted ORs, including only the rural or urban status indicator and no controls for any other characteristics. Then, we estimated 3 other sets of regression models and produced adjusted ORs, one controlling for age and sex, the second controlling for age, sex, race, and ethnicity, and the third controlling for age, sex, race, ethnicity, income, education, and obesity status. These adjusted regression results allow us to assess whether the differences in likelihood of diabetes between rural and urban areas can be explained by the differences in the sociodemographic composition and obesity rates of the populations living in rural and urban areas. All regression models were estimated by applying BRFSS sample weights to account for the complex survey design.

We controlled for age in years as a continuous variable. Race and ethnicity categories included 4 categories: non-Hispanic White, non-Hispanic Black, Hispanic, and non-Hispanic other races (which included Asian, American Indian and Alaska Native, and multiracial). We categorized income into 3 groups based on the annual household income: low income (<$35,000), middle income ($35,000 to $74,999), and high income (≥$75,000). These income categories were obtained by using Healthy People 2020 groupings and categorizations but collapsing BRFSS's 2 lowest income groups into 1 group (low income) and the middle and near-high income groups into another group (middle income) to ensure sufficient sample sizes (13). We defined educational attainment based on the highest grade or years of school completed: less than high school graduate, high school graduate, and more than high school graduate. Lastly, obesity status was determined by body mass index (BMI), calculated as weight in kilograms divided by the square of height in meters. The categories were underweight or normal weight (BMI <25), overweight (BMI 25 to 29.9), and obese (BMI ≥30).

We considered results significant in a specific state when the probability of a difference in likelihood of diabetes between rural and urban areas occurring by chance was less than 5% in that state. We conducted our analyses in 2023 by using Stata version 17 (StataCorp LLC).

Results

Unadjusted results

Across the 41 states included in this analysis, diabetes prevalence in 2021 was 14.3% (95% CI, 13.5%–15.0%) in rural areas and 11.2% (95% CI, 10.9%–11.4%) in urban areas (Table 1). Adults living in rural areas were, on average, older, had lower household incomes and lower levels of education, were more likely to be non-Hispanic White, and were less likely to be non-Hispanic Black, Hispanic, and non-Hispanic other races than adults living in urban areas.

Prevalence of diabetes in rural areas varied widely across states, ranging from 8.4% (95% CI, 6.1%–10.7%) in Colorado to 21.3% (95% CI, 15.9%–26.7%) in North Carolina, with the all-state median of 13.2% (Table 2). A total of 11 states in the Southeast (Alabama, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, West Virginia), plus Illinois, Oregon, and Pennsylvania, had the highest diabetes prevalence rates in rural areas. These 14 states had prevalences of 15.8% or higher and were in the top third of the distribution (ie, upper tertile). Six states in the Midwest (Iowa, Michigan, Minnesota, Nebraska, Ohio, and Wisconsin), 6 states in the West (Alaska, Colorado, Idaho, Montana, Utah, and Wyoming), along with Maine and Vermont, had the lowest diabetes prevalence rates in rural areas. These 14 states had prevalences of 11.8% or higher and were in the bottom third of the distribution (ie, lower tertile).

In urban areas of the 41 states included in the analysis, the diabetes prevalence ranged from 6.9% (95% CI, 6.3%–7.5%) in Colorado to 15.5% (95% CI, 14.4%–16.7%) in West Virginia, with the median of 10.9%.

Unadjusted ORs of diabetes in rural versus urban areas were significant and greater than 1 in the 41 states combined and in 19 individual states (Arkansas, Florida, Georgia, Illinois, Iowa, Kentucky, Maine, Minnesota, Missouri, Montana, Nebraska, North Carolina, North Dakota, Oregon, Pennsylvania, South Carolina, Tennessee, Virginia, and Washington) (Table 3). Across these 19 states, the unadjusted ORs ranged from 1.1 (95% CI, 1.0–1.3) in Nebraska to 2.5 (95% CI, 1.4–4.5) in Oregon.

Adjusted results

After adjusting for age and sex, the ORs of diabetes in rural versus urban areas remained significant and greater than 1 in the 41 states combined and in 4 individual states (North Carolina, North Dakota, Oregon, and Virginia) (Table 3). The ORs across these 4 states ranged from 1.3 (95% CI, 1.0–1.6) in North Dakota to 2.2 (95% CI, 1.2–4.1) in Oregon with a median of 1.5.

After further adjustment for race and ethnicity (in addition to age and sex), the ORs of diabetes in rural versus urban areas were significant and greater than 1 in the 41 states combined and 7 individual states (Florida, Illinois, Kentucky, Maryland, North Carolina, Oregon, and Virginia). The ORs across these 7 states ranged from 1.3 (95% CI, 1.0–1.6) in Kentucky to 2.0 (95% CI, 1.1–3.7) in Oregon with a median of 1.5.

With additional adjustment for income, education, and obesity status, the diabetes OR for the 41 states combined was no longer significant (P = .12). However, ORs remained significant and greater than 1 in 2 individual states, namely North Carolina (OR, 1.5; 95% CI, 1.0–2.1) and Oregon (OR, 2.5; 95% CI, 1.3–4.8). In 1 state (Ohio), this additional adjustment resulted in a significant OR of less than 1 (0.77; 95% CI, 0.60–0.98). This finding indicates that once adjusted for age, sex, race, ethnicity, income, education, and obesity status, the likelihood of diabetes was significantly lower in rural areas than in urban areas of Ohio.

Discussion

We examined the ORs of diabetes in rural versus urban areas at the state level and found that geographic disparities in likelihood of diabetes between rural and urban areas varied across the states.

Of the 41 states included in the study, the likelihood of diabetes was significantly higher in rural areas than in urban areas in 19 states. Differences in sociodemographic characteristics and obesity rates may have explained those rural–urban disparities in most states. Our study results could help decision makers at the state level understand the rural–urban differences in diabetes prevalence in their states and identify effective measures to close the rural–urban gaps.

The result that only 4 of 19 states had a significantly higher likelihood of diabetes in rural versus urban areas, after adjusting for age and sex, implies that differences in population composition could be the main driver of the rural–urban differences in diabetes prevalence. For example, older adults are more prone to have diabetes. In 2022, prevalence of diabetes at the national level was 2.4% among adults aged 18 to 44 years and 20.6% among adults aged 75 years or older (14). Adults in rural areas were older than those in urban areas (Table 1) (15,16). Similarly, compared with women, men have higher rates of diabetes and are more likely to live in rural than in urban areas (Table 1) (17,18).

After also adjusting for race and ethnicity, significant differences in likelihood of diabetes between rural and urban areas were observed in 4 additional states. This finding indicates that not considering the racial and ethnic differences between urban and rural areas may mask differences in diabetes prevalence between these populations. This finding is important, especially given the increasing racial and ethnic diversity in rural areas of the US (19). Adults from racial and ethnic minority groups living in rural areas may face additional challenges that their counterparts residing in urban areas do not. The higher prevalence of diabetes among Black people, coupled with limited access to health care services in rural settings, places them at an elevated risk for adverse health outcomes (4,20). Diabetes mortality rates among Black people in rural areas are higher than those among White people living in rural areas, underscoring the need for planned interventions (21,22).

Further adjustment for income, education, and obesity status in our models revealed that likelihood of diabetes remained significantly higher in rural than urban areas in only 2 states. Understanding the factors, specifically sociodemographic characteristics and obesity rates, that contribute to the differences in prevalence of diabetes between rural and urban areas could help develop more tailored interventions for populations in these areas.

Oregon and North Carolina were the 2 states where adjusting for sociodemographic characteristics and obesity status did not fully explain the higher likelihood of diabetes in rural versus urban areas. Further research is needed to understand what other factors, such as rural–urban differences in neighborhood characteristics, food and diet behaviors, physical activity levels, and access to healthy food and prevention efforts, could potentially explain these disparities. Identified barriers for people living in rural communities, especially for getting access to diabetes education and prevention programs, include limited number of providers, longer distance to medical facilities, higher costs, outdated cultural beliefs, lack of transportation, and limited community resources (23,24). More efforts to reduce these barriers may help reduce the overall high burden of diabetes in the rural US.

Results of our analysis aligned with a previous study that used 2008 BRFSS data and demonstrated that, at the national level, rural–urban disparities could be attributed to demographic characteristics and other common risk factors such as income and BMI (6). However, O'Connor and Wellenius found that, at the national level, after adjusting for household income, educational attainment, age, sex, BMI, race, and ethnicity, the likelihood of diabetes was significantly lower in rural areas than in urban areas (OR, 0.94; $P < .05$) (6). Using more recent data, we found that after controlling for these sociodemographic characteristics and obesity status, there were no significant differences in the likelihood of diabetes in rural and urban areas at the national level. At the state level, we found that likelihood of diabetes was significantly lower among respondents living in rural areas than among respondents living in urban areas in 1 state (Ohio). Our findings could indicate the worsening of rural–urban disparities over the last decade.

Our finding that most states with a high prevalence of diabetes were primarily in the Southeast was also consistent with a recent study from 2022 that reported similar geographic trends, indicating that the adults living in the rural South had the highest risk for diabetes (25).

Strengths and limitations

To our knowledge, this is the first study reporting differences in likelihood of diabetes in rural versus urban areas at the state level. Our findings highlight a higher likelihood of diabetes in rural counties compared with their urban counterparts in most states. This information could help policymakers and public health professionals better understand the diabetes burden in their states.

Our analysis is subject to several limitations. First, the lack of information in BRFSS to distinguish between diabetes types prevented us from generating separate estimates for type 1 and type 2 diabetes. This may hinder identification of effective strategies for addressing disparities in diabetes in rural and urban areas because of the differences in risk factors for type 1 and type 2 diabetes. Second, the sample size in some states might have been too small to detect significant ORs of diabetes in rural versus urban areas. This may lead to increased variability in estimates and reduced statistical power to determine meaningful differences. Third, because of the small sample sizes of the individual race categories included in the other race category (which included Asian, American Indian and Alaska Native, and multiracial) in most states, we were not able to separate these races into individual categories. Instead, we included the aggregated group of other races when adjusting the regressions models. Fourth, BRFSS uses telephone surveys, potentially leading to sampling bias. People, particularly those residing in rural areas who do not have telephones, have poor telecommunication service, or are less likely to answer telephone calls, may be underrepresented in the survey sample, affecting the generalizability of findings. Lastly, diabetes status was defined based on self-reported information, potentially underestimating the number of people living with diabetes. The rates of undiagnosed diabetes may be higher in rural areas (26,27).

Conclusion

Our study examined the ORs of diabetes in rural versus urban areas at the state level and identified potential factors that contribute to the differences. Results of this analysis highlight the need for establishing effective policies to lower risk of diabetes and improve the quality of and access to diabetes prevention and care in rural areas. Understanding of the impact of nonmodifiable and modifiable risk factors on these differences might be crucial for developing more effective strategies to reduce health disparities between rural and urban communities.

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Tables

Table 1. Demographic Characteristics by Rural and Urban Areas, 41 US States[a], Behavioral Risk Factor Surveillance System, 2021

Characteristic	Rural Areas, Mean (95% CI)	Urban Areas, Mean (95% CI)
Self-reported diagnosis of diabetes, %	**14.3 (13.5–15.0)**	**11.2 (10.9–11.4)**
Age, y	**51.5 (51.1–51.9)**	**47.9 (47.7–48.0)**
Annual household income, $, %		
Low (<35,000)	30.2 (29.3–31.2)	23.1 (22.7–23.4)
Middle (35,000 to 74,999)	26.2 (25.4–27.0)	23.2 (22.9–23.6)
High (≥75,000)	43.6 (42.6–44.5)	53.7 (53.3–54.1)
Sex, %		
Male	49.9 (49.0–50.9)	48.6 (48.2–49.0)
Female	50.1 (49.1–51.0)	51.4 (51.0–51.8)
Body weight[b] category, %		
Underweight or normal weight (<25)	24.6 (23.7–25.4)	28.3 (27.9–28.6)
Overweight (25 to 29.9)	30.5 (29.6–31.4)	30.1 (29.8–30.5)
Obese (≥30)	35.0 (34.0–36.0)	29.6 (29.2–29.9)
Race and ethnicity, %		
Non-Hispanic White	80.7 (79.8–81.7)	64.7 (64.3–65.1)
Non-Hispanic Black	7.9 (7.3–8.4)	13.5 (13.2–13.8)
Hispanic	6.7 (5.8–7.6)	14.8 (14.4–15.2)
Non-Hispanic other races	4.7 (4.4–5.0)	7.0 (6.8–7.2)
Education level, %		
Less than high school graduate	14.8 (13.9–15.6)	11.1 (10.8–11.5)
High school graduate	37.0 (36.0–38.0)	27.6 (27.3–28.0)
More than high school graduate	47.8 (46.8–48.7)	60.6 (60.2–61.0)

[a] The states of California, Connecticut, Delaware, Hawaii, Massachusetts, Nevada, New Hampshire, New Jersey, and Rhode Island and the District of Columbia were excluded from this analysis because of insufficient or unreliable data.
[b] Body weight category was determined by calculating weight in kilograms divided by the square of height in meters.

Table 2. Prevalence of Diagnosed Diabetes in Rural and Urban Counties by State[a], Behavioral Risk Factor Surveillance System, 2021

State	Rural areas		Urban areas	
	N[b]	% (95% CI)	N[b]	% (95% CI)
Alabama	625	15.9 (12.5–19.4)	3,955	14.9 (13.5–16.3)
Alaska	2,149	9.8 (7.9–11.6)	3,330	7.8 (6.6–9.1)
Arizona	573	12.7 (7.8–17.7)	10,060	11.0 (10.2–11.8)
Arkansas	1,227	15.7 (13.1–18.2)	4,134	11.7 (10.5–12.9)
Colorado	723	8.4 (6.1–10.7)	9,738	6.9 (6.3–7.5)
Florida	1,376	17.2 (13.0–21.4)	6,539	10.8 (9.4–12.3)
Georgia	981	17.3 (14.1–20.6)	7,186	11.9 (10.8–12.9)
Idaho	805	11.5 (8.9–14.1)	5,964	9.6 (8.7–10.4)
Illinois	194	18.1 (10.9–25.3)	3,004	10.4 (9.1–11.8)
Indiana	617	14.1 (10.9–17.3)	9,285	12.0 (11.3–12.7)
Iowa	2,721	11.2 (9.8–12.6)	6,890	9.2 (8.4–10.0)
Kansas	3,084	12.0 (10.7–13.3)	14,450	10.9 (10.3–11.5)
Kentucky	1,615	16.7 (14.1–19.4)	3,802	13.0 (11.6–14.4)
Louisiana	329	15.8 (9.4–22.3)	4,760	13.5 (12.2–14.7)
Maine	6,139	11.5 (10.4–12.5)	5,643	10.0 (9.0–10.9)
Maryland	519	13.7 (10.1–17.3)	15,071	11.0 (10.4–11.7)
Michigan	666	10.4 (7.9–12.8)	8,731	10.8 (10.0–11.6)
Minnesota	1,892	10.7 (9.0–12.3)	14,040	8.8 (8.2–9.3)
Mississippi	1,276	16.4 (13.9–19.0)	3,140	14.9 (13.3–16.4)
Missouri	3,322	13.2 (11.7–14.6)	8,923	11.0 (10.1–11.9)
Montana	2,958	10.7 (9.3–12.1)	3,277	7.9 (6.9–8.8)
Nebraska	4,976	10.7 (9.7–11.6)	9,923	9.4 (8.7–10.1)
New Mexico	335	15.4 (11.0–19.8)	6,022	13.1 (11.9–14.2)
New York	4,225	12.1 (10.1–14.1)	34,753	11.4 (10.8–12.0)
North Carolina	377	21.3 (15.9–26.7)	4,555	12.1 (10.9–13.3)
North Dakota	2,406	12.7 (11.0–14.5)	3,493	8.4 (7.4–9.5)
Ohio	1,136	11.8 (9.5–14.1)	13,140	12.6 (11.8–13.4)
Oklahoma	1,012	14.3 (11.8–16.8)	4,428	12.6 (11.4–13.8)
Oregon	150	20.4 (11.2–29.6)	5,214	9.2 (8.3–10.2)
Pennsylvania	238	17.1 (9.9–24.3)	6,164	10.9 (9.9–11.9)
South Carolina	908	17.8 (14.1–21.5)	9,122	13.5 (12.6–14.4)
South Dakota	2,295	12.6 (8.2–16.9)	4,972	10.3 (8.6–12.0)
Tennessee	661	18.5 (14.5–22.5)	4,110	13.4 (12.1–14.7)
Texas	403	13.2 (7.2–19.3)	10,383	11.4 (10.4–12.4)
Utah	1,227	8.8 (6.8–10.8)	9,373	7.9 (7.3–8.5)
Vermont	2,311	9.0 (7.5–10.5)	4,256	8.3 (7.2–9.5)

[a] The states of California, Connecticut, Delaware, Hawaii, Massachusetts, Nevada, New Hampshire, New Jersey, and Rhode Island and the District of Columbia were excluded from this analysis because of insufficient or unreliable data.
[b] Represents the unweighted number of observations from the 2021 Behavioral Risk Factor Surveillance System.

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Table 2. Prevalence of Diagnosed Diabetes in Rural and Urban Counties by State[a], Behavioral Risk Factor Surveillance System, 2021

State	Rural areas		Urban areas	
	N[b]	% (95% CI)	N[b]	% (95% CI)
Virginia	1,347	16.4 (13.5–19.2)	8,511	10.9 (10.0–11.7)
Washington	985	12.7 (8.5–16.9)	12,141	8.6 (8.0–9.2)
West Virginia	1,453	17.0 (14.7–19.3)	5,281	15.5 (14.4–16.7)
Wisconsin	1,635	10.6 (8.3–12.9)	4,463	8.9 (7.8–10.0)
Wyoming	1,399	9.1 (7.3–10.9)	3,008	8.7 (7.4–9.9)
Total	63,270	14.3 (13.5–15.0)	315,234	11.2 (10.9–11.4)
Median		13.2		10.9

[a] The states of California, Connecticut, Delaware, Hawaii, Massachusetts, Nevada, New Hampshire, New Jersey, and Rhode Island and the District of Columbia were excluded from this analysis because of insufficient or unreliable data.
[b] Represents the unweighted number of observations from the 2021 Behavioral Risk Factor Surveillance System.

Table 3. Odds Ratios of Diabetes in Rural Versus Urban Areas by State[a], Behavioral Risk Factor Surveillance System, 2021

State	Model 1: unadjusted		Model 2: adjusted for age and sex		Model 3: adjusted for age, sex, race, ethnicity		Model 4: adjusted for age, sex, race, ethnicity, income, education, obesity status	
	OR (95% CI)	*P* value	OR (95% CI)	*P* value	OR (95% CI)	*P* value	OR (95% CI)	*P* value
Alabama	1.1 (0.8–1.4)	.59	1.0 (0.7–1.3)	.75	0.9 (0.7–1.3)	.70	0.9 (0.6–1.1)	.29
Alaska	1.3 (1.0–1.7)	.08	1.2 (0.9–1.5)	.29	1.1 (0.8–1.5)	.38	1.1 (0.8–1.5)	.52
Arizona	1.2 (0.7–1.8)	.48	1.1 (0.7–1.8)	.63	0.8 (0.5–1.3)	.48	0.7 (0.4–1.1)	.14
Arkansas	1.4[b] (1.1–1.8)	.00	1.2 (1.0–1.5)	.12	1.2 (1.0–1.6)	.09	1.2 (0.9–1.5)	.13
Colorado	1.2 (0.9–1.7)	.20	1.0 (0.7–1.4)	.99	1.0 (0.7–1.4)	.96	1.0 (0.7–1.4)	.86
Florida	1.7[b] (1.2–2.4)	.00	1.4 (1.0–2.0)	.07	1.5[b] (1.0–2.1)	.03	1.2 (0.9–1.8)	.26
Georgia	1.6[b] (1.2–2.0)	.00	1.2 (0.9–1.5)	.15	1.3 (1.0–1.6)	.08	1.1 (0.8–1.5)	.51
Idaho	1.2 (0.9–1.6)	.14	1.0 (0.8–1.3)	.93	1.0 (0.8–1.3)	.92	0.9 (0.7–1.2)	.45
Illinois	1.9[b] (1.1–3.1)	.01	1.6 (0.9–2.7)	.12	1.8[b] (1.0–3.2)	.03	1.7 (1.0–3.0)	.06
Indiana	1.2 (0.9–1.6)	.18	1.1 (0.8–1.4)	.59	1.2 (0.9–1.6)	.30	1.1 (0.8–1.5)	.50
Iowa	1.2[b] (1.0–1.5)	.01	1.0 (0.9–1.2)	.66	1.1 (0.9–1.3)	.33	1.0 (0.8–1.2)	.95
Kansas	1.1 (1.0–1.3)	.12	0.9 (0.8–1.1)	.37	1.0 (0.8–1.1)	.68	0.9 (0.7–1.0)	.05
Kentucky	1.3[b] (1.1–1.7)	.01	1.2 (1.0–1.5)	.11	1.3[b] (1.0–1.6)	.04	1.1 (0.9–1.4)	.46
Louisiana	1.2 (0.7–2.0)	.45	1.0 (0.6–1.8)	.97	1.0 (0.5–1.9)	.97	0.9 (0.5–1.7)	.82
Maine	1.2[b] (1.0–1.4)	.04	1.0 (0.9–1.2)	.61	1.0 (0.9–1.2)	.60	0.9 (0.8–1.1)	.46
Maryland	1.3 (0.9–1.7)	.12	1.2 (0.9–1.6)	.16	1.4[b] (1.1–1.9)	.02	1.2 (0.9–1.6)	.25
Michigan	1.0 (0.7–1.3)	.74	0.8 (0.6–1.1)	.12	0.9 (0.7–1.2)	.50	0.8 (0.6–1.1)	.22
Minnesota	1.2[b] (1.0–1.5)	.02	1.1 (0.9–1.3)	.58	1.1 (0.9–1.3)	.31	1.0 (0.8–1.2)	.81
Mississippi	1.1 (0.9–1.4)	.28	1.0 (0.8–1.3)	.72	1.1 (0.8–1.3)	.63	1.0 (0.8–1.3)	.91
Missouri	1.2[b] (1.1–1.4)	.01	1.1 (0.9–1.3)	.44	1.1 (1.0–1.4)	.11	1.0 (0.8–1.2)	.90
Montana	1.4[b] (1.2–1.7)	.00	1.2 (1.0–1.5)	.07	1.1 (0.9–1.4)	.29	1.1 (0.9–1.3)	.55
Nebraska	1.1[b] (1.0–1.3)	.04	0.9 (0.8–1.1)	.26	1.0 (0.9–1.1)	1.00	0.9 (0.8–1.1)	.30
New Mexico	1.2 (0.9–1.7)	.28	1.0 (0.7–1.4)	.85	1.0 (0.7–1.5)	.84	1.0 (0.7–1.4)	.95
New York	1.1 (0.9–1.3)	.52	0.9 (0.8–1.2)	.58	1.2 (1.0–1.5)	.09	1.0 (0.8–1.3)	.71
North Carolina	2.0[b] (1.4–2.8)	.00	1.6[b] (1.1–2.3)	.01	1.7[b] (1.1–2.4)	.01	1.5[b] (1.0–2.1)	.04
North Dakota	1.6[b] (1.3–1.9)	.00	1.3[b] (1.0–1.6)	.04	1.1 (0.9–1.4)	.22	1.1 (0.9–1.4)	.32
Ohio	0.9 (0.7–1.2)	.51	0.8 (0.7–1.1)	.12	0.9 (0.7–1.1)	.21	0.8[b] (0.6–1.0)	.04
Oklahoma	1.2 (0.9–1.5)	.21	1.0 (0.8–1.2)	.75	1.0 (0.8–1.2)	.84	0.9 (0.7–1.2)	.68
Oregon	2.5[b] (1.4–4.5)	.00	2.2[b] (1.2–4.1)	.01	2.0[b] (1.1–3.7)	.02	2.5[b] (1.3–4.8)	.00
Pennsylvania	1.7[b] (1.0–2.8)	.04	1.4 (0.8–2.3)	.24	1.5 (0.9–2.6)	.11	1.4 (0.8–2.3)	.22
South Carolina	1.4[b] (1.1–1.8)	.01	1.3 (1.0–1.8)	.05	1.2 (0.9–1.6)	.24	1.1 (0.8–1.5)	.42
South Dakota	1.2 (0.8–1.9)	.32	1.0 (0.6–1.5)	.92	0.8 (0.5–1.3)	.46	0.8 (0.5–1.2)	.25
Tennessee	1.5[b] (1.1–1.9)	.01	1.2 (0.9–1.6)	.33	1.2 (0.9–1.7)	.17	1.1 (0.8–1.5)	.42
Texas	1.2 (0.7–2.0)	.53	1.1 (0.6–2.0)	.81	1.2 (0.6–2.2)	.61	1.0 (0.5–1.9)	.97

Abbreviation: OR, odds ratio.
[a] The states of California, Connecticut, Delaware, Hawaii, Massachusetts, Nevada, New Hampshire, New Jersey, and Rhode Island and the District of Columbia were excluded from this analysis because of insufficient or unreliable data.
[b] Indicates significant odds ratios ($P < .05$).

(continued on next page)

(continued)

Table 3. Odds Ratios of Diabetes in Rural Versus Urban Areas by State[a], Behavioral Risk Factor Surveillance System, 2021

State	Model 1: unadjusted		Model 2: adjusted for age and sex		Model 3: adjusted for age, sex, race, ethnicity		Model 4: adjusted for age, sex, race, ethnicity, income, education, obesity status	
	OR (95% CI)	*P* value	OR (95% CI)	*P* value	OR (95% CI)	*P* value	OR (95% CI)	*P* value
Utah	1.1 (0.9–1.5)	.38	0.9 (0.7–1.2)	.68	1.0 (0.7–1.3)	.90	0.9 (0.7–1.2)	.48
Vermont	1.1 (0.9–1.4)	.48	1.0 (0.8–1.3)	.94	1.0 (0.8–1.3)	.93	1.0 (0.7–1.2)	.71
Virginia	1.6[b] (1.3–2.0)	.00	1.3[b] (1.0–1.6)	.04	1.4[b] (1.1–1.8)	.00	1.2 (0.9–1.5)	.20
Washington	1.5[b] (1.0–2.3)	.03	1.1 (0.7–1.6)	.80	1.1 (0.7–1.7)	.64	1.1 (0.7–1.6)	.74
West Virginia	1.1 (0.9–1.3)	.25	1.0 (0.8–1.2)	.83	1.0 (0.8–1.2)	.77	0.9 (0.8–1.2)	.60
Wisconsin	1.2 (0.9–1.6)	.17	1.0 (0.8–1.4)	.76	1.2 (0.9–1.6)	.24	1.1 (0.8–1.4)	.58
Wyoming	1.1 (0.8–1.4)	.71	0.9 (0.7–1.1)	.27	0.9 (0.7–1.2)	.35	0.9 (0.7–1.2)	.40
Total	1.3[b] (1.2–1.4)	.00	1.1[b] (1.0–1.2)	.00	1.2[b] (1.1–1.3)	.00	1.1 (1.0–1.1)	.12

Abbreviation: OR, odds ratio.
[a] The states of California, Connecticut, Delaware, Hawaii, Massachusetts, Nevada, New Hampshire, New Jersey, and Rhode Island and the District of Columbia were excluded from this analysis because of insufficient or unreliable data.
[b] Indicates significant odds ratios ($P < .05$).

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ORIGINAL RESEARCH

Prevalence of Self-Reported Diagnosed Diabetes Among Adults, by County Metropolitan Status and Region, United States, 2019–2022

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PEER REVIEWED

Summary

What is already known on this topic?

Rural–urban disparities in diabetes mortality, hospitalization, and incidence rates may manifest differently across US regions.

What is added by this report?

We found that the association of metropolitan residence with diabetes prevalence differs across regions of the US. Diabetes prevalence ranged from 7.0% in large fringe metro counties in the Northeast to 14.8% in nonmetro counties in the South.

What are the implications for public health practice?

These findings can help guide efforts in areas where diabetes prevention and care resources may be better directed.

Abstract

Introduction

Previous research suggests that rural–urban disparities in diabetes mortality, hospitalization, and incidence rates may manifest differently across US regions. However, no studies have examined disparities in diabetes prevalence by metropolitan residence and region.

Methods

We used data from the 2019–2022 National Health Interview Survey to compare diabetes status, socioeconomic characteristics, and weight status among adults in each census region (Northeast, Midwest, South, West) according to county metropolitan status of residence (large central metro, large fringe metro, small/medium metro, and nonmetro). We used χ^2 tests and logistic regression models to assess the association of metropolitan residence with diabetes prevalence in each region.

Results

Diabetes prevalence ranged from 7.0% in large fringe metro counties in the Northeast to 14.8% in nonmetro counties in the South. Compared with adults from large central metro counties, those from small/medium metro counties had significantly higher odds of diabetes in the Midwest (age-, sex-, and race and ethnicity–adjusted odds ratio [OR] = 1.24; 95% CI, 1.06–1.45) and South (OR = 1.15; 95% CI, 1.02–1.30). Nonmetro residence was also associated with diabetes in the South (OR = 1.62 vs large central metro; 95% CI, 1.43–1.84). After further adjustment for socioeconomic and body weight status, small/medium metro associations with diabetes became nonsignificant, but nonmetro residence in the South remained significantly associated with diabetes (OR = 1.22; 95% CI, 1.07–1.39).

Conclusion

The association of metropolitan residence with diabetes prevalence differs across US regions. These findings can help to guide efforts in areas where diabetes prevention and care resources may be better directed.

Introduction

Diabetes is a costly chronic disease that shortens lifespans and leads to substantial illness that negatively affects quality of life. In

2021, approximately 8.5% of the US adult population had diagnosed diabetes, although prevalence varied widely among states and territories, ranging from 14.4% in Puerto Rico to 6.5% in Colorado (1). The substantial geographic variation of prevalence estimates may be driven partly by differences in age, race and ethnicity, and socioeconomic status (2). However, other contextual factors such as access to health care, the built environment, behavioral risk factors such as physical inactivity, and cultural elements such as dietary patterns may further affect diabetes prevalence. Rural areas in the US have higher prevalence of obesity (3), heart disease (4), stroke mortality (5), and chronic disease risk factors such as cigarette smoking (6), physical inactivity (7), and poor nutrition (8). Diabetes mortality rates are also higher in rural counties than urban counties and have declined more slowly than in urban counties in recent decades (9).

Rural areas in the US are diverse in terms of land use, employment, and culture. Previous research suggests that rural–urban disparities in diabetes mortality, hospitalization, and incidence rates may manifest differently across different US regions. For example, urban–rural disparities in diabetes mortality rates appear to be greater in the South census region and lesser in the West region compared with the Northeast and Midwest regions (10). Similar patterns have also been observed in diabetes-related hospitalization rates following an emergency department visit (11). Finally, health care data from the Veterans Administration also suggests higher incidence of type 2 diabetes in the rural South and in higher-density urban environments of the Northeast and West than in other areas of the US (12). Although diabetes prevalence is a function of both diabetes incidence (new cases) and mortality (survival of existing cases), no recent studies have examined how disparities of diabetes prevalence according to urban/rural status may vary according to region. Therefore, the purpose of this study was to examine differences in the association of diabetes prevalence and urban/rural status of residence by region, as well as how demographic and socioeconomic factors and weight status may help to explain any observed disparities.

Methods

We used data from the 2019–2022 National Health Interview Survey (NHIS), an annual survey of US households and noninstitutional group quarters (eg, college dormitories, group homes) from the 50 states and the District of Columbia (13). The sample is drawn using a geographically clustered design in a manner such that each month's sample is nationally representative. A sample adult from each household responds to various survey questions regarding health status and behaviors and demographic and socioeconomic characteristics. Most interviews are conducted face-to-face using a computer-aided personal interview, although some interviews are conducted, in part or whole, over the telephone. For 2019–2022, NHIS sample sizes and final response rates for sample adults were 31,997 (59.1%) for 2019; 21,153 (48.9%) for 2020; 29,482 (50.9%) for 2021; and 27,651 (47.7%) for 2022 (13). Participants from the 2019 NHIS who were reinterviewed in 2020 as part of a one-time NHIS longitudinal data collection were only included in the 2019 sample. For the present study, 110,283 participants were included across all years. A total of 725 participants were excluded due to missing data for diabetes status (n = 135), educational attainment (n = 590), sex (n = 9), or a combination of these variables, resulting in a final analytic sample of 109,558.

The primary outcome, diabetes status, was based on self-report of physician diagnosis ascertained with the question, "(Not including gestational diabetes or prediabetes) Has a doctor or other health professional EVER told you that you had diabetes?" The primary predictor variables were region, which was classified according to the US census regions (Northeast, Midwest, South, and West) and metropolitan residence, which was based on the county of residence of the household and serves as a proxy for urban/rural status. Metropolitan residence was classified based on the 6 categories of the 2013 National Center for Health Statistics (NCHS) Urban–Rural Classification Scheme, which are collapsed into 4 categories in NHIS public use data sets: large central metro, large fringe metro, medium and small metro, and nonmetro (includes micropolitan and noncore) (14). Demographic variables were age (18–44 y, 45–64 y, 65–74 y, and ≥75 y), sex (female, male), and race and ethnicity (Hispanic, non-Hispanic [NH] Asian, NH Black, NH White, or NH Other). Socioeconomic status variables were educational attainment (less than high school, high school or equivalent, some college or associate degree, or bachelor's degree and above) and family income-to-poverty ratio (<100%, 100%–199%, 200%–299%, 300%–399%, 400%–499%, or ≥500%), the ratio of annual family income to the poverty threshold for household size. Because of missing or incomplete data on family income, approximately 23% to 24% of family income-to-poverty ratio values for each survey year were replaced with a single imputation provided by NCHS. Body weight status was based on self-reported height and weight and classified according to body mass index (BMI, kg/m^2) as underweight or normal weight (<25.0), overweight (25.0–29.9), obese (≥30.0), or missing.

Statistical analysis

Analysis was conducted using SAS version 9.4 (SAS Institute) with survey procedures to account for sample weights and survey design variables. Significance was set at $P < .05$. Diabetes status, demographic and socioeconomic characteristics, and body weight status were compared within each region according to metropolitan residence using the Rao-Scott F-adjusted χ^2 test. Odds ratios

(ORs) with 95% CIs from logistic regression models were used to assess the association between metropolitan residence and diabetes prevalence within each region. In all models, the interaction between region and metropolitan residence was tested using type 3 analysis of effects F-test, and a SLICE statement was used to perform a partitioned analysis to estimate the effect of metropolitan residence on diabetes prevalence within each region. In addition to region and metropolitan residence, the first model also included age, sex, and race and ethnicity as covariates. The second model additionally included income-to-poverty ratio and educational attainment, and the third model included variables from the second model plus body weight status.

Results

Age differed significantly by metropolitan residence for all regions, with large central and fringe metro counties containing a younger population compared with nonmetro counties (Table 1a and Table 1b). Race and ethnicity distribution also differed according to metropolitan residence across all regions, with NH White adults constituting most (≥71%) residents of nonmetro areas in every region. For all regions, educational attainment was lower among adults from nonmetro counties compared with those from large metro counties. Income and body weight status also differed by metropolitan residence across all regions, with residents from nonmetro counties having lower incomes and greater prevalence of obesity.

Unadjusted diabetes prevalence differed by metropolitan residence in the Northeast and South, with prevalence highest among adults residing in nonmetro counties and lowest among those in large fringe metro counties (Figure). Unadjusted diabetes prevalence among adults from nonmetro counties ranged from 9.0% (95% CI, 7.0%–11.1%) in the West to 14.8% (95% CI, 13.5%–16.1%) in the South.

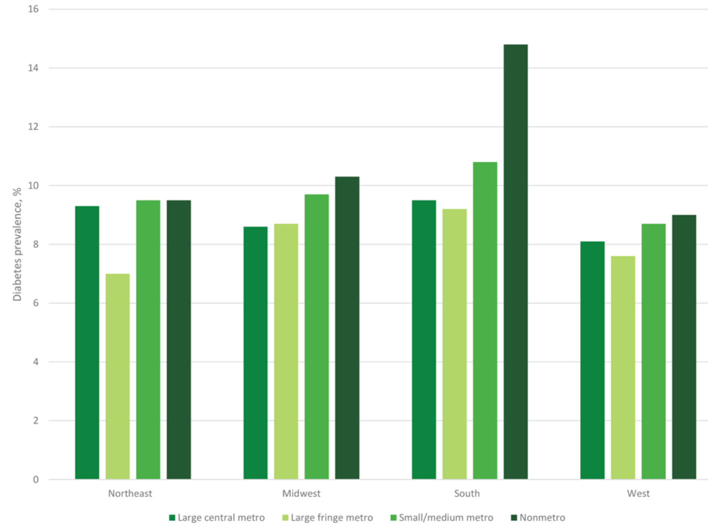

Figure. Unadjusted prevalence of self-reported diagnosed diabetes according to US census region and metropolitan status of county of residence, United States, 2019–2022.

A significant interaction was detected between region and metropolitan residence in the logistic regression model adjusting for age, sex, and race and ethnicity (*P* = .01, Table 2). Compared with adults from large central metro counties, those from small/medium metro counties had significantly higher odds of diabetes in both the Midwest (OR = 1.24; 95% CI, 1.06–1.45) and South (OR = 1.15; 95% CI, 1.02–1.30). In the South region only, adults from nonmetro counties had significantly higher odds of diabetes compared with those from large central metro counties (OR = 1.62; 95% CI, 1.43–1.84). After further adjustment for socioeconomic status variables, the interaction between region and metropolitan residence remained significant (*P* = .01) and small/medium metro counties had significantly higher odds of diabetes only in the Northeast (OR = 1.16; 95% CI, 1.00–1.34). Nonmetro county residence remained significantly associated with diabetes in the South (OR = 1.30; 95% CI, 1.15–1.47). After further adjustment for body weight status, this interaction remained significant and only nonmetro county residence in the South remained significantly associated with diabetes (OR = 1.22; 95% CI, 1.07–1.39).

Discussion

The results of our study suggest that the association of metropolitan status with diabetes prevalence is not homogenous across the US. Rather, the highest unadjusted prevalence of diabetes was observed among adults residing in nonmetro counties in the South (14.8%). The odds of having diabetes were 62% higher among Southern nonmetro residents compared with those from large central metro counties after adjustment for age, sex, and race and ethnicity, and this association remained significant, though reduced, after further adjustment for income, education, and body weight status. By contrast, residence in nonmetro counties in other regions of the US was not associated with higher odds of diabetes. Higher odds of diabetes were also observed among residents of small and medium metro counties in the Northeast, Midwest, and South as compared with large metro counties within their respective regions, although these associations became nonsignificant after further adjustment for income, education, and body weight status.

Numerous disparities in health (15,16), health behaviors (6,17), socioeconomic status (18), and access to health care (19) have been reported among those living in rural areas. However, relatively fewer studies have examined how rural health disparities may differ across regions of the US. Although all rural, nonmetro counties in the US typically share characteristics such as lower population density and distance from large metropolitan areas, they may differ in terms of racial and ethnic distribution, socioeconomic status, the environment, and economy. For example, although nonmetro counties across every region have larger proportions of non-Hispanic White residents compared with large metro counties, Southern and Western nonmetro counties have smaller majorities of non-Hispanic White residents with greater proportions of Black residents in the South and Hispanic, Asian, and NH Other residents in the West (20). Furthermore, although rural–urban disparities in poverty and educational attainment are observed across all US regions, they manifest more severely in the rural South. Similar patterns in race and ethnicity, poverty, and educational attainment across region and metropolitan status were observed in our study. However, controlling for these variables in multivariable models did not fully explain the association of nonmetro county status with greater diabetes prevalence in the South. Regarding environment and economy, nonmetro counties can vary from those with tourist economies based on natural amenities such as mountains and lakes, to agricultural areas where cultivated fields or range land stretch for large distances, to places where mining or manufacturing is the key economic activity (19). These differences in environment and economy may further affect employment opportunities and commuting distances, access to health care, the retail food environment, and opportunities for physical activity (19). Unfortunately, exploring the potential effect of these environmental and economic contextual factors was not possible in this study because these data are not available in the NHIS data set.

This finding of elevated diabetes prevalence in the nonmetro South is consistent with research regarding diabetes mortality rates (10), diabetes incidence among the Veterans Administration patient population (12), and hospitalization rates following diabetes-related emergency department visits (11). Furthermore, the Southeastern region has long been designated as the "stroke belt" due to elevated stroke mortality rates observed since the middle of the 20th century, and stroke incidence has been observed to be particularly high among nonmetro areas in the South (21). Likewise, more recent research using Bayesian multilevel modeling of Behavioral Risk Factor Surveillance System data has also proposed a "diabetes belt" that occurs in the South (22). The factors contributing to the elevated prevalence of stroke and diabetes in the rural South are not entirely understood (21,22) but could include greater prevalence of risk factors such as lower socioeconomic status, obesity (3), poor diet (23), and insufficient physical activity (7). Although the association of diabetes with nonmetro county residence in the South was attenuated when we controlled for age, race and ethnicity, socioeconomic status, and body weight status, these factors did not entirely explain the association. Unfortunately, we were not able to assess whether physical activity or dietary quality explained the increased prevalence because data on these variables were not available for the entirety of the study period. However, in previous research by Barker et al regarding the "diabetes belt," sociodemographic factors, body weight status, and sedentary lifestyle did not fully account for increased diabetes prevalence observed (22). Some literature also suggests that other unmeasured social factors such as discrimination and institutional racism could help explain the increased prevalence in the rural South, but information on these factors was also unavailable in our data (24). Finally, higher diabetes prevalence in the nonmetro South may also be linked to limited health insurance access among low-income populations, who are disproportionately concentrated there. As of May 2024, 7 of the 10 states that have not adopted Medicaid expansion under the Affordable Care Act to cover adults with incomes up to 138% of the poverty line are in the South census region (25). However, data on state of residence is unavailable in public use data, so we were unable to assess the potential impact of state Medicaid eligibility criteria on the results.

We also observed greater prevalence of diabetes among adults living in small and medium metro counties in the Midwest and South. However, our results suggest that this increased prevalence was largely explained by disparities in socioeconomic status, as these associations became nonsignificant when we controlled for income and education and further attenuated when we controlled for body weight status. Smaller cities in the Midwest and South, particularly those reliant on manufacturing, have been disrupted in recent decades by foreign trade and automation and have seen slower growth in employment and income compared with larger cities (26). We also observed a significant association of small and medium metro residence with diabetes in the Northeast after controlling for socioeconomic status, although the odds ratio remained of similar magnitude as in the previous model. This association may have been due to increased prevalence of risk factors such as body weight status, as the association became insignificant and attenuated after controlling for this variable.

Our study has several limitations. We relied on self-report of diabetes, which may be subject to misclassification; self-report also does not capture undiagnosed diabetes, which may occur more frequently among people without sufficient access to health care such as in nonmetro areas, although research suggests that diabetes screening rates are similar in urban and rural counties (27). Furthermore, we did not have adequate data on physical activity, dietary intake, or distance from health care resources, which could help elucidate potential mechanisms by which metropolitan residence could be associated with diabetes. Nonetheless, the large sample size allowed us to examine how the association of metropolitan residence with diabetes differs across US regions. In addition, our use of county metropolitan status as a proxy measure for rurality may limit the generalizability of the results since counties across metropolitan status categories may contain both urban and rural places and populations (28).

In conclusion, we found that the association of metropolitan residence with diabetes prevalence differs across regions of the US. These findings can help to guide efforts in areas where diabetes prevention and care resources may be better directed. Future research on rural–urban health disparities may consider examining how these disparities differ across US regions.

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Tables

Table 1a. Demographic Characteristics of Adults, by Region and County Metropolitan Status, US Northeast and Midwest Regions, National Health Interview Survey, 2019–2022

Characteristic	Northeast (n = 18,461), % (95% CI)				Midwest (n = 24,081), % (95% CI)			
	Large central metro (n = 5,250)	Large fringe metro (n = 6,788)	Small/ medium metro (n = 5,005)	Nonmetro (n = 1,418)	Large central metro (n = 5,110)	Large fringe metro (n = 6,005)	Small/ medium metro (n = 7,180)	Nonmetro (n = 5,786)
Age, y								
18–44	48.0 (45.8–50.2)	43.0 (41.3–44.6)	40.3 (38.3–42.3)	36.6 (33.5–39.7)	50.8 (48.8–52.8)	44.6 (42.8–46.3)	48.4 (45.8–50.9)	37.8 (35.9–39.7)
45–64	31.4 (29.9–32.9)	34.1 (32.9–35.3)	35.1 (33.5–36.7)	36.1 (33.8–38.4)	30.7 (28.9–32.5)	34.2 (32.7–35.7)	30.2 (28.3–32.1)	34.7 (33.3–36.1)
65–74	12.1 (11.1–13.2)	13.3 (12.5–14.1)	14.5 (13.0–16.1)	16.5 (15.3–17.7)	11.7 (10.7–12.7)	12.8 (11.8–13.7)	12.6 (11.8–13.5)	15.4 (14.5–16.4)
≥75	8.5 (7.5–9.4)	9.7 (8.9–10.4)	10.1 (9.3–10.9)	10.7 (9.0–12.5)	6.9 (6.1–7.7)	8.5 (7.5–9.5)	8.8 (7.9–9.7)	12.1 (11.0–13.2)
Sex								
Female	51.9 (50.1–53.6)[a]	51.1 (49.6–52.6)[a]	51.8 (50.0–53.6)[a]	51.0 (46.4–55.6)[a]	51.1 (49.6–52.6)[a]	52.0 (50.4–53.5)[a]	51.5 (49.9–53.1)[a]	50.2 (48.2–52.1)[a]
Male	48.1 (46.4–49.9)[a]	48.9 (47.4–50.4)[a]	48.2 (46.4–50.0)[a]	49.0 (44.4–53.6)[a]	48.9 (47.4–50.4)[a]	48.0 (46.5–49.5)[a]	48.5 (46.9–50.1)[a]	49.8 (47.9–51.8)[a]
Race and ethnicity								
Hispanic	19.9 (16.3–23.5)	11.1 (8.8–13.4)	8.9 (6.7–11.1)	2.8 (0.1–5.5)	11.5 (8.9–14.1)	6.8 (5.0–8.5)	6.7 (4.4–9.0)	3.0 (2.0–4.0)
Non-Hispanic Asian	13.1 (10.6–15.6)	7.2 (6.1–8.2)	3.1 (2.0–4.1)	1.1 (0.6–1.7)	5.3 (4.3–6.4)	3.7 (2.9–4.6)	2.8 (2.0–3.5)	0.9 (0.5–1.3)
Non-Hispanic Black	19.9 (17.1–22.7)	6.3 (4.6–8.0)	6.0 (4.2–7.8)	1.2 (0.4–1.9)	18.5 (15.9–21.1)	6.3 (4.9–7.7)	6.7 (5.6–7.8)	1.8 (0.7–2.9)
Non-Hispanic White	45.7 (39.1–52.3)	74.2 (70.9–77.4)	80.8 (76.7–85.0)	92.9 (89.4–96.5)	62.8 (59.1–66.5)	81.2 (78.7–83.8)	80.8 (77.9–83.7)	91.8 (89.8–93.9)
Non-Hispanic Other	1.4 (1.0–1.8)	1.3 (0.9–1.6)	1.3 (0.8–1.7)	2.0 (1.2–2.7)	1.9 (1.3–2.4)	2.0 (1.5–2.5)	3.0 (2.4–3.6)	2.5 (1.5–3.5)
Education level								
Less than high school	12.1 (9.7–14.4)	7.3 (6.2–8.4)	8.6 (7.2–10.0)	10.0 (7.2–12.8)	9.0 (7.5–10.4)	6.0 (5.0–7.0)	8.2 (6.6–9.8)	11.1 (8.9–13.3)
High school diploma/GED	26.0 (24.2–27.9)	26.0 (24.3–27.7)	31.4 (28.4–34.4)	34.8 (30.0–39.5)	22.2 (20.4–23.9)	26.9 (25.3–28.5)	30.9 (28.1–33.8)	37.9 (35.0–40.8)
Some college/associate degree	22.9 (20.9–24.9)	25.5 (24.1–26.8)	26.9 (25.0–28.8)	31.2 (27.5–34.9)	28.3 (26.6–30.0)	31.3 (29.6–33.0)	31.8 (29.9–33.6)	31.9 (29.7–34.2)
Bachelor's degree or higher	39.0 (36.6–41.3)	41.3 (39.0–43.6)	33.1 (29.4–36.7)	24.0 (18.5–29.5)	40.6 (38.1–43.1)	35.8 (33.3–38.3)	29.2 (25.4–32.9)	19.1 (16.9–21.2)
Family income-to-poverty ratio, %								
<100	13.5 (11.4–15.5)	5.0 (4.1–5.8)	7.7 (6.3–9.1)	10.4 (7.4–13.3)	10.8 (9.3–12.3)	5.2 (4.3–6.0)	10.0 (8.5–11.6)	10.2 (8.2–12.3)
100–199	18.4 (16.3–20.4)	12.2 (10.8–13.5)	15.5 (13.5–17.6)	20.0 (16.4–23.5)	16.9 (15.3–18.5)	12.1 (10.8–13.4)	17.0 (15.4–18.7)	21.1 (19.3–22.8)

Abbreviation: GED, general educational development.
[a] Not significant according to χ^2 test ($P > .05$). All other values significant at $P < .05$ of characteristic differing according to county metropolitan status within region.

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Table 1a. Demographic Characteristics of Adults, by Region and County Metropolitan Status, US Northeast and Midwest Regions, National Health Interview Survey, 2019–2022

Characteristic	Northeast (n = 18,461), % (95% CI)				Midwest (n = 24,081), % (95% CI)			
	Large central metro (n = 5,250)	Large fringe metro (n = 6,788)	Small/ medium metro (n = 5,005)	Nonmetro (n = 1,418)	Large central metro (n = 5,110)	Large fringe metro (n = 6,005)	Small/ medium metro (n = 7,180)	Nonmetro (n = 5,786)
200–299	14.6 (13.5–15.8)	12.1 (11.1–13.2)	16.1 (14.3–18.0)	18.1 (16.0–20.3)	15.4 (14.0–16.8)	14.8 (13.4–16.2)	18.0 (16.9–19.1)	20.1 (18.7–21.5)
300–399	11.5 (10.3–12.7)	12.6 (11.5–13.6)	14.3 (13.1–15.5)	15.2 (12.2–18.2)	11.9 (10.8–13.1)	15.0 (14.0–16.0)	15.3 (14.3–16.3)	16.6 (15.4–17.8)
400–499	9.2 (7.9–10.6)	11.7 (10.7–12.8)	12.1 (10.6–13.6)	12.2 (10.0–14.4)	10.5 (9.6–11.3)	14.2 (13.1–15.2)	12.5 (11.6–13.5)	13.1 (11.7–14.5)
≥500	32.8 (30.1–35.4)	46.4 (44.1–48.8)	34.2 (31.0–37.5)	24.1 (18.3–30.0)	34.5 (32.0–37.0)	38.8 (36.0–41.5)	27.1 (24.5–29.7)	18.9 (16.7–21.1)
Body weight status								
Underweight/normal weight	36.5 (34.8–38.3)	35.9 (34.3–37.4)	32.3 (29.8–34.8)	28.5 (25.8–31.3)	34.5 (32.7–36.4)	32.8 (32.2–34.3)	30.3 (28.5–32.1)	26.2 (24.5–27.8)
Overweight	33.7 (32.3–35.1)	35.1 (33.6–36.7)	33.3 (31.8–34.8)	30.4 (27.9–32.8)	35.0 (33.4–36.5)	32.6 (31.1–34.1)	31.5 (30.3–32.7)	32.4 (30.6–34.2)
Obese	26.3 (24.8–27.9)	26.2 (24.3–28.0)	31.3 (28.9–33.6)	38.1 (35.1–41.1)	28.5 (26.3–30.7)	32.6 (30.8–34.3)	36.0 (34.3–37.7)	39.0 (37.3–40.6)
Missing	3.5 (2.8–4.2)	2.8 (2.2–3.5)	3.1 (2.4–3.8)	3.0 (1.9–4.2)	2.0 (1.4–2.5)	2.1 (1.6–2.6)	2.2 (1.6–2.9)	2.4 (1.8–3.0)

Abbreviation: GED, general educational development.
[a] Not significant according to χ^2 test (*P* > .05). All other values significant at *P* < .05 of characteristic differing according to county metropolitan status within region.

Table 1b. Demographic Characteristics of Adults, by Region and County Metropolitan Status, US South and West Regions, National Health Interview Survey, 2019–2022

Characteristic	South (n = 39,671), % (95% CI)				West (n = 27,345), % (95% CI)			
	Large central metro (n = 10,167)	Large fringe metro (n = 9,572)	Small/ medium metro (n = 13,108)	Nonmetro (n = 6,824)	Large central metro (n = 12,056)	Large fringe metro (n = 3,434)	Small/ medium metro (n = 9,291)	Nonmetro (n = 2,564)
Age, y								
18–44	52.0 (50.4–53.7)	45.2 (43.8–46.6)	43.7 (41.9–45.6)	36.4 (36.0–40.7)	50.4 (49.0–51.8)	49.0 (46.3–51.8)	47.2 (44.2–50.3)	40.9 (36.8–44.9)
45–64	30.5 (29.1–31.9)	33.8 (32.6–35.0)	32.4 (31.3–33.6)	34.5 (33.0–36.0)	31.1 (29.9–32.3)	30.9 (28.9–32.8)	30.2 (28.5–32.0)	34.5 (31.9–37.2)
65–74	10.4 (9.7–11.2)	12.6 (11.8–13.3)	13.9 (13.0–14.8)	15.8 (14.5–17.1)	10.6 (9.9–11.3)	11.7 (10.7–12.8)	13.8 (12.5–15.1)	15.3 (13.3–17.4)
≥75	7.0 (6.4–7.7)	8.4 (7.7–9.1)	10.0 (9.1–10.9)	11.3 (10.2–12.5)	7.9 (7.3–8.5)	8.4 (6.9–9.8)	8.7 (7.8–9.6)	9.3 (8.0–10.6)
Sex								
Female	52.3 (51.2–53.4)	51.2 (50.1–52.4)	53.7 (52.6–54.8)	53.4 (52.0–54.8)	49.8 (48.8–50.8)[a]	51.3 (49.2–53.4)[a]	51.1 (50.0–52.2)[a]	50.9 (48.1–53.7)[a]
Male	47.7 (45.6–48.8)	48.8 (47.6–49.9)	46.3 (45.2–47.4)	46.6 (45.2–48.0)	50.2 (49.2–51.2)[a]	48.7 (46.6–50.8)[a]	48.9 (47.8–50.0)[a]	49.1 (46.3–51.9)[a]
Race and ethnicity								
Hispanic	29.4 (24.9–33.9)	14.5 (12.2–16.7)	13.4 (8.4–18.4)	8.2 (1.5–14.9)	33.1 (29.8–36.4)	25.8 (20.0–31.6)	26.6 (20.2–32.9)	11.5 (6.6–13.3)
Non-Hispanic Asian	5.8 (4.9–6.7)	6.6 (5.3–7.9)	1.6 (1.3–2.0)	0.6 (0.4–0.8)	15.7 (13.4–17.9)	9.2 (7.2–11.3)	6.5 (3.4–9.7)	2.5 (0.1–4.9)
Non-Hispanic Black	22.7 (19.8–25.7)	18.3 (15.5–21.1)	18.8 (15.6–22.1)	15.4 (10.5–20.3)	5.7 (4.8–6.6)	5.4 (4.4–6.5)	2.2 (1.4–2.9)	0.5 (0.1–0.8)
Non-Hispanic White	40.2 (33.4–43.9)	58.6 (55.1–62.1)	63.9 (59.4–68.4)	71.6 (64.4–78.8)	42.6 (38.9–46.3)	56.1 (49.6–62.7)	60.6 (53.3–67.9)	72.0 (55.5–88.5)
Non-Hispanic Other	1.9 (1.5–2.3)	2.0 (1.5–2.4)	2.2 (1.5–3.0)	4.2 (1.9–6.4)	3.0 (2.5–3.4)	3.4 (2.6–4.2)	4.2 (3.0–5.4)	13.6 (0.0–29.9)
Education level								
Less than high school	13.2 (11.7–14.6)	9.4 (8.4–10.4)	12.7 (11.2–14.2)	19.3 (17.0–21.7)	12.2 (10.9–13.5)	10.1 (7.6–12.6)	12.5 (9.7–15.3)	13.1 (9.9–16.2)
High school diploma/GED	24.6 (22.9–26.4)	25.2 (23.6–26.8)	31.4 (29.8–33.0)	36.0 (34.1–37.9)	22.5 (20.9–24.0)	23.2 (21.5–25.0)	25.3 (23.0–27.6)	31.6 (28.9–34.3)
Some college/associate degree	26.3 (25.0–27.7)	29.4 (27.7–31.0)	30.6 (29.3–32.0)	28.9 (26.8–31.0)	28.2 (26.8–29.5)	32.3 (29.5–35.2)	34.9 (32.8–37.0)	34.7 (31.6–37.9)
Bachelor's degree or higher	35.9 (33.1–38.7)	36.0 (33.4–38.6)	25.3 (23.5–27.1)	15.8 (13.9–17.7)	37.2 (34.5–39.9)	34.3 (30.8–37.9)	27.3 (24.3–30.3)	20.6 (15.4–25.8)
Family income-to-poverty ratio, %								
<100	12.2 (10.9–13.5)	7.0 (6.2–7.9)	12.9 (11.4–14.5)	17.3 (14.8–19.8)	8.9 (7.9–9.8)	7.0 (5.8–8.1)	9.9 (8.2–11.5)	12.8 (6.4–19.3)
100–199	19.4 (17.9–20.9)	14.7 (13.2–16.3)	21.8 (20.6–23.0)	26.7 (25.3–28.2)	16.9 (15.4–18.4)	14.5 (12.2–16.7)	19.0 (17.2–20.9)	20.1 (17.0–23.2)
200–299	17.0 (15.9–18.2)	15.6 (14.3–16.8)	17.5 (16.6–18.5)	19.8 (18.5–21.1)	15.2 (14.1–16.2)	16.1 (14.3–18.0)	17.8 (16.6–19.1)	19.2 (17.1–21.4)

Abbreviation: GED, general educational development.
[a] Not significant according to χ^2 test ($P > .05$). All other values significant at $P < .05$ of characteristic differing according to county metropolitan status within region.

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Table 1b. Demographic Characteristics of Adults, by Region and County Metropolitan Status, US South and West Regions, National Health Interview Survey, 2019–2022

Characteristic	South (n = 39,671), % (95% CI)				West (n = 27,345), % (95% CI)			
	Large central metro (n = 10,167)	Large fringe metro (n = 9,572)	Small/ medium metro (n = 13,108)	Nonmetro (n = 6,824)	Large central metro (n = 12,056)	Large fringe metro (n = 3,434)	Small/ medium metro (n = 9,291)	Nonmetro (n = 2,564)
300–399	12.0 (11.1–12.8)	13.9 (12.9–14.9)	13.6 (12.8–14.3)	12.6 (11.4–13.8)	12.5 (11.7–13.4)	13.8 (11.9–15.6)	14.1 (12.9–15.2)	13.4 (10.8–16.0)
400–499	9.9 (9.1–10.8)	12.0 (11.0–12.9)	11.1 (10.4–11.8)	9.5 (8.4–10.6)	9.7 (8.9–10.5)	11.2 (9.7–12.7)	11.6 (10.6–12.6)	9.9 (7.7–12.1)
≥500	29.5 (27.0–32.0)	36.8 (34.1–39.5)	23.1 (21.3–24.9)	14.1 (12.7–15.5)	36.8 (34.2–39.3)	37.4 (33.4–41.4)	27.6 (24.6–30.5)	24.5 (17.5–31.5)
Body weight status								
Underweight/normal weight	33.1 (31.7–34.6)	32.8 (31.5–34.1)	28.4 (27.2–29.5)	26.0 (24.3–27.6)	38.6 (37.2–40.0)	33.3 (30.9–35.6)	34.1 (32.1–36.1)	31.2 (25.7–36.7)
Overweight	33.2 (31.9–34.5)	33.2 (31.9–34.5)	32.7 (31.6–33.8)	31.0 (29.7–32.3)	33.6 (32.5–34.7)	34.8 (32.6–36.9)	33.4 (32.1–34.7)	31.7 (29.4–34.0)
Obese	31.1 (29.7–32.4)	31.8 (30.5–33.1)	36.5 (35.1–37.9)	40.9 (39.1–42.7)	25.8 (24.3–27.2)	30.1 (27.6–36.7)	30.4 (29.0–31.9)	35.1 (28.6–41.5)
Missing	2.6 (2.2–3.0)	2.2 (1.8–2.6)	2.4 (2.0–2.9)	2.1 (1.6–2.6)	2.0 (1.7–2.4)	1.8 (1.3–2.4)	2.0 (1.5–2.5)	2.0 (1.3–2.8)

Abbreviation: GED, general educational development.
[a] Not significant according to χ^2 test ($P > .05$). All other values significant at $P < .05$ of characteristic differing according to county metropolitan status within region.

Table 2. Association Between County Metropolitan Status and Prevalence of Self-Reported Diagnosed Diabetes, by US Census Region, National Health Interview Survey, 2019–2022

Census region	Large fringe metro	Small/medium metro	Nonmetro
	Odds ratio[a] (95% CI)		
Model 1[b]			
Northeast	0.84 (0.72–0.99)[c]	1.15 (0.99–1.34)	1.18 (0.95–1.45)
Midwest	1.04 (0.87–1.25)	1.24 (1.06–1.45)[c]	1.17 (0.97–1.40)
South	0.97 (0.86–1.11)	1.15 (1.02–1.30)[c]	1.62 (1.43–1.84)[c]
West	1.00 (0.84–1.19)	1.13 (0.98–1.30)	1.16 (0.90–1.48)
Model 2[b]			
Northeast	0.91 (0.78–1.07)	1.16 (1.00–1.34)[c]	1.05 (0.89–1.25)
Midwest	1.05 (0.88–1.26)	1.15 (0.99–1.34)	0.99 (0.82–1.20)
South	1.00 (0.88–1.13)	1.05 (0.94–1.18)	1.30 (1.15–1.47)[c]
West	1.00 (0.85–1.17)	1.06 (0.93–1.21)	1.00 (0.79–1.26)
Model 3[b]			
Northeast	0.90 (0.76–1.06)	1.10 (0.95–1.28)	0.94 (0.79–1.12)
Midwest	1.00 (0.83–1.20)	1.06 (0.92–1.23)	0.89 (0.74–1.07)
South	0.99 (0.87–1.12)	1.00 (0.89–1.13)	1.22 (1.07–1.39)[c]
West	0.95 (0.80–1.12)	1.04 (0.91–1.19)	0.94 (0.77–1.16)

[a] Odds ratios and confidence intervals shown for each model reflect parameterization of region and metropolitan status main effect coefficients and corresponding interaction terms. Estimates represent the association of metropolitan residence and diabetes prevalence within each region. Model 1 joint interaction, $P = .002$; model 2 joint interaction, $P = .01$; model 3 joint interaction, $P = .008$.
[b] Model 1 adjusted for age, sex, and race and ethnicity; model 2 adjusted for model 1 covariates plus income-to-poverty ratio and educational attainment; model 3 adjusted for model 2 covariates plus body weight status; reference group for each region is large central metro.
[c] $P < .05$.

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ORIGINAL RESEARCH

Disparities in Cardiovascular Disease Prevalence by Race and Ethnicity, Socioeconomic Status, Urbanicity, and Social Determinants of Health Among Medicare Beneficiaries With Diabetes

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PEER REVIEWED

Summary

What is already known on this topic?

Disparities in cardiovascular disease (CVD) prevalence are present in the general population and among people with diabetes.

What is added by this report?

We found that a low income-to-poverty ratio and food insecurity were positively associated with myocardial infarction, stroke, and heart failure among Medicare beneficiaries with diabetes. Disparities in CVD prevalence by race and ethnicity varied.

What are the implications for public health practice?

Our findings can assist with targeting intervention efforts toward people who are at an increased risk for CVD to reduce CVD disparities.

Abstract

Introduction

The association between various disparity factors and cardiovascular disease (CVD) prevalence among older US adults with diabetes has not been comprehensively explored. We examined disparities in CVD prevalence among Medicare beneficiaries with diabetes.

Methods

Data were from the 2015–2019 Medicare Current Beneficiary Survey. Diabetes and CVD conditions — myocardial infarction (MI), stroke, and heart failure — were self-reported. We estimated the adjusted prevalence ratios (APRs) of CVD by race and ethnicity, education, income-to-poverty ratio (IPR), urbanicity, food insecurity, and social vulnerability using logistic regressions that controlled for these factors as well as age and sex.

Results

Annually, an estimated 9.2 million Medicare beneficiaries aged 65 years or older had diabetes. Among them, 16.7% had MI, 13.7% had stroke, and 12.5% had heart failure. Beneficiaries who were food insecure, socially vulnerable, with an IPR less than or equal to 135%, and residing in rural areas had a higher crude CVD prevalence. After controlling for other factors, low IPR and food insecurity were linked to a higher prevalence of CVD. Hispanic beneficiaries had lower stroke and heart failure prevalence than non-Hispanic (NH) White and NH Black beneficiaries. NH Black beneficiaries had lower MI prevalence but higher heart failure prevalence compared with NH White beneficiaries. Female respondents with an IPR less than or equal to 135% had higher MI and stroke prevalence; this was not seen in male respondents.

Conclusion

Low IPR and food insecurity were associated with higher MI, stroke, and heart failure prevalence among Medicare beneficiaries with diabetes. Our findings can inform targeted interventions to reduce CVD disparities in these populations.

Introduction

Cardiovascular disease (CVD) is among the leading causes of death among people with diabetes, accounting for approximately one-third of all deaths in this population in the US (1,2). However, the public health burden of CVD is distributed unevenly across groups. Research among populations with diabetes has identified factors such as low income, low educational attainment, and high social vulnerability as significant predictors of high CVD incidence, prevalence, and hospitalization and death rates (3–5). However, most existing studies have been conducted outside the US, making them less representative of the US adult population. The few US-based studies focused on a narrow set of disparity factors, highlighting the need for an updated analysis that examines a more comprehensive set of factors (2).

Moreover, research focusing on the older US population, who have a disproportionately higher prevalence of CVD compared with their younger counterparts, is lacking (6). One longitudinal study of adults aged 60 years or older with diabetes showed a consistently increasing hazard ratio for CVD-related death with each passing year (7). Given the increase in the number of older adults in the US population, the growing burden of diabetes will likely be accompanied by a corresponding increase in CVD cases (7).

Our study explored disparities in CVD prevalence among Medicare beneficiaries with diabetes based on factors including race and ethnicity, socioeconomic status, urbanicity, and social determinants of health (SDOH). Additionally, we conducted separate analyses by sex, given recent evidence of significant sex-specific differences in CVD prevalence, hospital admission rates, and death rates (8–10). Understanding CVD prevalence among different groups is crucial for developing effective treatment strategies to treat people with both CVD and diabetes, while also reducing disparities.

Methods

Data source and study sample

Data were from the Medicare Current Beneficiary Survey (MCBS), an annual survey of a nationally representative sample of Medicare beneficiaries in the US. This pooled cross-sectional analysis of the 2015–2019 MCBS focuses on Medicare beneficiaries aged 65 years or older with diabetes. The MCBS is sponsored by the Centers for Medicare & Medicaid Services (CMS) and is intended to monitor and evaluate Medicare programs by self-reported information on demographics, socioeconomic status, and health outcomes that are not captured in medical claims data. This study was exempt from the institutional review board's review.

Diabetes was identified by an affirmative response to the question, "Has a doctor or other health professional ever told you that you had diabetes?" The outcomes of interest were self-reported myocardial infarction (MI), stroke, and heart failure. These 3 conditions were among the most frequently reported initial CVD complications in people with diabetes according to the Cardiovascular Disease Research Using Linked Bespoke Studies and Electronic Health Records cohort (11). Additionally, we created a composite variable to indicate if a beneficiary had any of the 3 CVD complications.

We examined the association between race and ethnicity (Hispanic, non-Hispanic [NH] White, NH Black, and NH Other), educational attainment (high school diploma or less vs more than high school diploma), income-to-poverty ratio (IPR [income ≤135% vs >135% of the federal poverty level]), urbanicity (rural vs urban), SDOH, and CVD prevalence. These factors are important markers of inequity, as identified in previous literature (12–15). We assessed 2 SDOH-related factors: food security (insecure vs secure) and social vulnerability (vulnerable vs not vulnerable). Food insecurity was a binary variable determined by using the US Department of Agriculture (USDA) Six-Item Short Form of the Food Security Survey module (16). The 6 questions are: 1) The food bought just didn't last and I/we didn't have money to get more; was that often, sometimes, or never true for you in the last 12 months? 2) I/we couldn't afford to eat balanced meals; was this often, sometimes, or never true for you in the last 12 months? 3) In the past 12 months, did you ever cut the size of meals or skip meals because there wasn't enough money for food? 4) How often did this happen? 5) In the past 12 months, did you ever eat less than you felt you should because there wasn't enough money for food? 6) In the last 12 months, were you ever hungry but didn't eat because there wasn't enough money for food? If people gave positive responses (responses of often/sometimes or yes were coded as affirmative) to none or 1 of the 6 questions in the module, they were categorized as food secure (17). The USDA Food Security Survey Module is widely used to assess food insecurity, and studies have shown that it produces consistent results compared with other measures of food insecurity (18). Social vulnerability was a binary variable indicating whether the beneficiary's county of residence ranked in the most vulnerable 20th percentile based on the Social Vulnerability Index. This index, created by the Centers for Disease Control and Prevention (CDC), assesses various social factors to determine the relative vulnerability of communities in their capacity to respond to hazardous public health events (19). It shows a strong association between high social vulnerability scores and worse health outcomes (19,20). In addition, we controlled for age group (aged 65–74 y and ≥75 y) and sex as confounding factors.

Statistical analyses

We calculated the crude prevalence of MI, stroke, heart failure, and the composite of 1 or more of the conditions. For each CVD condition, we conducted logistic regressions to estimate the adjusted prevalence ratios (APRs) by each included factor (race and ethnicity, education, IPR, urbanicity of residence, food insecurity, and social vulnerability) (21). All factors except the one being examined, plus age group and sex,served as control variables in the regression models. We conducted separate analyses by sex for each CVD condition using the same statistical model. This separation was motivated by previous studies indicating significant sex differences in the response to the prevention of CVD and adverse CVD outcomes following a cardiac event (8–10). All estimates incorporated the sampling weights of MCBS and used the balanced repeated replication method of variance estimation in the pooled analysis (22). The weighted estimates represent the national noninstitutionalized population that was continuously enrolled in Medicare for at least 1 full calendar year during the study period. Year-fixed effects were also added in regressions to control for unobserved characteristics that change each year and are common to all beneficiaries for a given year. We report the estimates and their 95% CIs.

Results

From 2015 to 2019, an estimated annual average of 9.2 million Medicare beneficiaries aged 65 years or older were living with diabetes (Table 1). Among them, 16.7% had MI, 13.7% had stroke, 12.5% had heart failure, and 32.2% had 1 or more of the 3 conditions. Overall, 58.7% of beneficiaries were aged 65 to 74 years; more than two-thirds were NH White (68.3%), and more than half had more than high school education (54.2%). Compared with male beneficiaries, female beneficiaries with diabetes tended to be older and included more NH Black beneficiaries. The female group also had lower educational attainment, had a higher percentage with an IPR of less than or equal to 135%, and were more likely to be food insecure.

In terms of crude prevalence of CVD, heart failure was most prevalent among NH Black beneficiaries and those with lower educational achievement (Table 2). The prevalence of MI and stroke did not show significant differences by race and ethnicity and education. Stroke and heart failure were more prevalent among beneficiaries with lower IPR whereas MI was more prevalent among those residing in rural areas. All CVD conditions were more prevalent among beneficiaries experiencing food insecurity.

Compared with White respondents, NH Black respondents had a lower prevalence of MI (APR = 0.80; 95% CI, 0.66–0.95) and a higher prevalence of heart failure (APR = 1.30; 95% CI, 1.02–1.58) (Table 3). Hispanic people had a lower prevalence of stroke and heart failure than both NH White people and NH Black people, with APRs ranging between 0.42 and 0.74. Beneficiaries with an IPR ≤135% had a higher prevalence of all CVD conditions than those with an IPR >135%, with APRs ranging between 1.16 and 1.26. In addition, beneficiaries residing in rural areas had a higher prevalence of MI than those in urban areas (APR = 1.25; 95% CI, 1.09–1.42). Beneficiaries experiencing food insecurity had a higher prevalence of all CVD conditions than those who were food secure, with APRs ranging between 1.37 and 1.53. No significant disparities were found based on social vulnerability.

We found different disparity patterns by sex (Table 4). Among male beneficiaries, those that were Hispanic had a lower prevalence of stroke and heart failure than both NH Black and NH White beneficiaries, with APRs ranging between 0.45 and 0.67. Also, among male beneficiaries, those that were NH Black had a lower prevalence of MI than NH White beneficiaries. We found no disparity by race and ethnicity in the prevalence of MI and stroke among female beneficiaries. Although no significant disparity in IPR was found in male beneficiaries, female beneficiaries with a lower IPR had a higher prevalence of MI, stroke, and the composite condition, with APRs ranging between 1.27 and 1.51.

Discussion

Using data from 2015 to 2019, we found inverse associations between the prevalence of CVD and income-to-poverty ratio and food security status among a nationally representative sample of noninstitutionalized Medicare beneficiaries aged 65 years or older with diabetes. Those with a lower income level and with food insecurity had a higher prevalence of all 3 CVD conditions. In addition, we found that the relationship between race and ethnicity and CVD prevalence varied depending on the type of CVD; race and ethnicity exhibited a strong association with the prevalence of stroke and heart failure but a more modest association with the prevalence of MI. Such association was more often significant among male beneficiaries than female beneficiaries.

Our findings are generally in line with existing literature. Previous studies have consistently shown a higher prevalence of CVD among individuals in lower-resource groups, and similar associations have been observed with various factors in the general population, such as access to health care, the built environment, and social support (23–25). Among people with diabetes, studies have also documented associations between income, educational attainment, and cardiovascular outcomes (3–5). Our study offers a more comprehensive understanding of the differences in CVD prevalence among various groups. An adequately sized sample representing Medicare beneficiaries in the US strengthens the reliability and generalizability of the findings. We found that the prevalence of MI was higher among NH White people than NH Black people, while heart failure prevalence was higher among NH Black people than NH White people. Our findings align with previous studies showing a similar pattern in hospitalization rates for MI and heart failure (26,27). Moreover, while previous studies have documented differences in CVD prevalence between men and women, our study provides additional evidence showing that CVD prevalence also varies by disparity factor within each sex group.

Addressing disparities in complications and illnesses for people with diabetes is a priority because of its high prevalence, economic costs, and public health burden (28). Our study offers clear and comprehensive evidence on the factors associated with disparities in CVD prevalence. The findings can inform the development of CVD prevention interventions for people with diabetes, particularly by identifying relevant subpopulations to maximize the effectiveness of such interventions. The evidence from our study can help identify approaches to improving patient outcomes through nonmedical interventions.

Our study has several limitations. First, CVD conditions were self-reported, and the estimates only account for people who survived a CVD episode; this factor may result in an underestimation of the overall CVD disparity, as fatal CVD incidence may be more prevalent among disadvantaged populations (29). Similarly, diabetes was also self-reported, so people unaware of their condition were not included in the study, potentially introducing bias. According to the National Diabetes Statistics Report, 2.7 million people aged 65 years or older had undiagnosed diabetes in 2021 in the US (30). Second, as a cross-sectional study, our findings can only identify associations, not causality. Lastly, all potential confounders may not have been accounted for, which may have influenced the results.

A low IPR and food insecurity status were positively associated with the prevalence of MI, stroke, and heart failure. Our findings can help identify interventions to reduce CVD disparities among Medicare beneficiaries with diabetes in the US.

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Tables

Table 1. Sociodemographic Characteristics of Medicare Beneficiaries With Diabetes (≥65 y), Medicare Current Beneficiary Survey, 2015–2019[a]

Characteristic	Overall (N = 11,223)	Male (n = 5,520)	Female (n = 5,703)
Weighted average annual population	9,241,660	4,636,771	4,604,889
Complications			
Myocardial infarction	16.7 (15.6–17.7)	20.4 (18.6–22.2)	12.9 (11.5–14.4)
Stroke	13.7 (12.7–14.8)	13.5 (12.2–14.9)	13.9 (12.4–15.4)
Heart failure	12.5 (11.5–13.5)	12.0 (10.8–13.2)	13.0 (11.3–14.6)
Composite[b]	32.2 (30.8–33.5)	34.1 (32.1–36.2)	30.2 (28.0–32.5)
Age group, y			
65–74	58.7 (57.5–59.9)	60.6 (58.7–62.5)	56.8 (55.0–58.6)
≥75	41.3 (40.1–42.5)	39.4 (37.5–41.3)	43.2 (41.4–45.0)
Race and ethnicity			
Hispanic	10.2 (8.5–12.0)	9.4 (7.6–11.2)	11.1 (9.0–13.2)
Non-Hispanic White	68.3 (65.9–70.8)	71.5 (68.7–74.2)	65.2 (62.3–68.0)
Non-Hispanic Black	13.0 (11.8–14.2)	10.7 (9.2–12.2)	15.4 (13.5–17.3)
Non-Hispanic Other	8.4 (7.1–9.8)	8.4 (6.8–10.1)	8.4 (6.8–9.9)
Education			
High school diploma or less	45.8 (43.7–48.0)	39.9 (37.2–42.6)	51.9 (49.2–54.5)
More than high school diploma	54.2 (52.0–56.3)	60.1 (57.4–62.8)	48.1 (45.5–50.8)
Income-to-poverty ratio[c]			
≤135%	25.7 (24.4–27.1)	17.9 (16.4–19.4)	33.6 (31.7–35.6)
>135%	74.3 (72.9–75.6)	82.1 (80.6–83.6)	66.4 (64.4–68.3)
Residence urbanicity			
Rural	21.8 (20.2–23.3)	20.8 (19.1–22.5)	22.7 (20.5–24.9)
Urban	78.2 (76.7–79.8)	79.2 (77.5–80.9)	77.3 (75.1–79.5)
Food insecurity			
Food secure	91.8 (91.1–92.5)	94.5 (93.8–95.2)	89.1 (87.9–90.4)
Food insecure	8.2 (7.5–8.9)	5.5 (4.8–6.2)	10.9 (9.6–12.1)
Social vulnerability[d]			
Not vulnerable	81.0 (75.7–86.4)	82.0 (76.7–87.3)	80.1 (74.3–85.9)
Vulnerable	19.0 (13.6–24.3)	18.0 (12.7–23.3)	19.9 (14.1–25.7)

[a] Values are % (95% CI) unless otherwise indicated.
[b] The composite variable indicates that a beneficiary has any of the 3 conditions.
[c] Income-to-poverty ratio is defined as income less than or equal to 135% or greater than 135% of the federal poverty level.
[d] Social vulnerability indicates whether the beneficiary's county of residence ranked in the most vulnerable 20th percentile based on the Centers for Disease Control and Prevention's Social Vulnerability Index.

Table 2. Crude Prevalence of Cardiovascular Disease Among Medicare Beneficiaries With Diabetes, Medicare Current Beneficiary Survey, 2015–2019

Sociodemographic characteristic	Myocardial infarction	Stroke	Heart failure	Composite[a]
	% (95% CI)			
Race and ethnicity				
Hispanic	16.1 (13.5–18.7)	11.1 (8.7–13.5)	7.8 (5.3–10.3)	27.0 (23.8–30.1)
Non-Hispanic White	17.2 (16.0–18.5)	13.4 (12.1–14.7)	12.4 (11.1–13.7)	32.5 (30.7–34.4)
Non-Hispanic Black	14.4 (11.5–17.3)	16.4 (12.8–20.0)	18.6 (15.4–21.8)	35.3 (31.2–39.3)
Non-Hispanic Other	16.4 (12.4–20.3)	15.6 (12.0–19.3)	9.5 (6.1–12.9)	30.8 (25.6–36.0)
Education				
High school diploma or less	18.0 (16.3–19.7)	15.0 (13.6–16.4)	14.4 (12.7–16.1)	35.7 (33.9–37.6)
More than high school diploma	15.6 (14.2–17.0)	12.6 (11.2–14.1)	10.9 (9.6–12.1)	29.2 (27.4–30.9)
Income-to-poverty ratio[b]				
≤135%	19.1 (16.8–21.3)	16.6 (14.7–18.5)	15.9 (13.8–18.1)	37.2 (34.5–39.8)
>135%	15.9 (14.6–17.1)	12.7 (11.5–13.9)	11.3 (10.2–12.3)	30.4 (28.8–32.1)
Residence urbanicity				
Rural	20.5 (18.5–22.5)	15.6 (13.5–17.8)	14.8 (12.5–17.1)	36.9 (34.0–39.8)
Urban	15.6 (14.4–16.8)	13.2 (12.0–14.4)	11.8 (10.7–13.0)	30.9 (29.4–32.4)
Food insecurity				
Food secure	16.3 (15.2–17.3)	13.1 (12.1–14.1)	11.9 (11.0–12.8)	31.2 (29.9–32.6)
Food insecure	21.3 (17.6–25.1)	20.7 (16.9–24.5)	19.1 (14.9–23.2)	42.9 (38.4–47.3)
Social vulnerability[c]				
Not vulnerable	16.1 (14.9–17.2)	13.3 (12.1–14.5)	11.7 (10.7–12.7)	31.1 (29.6–32.5)
Vulnerable	19.3 (16.5–22.1)	15.5 (13.1–18.0)	15.8 (12.7–18.8)	36.9 (33.2–40.6)

[a] The composite variable indicates that a beneficiary has any of the 3 conditions.
[b] Income-to-poverty ratio is defined as income less than or equal to 135% or greater than 135% of the federal poverty level.
[c] Social vulnerability indicates whether the beneficiary's county of residence ranked in the most vulnerable 20th percentile based on the Centers for Disease Control and Prevention's Social Vulnerability Index.

Table 3. Adjusted Prevalence Ratios (APRs) of Cardiovascular Disease Among Medicare Beneficiaries With Diabetes, Medicare Current Beneficiary Survey, 2015–2019[a]

Sociodemographic characteristic	Myocardial infarction	Stroke	Heart failure	Composite[b]
	APR (95% CI)			
Race and ethnicity				
Hispanic vs NH White	0.87 (0.72–1.03)	0.74 (0.56–0.92)	0.55 (0.36–0.75)	0.76 (0.66–0.86)
NH Black vs NH White	0.80 (0.66–0.95)	1.11 (0.83–1.39)	1.30 (1.02–1.58)	1.01 (0.88–1.14)
NH Other vs NH White	0.91 (0.69–1.14)	1.11 (0.83–1.40)	0.73 (0.45–1.02)	0.92 (0.76–1.08)
Hispanic vs NH Black	1.09 (0.80–1.37)	0.67 (0.45–0.88)	0.42 (0.27–0.58)	0.75 (0.65–0.86)
Hispanic vs NH Other	0.96 (0.67–1.24)	0.67 (0.48–0.85)	0.75 (0.37–1.14)	0.83 (0.67–0.99)
NH Black vs NH Other	0.88 (0.62–1.14)	1.00 (0.69–1.30)	1.78 (1.08–2.48)	1.10 (0.90–1.30)
Education				
High school diploma or less vs more than high school diploma	1.11 (0.95–1.27)	1.10 (0.94–1.27)	1.17 (0.96–1.39)	1.16 (1.07–1.25)
Income-to-poverty ratio[c]				
≤135% vs >135%	1.25 (1.06–1.44)	1.20 (1.01–1.39)	1.26 (1.03–1.50)	1.16 (1.05–1.28)
Residence urbanicity				
Rural vs urban	1.25 (1.09–1.42)	1.13 (0.94–1.32)	1.13 (0.93–1.33)	1.12 (1.02–1.22)
Food insecurity				
Food insecure vs food secure	1.39 (1.13–1.64)	1.53 (1.24–1.82)	1.46 (1.11–1.82)	1.37 (1.20–1.53)
Social vulnerability[d]				
Vulnerable vs not vulnerable	1.16 (0.97–1.35)	1.08 (0.89–1.28)	1.21 (0.96–1.46)	1.13 (1.00–1.25)

Abbreviation: NH, non-Hispanic.
[a] Logistic regression models were used to estimate the adjusted prevalence ratios, adjusted for race/ethnicity, education, income-to-poverty ratio, urbanicity, food insecurity, and social vulnerability, in addition to age and sex.
[b] The composite variable indicates that a beneficiary has any of the 3 conditions.
[c] Income-to-poverty ratio is defined as income less than or equal to 135% or greater than 135% of the federal poverty level.
[d] Social vulnerability indicates whether the beneficiary's county of residence ranked in the most vulnerable 20th percentile based on the Centers for Disease Control and Prevention's Social Vulnerability Index.

Table 4. Adjusted Prevalence Ratios (APRs) of Cardiovascular Disease Among Medicare Beneficiaries With Diabetes, by Sex, Medicare Current Beneficiary Survey, 2015–2019[a]

Sociodemographic characteristic	Myocardial infarction	Stroke	Heart Failure	Composite[b]
	APR (95% CI)			
Male sex				
Race and ethnicity				
Hispanic vs NH White	0.81 (0.56–1.06)	0.67 (0.36–0.99)	0.52 (0.26–0.77)	0.74 (0.58–0.91)
NH Black vs NH White	0.67 (0.47–0.87)	1.24 (0.80–1.68)	1.14 (0.75–1.54)	0.98 (0.77–1.18)
NH Other vs NH White	0.82 (0.55–1.09)	1.21 (0.76–1.65)	0.51 (0.26–0.75)	0.90 (0.72–1.09)
Hispanic vs NH Black	1.20 (0.70–1.70)	0.54 (0.26–0.82)	0.45 (0.21–0.70)	0.76 (0.59–0.93)
Hispanic vs NH Other	0.99 (0.57–1.40)	0.56 (0.25–0.86)	1.02 (0.31–1.72)	0.82 (0.59–1.06)
NH Black vs NH Other	0.82 (0.49–1.16)	1.03 (0.52–1.54)	2.25 (1.15–3.35)	1.08 (0.79–1.37)
Education				
High school diploma or less vs more than high school diploma	1.11 (0.90–1.33)	1.29 (1.04–1.53)	1.25 (0.95–1.55)	1.16 (1.02–1.30)
Income-to-poverty ratio[c]				
≤135% vs >135%	1.05 (0.80–1.30)	1.07 (0.80–1.34)	1.21 (0.83–1.59)	1.04 (0.88–1.20)
Residence urbanicity				
Rural vs Urban	1.30 (1.09–1.50)	1.03 (0.83–1.24)	1.05 (0.73–1.36)	1.15 (1.02–1.27)
Food insecurity				
Food insecure vs food secure	1.37 (1.02–1.73)	1.19 (0.70–1.69)	1.74 (1.01–2.47)	1.32 (1.02–1.62)
Social vulnerability[d]				
Vulnerable vs not vulnerable	1.19 (0.88–1.50)	1.10 (0.77–1.42)	1.09 (0.76–1.43)	1.14 (0.95–1.32)
Female sex				
Race and ethnicity				
Hispanic vs NH White	1.00 (0.67–1.32)	0.80 (0.55–1.05)	0.59 (0.28–0.90)	0.78 (0.58–0.97)
NH Black vs NH White	0.99 (0.72–1.26)	1.02 (0.69–1.36)	1.41 (1.02–1.80)	1.04 (0.87–1.22)
Other vs NH White	1.11 (0.68–1.53)	1.03 (0.61–1.46)	0.96 (0.45–1.46)	0.94 (0.67–1.21)
Hispanic vs NH Black	1.00 (0.62–1.39)	0.78 (0.48–1.09)	0.42 (0.18–0.65)	0.74 (0.56–0.93)
Hispanic vs Other	0.90 (0.49–1.31)	0.78 (0.47–1.08)	0.61 (0.18–1.05)	0.83 (0.56–1.09)
NH Black vs Other	0.90 (0.51–1.29)	0.99 (0.57–1.41)	1.48 (0.68–2.27)	1.11 (0.80–1.42)
Education				
High school diploma or less vs more than high school diploma	1.12 (0.85–1.40)	0.96 (0.77–1.16)	1.13 (0.82–1.44)	1.17 (1.02–1.32)
Income-to-poverty ratio[c]				
≤135% vs >135%	1.51 (1.18–1.83)	1.30 (1.03–1.57)	1.28 (0.99–1.57)	1.27 (1.10–1.43)

Abbreviation: NH, non-Hispanic.
[a] Logistic regression models were used to estimate the adjusted prevalence ratios, adjusted for race/ethnicity, education, income-to-poverty ratio, urbanicity, food insecurity, and social vulnerability, in addition to age and sex.
[b] The composite variable indicates that a beneficiary has any of the 3 conditions.
[c] Income-to-poverty ratio is defined as income less than or equal to 135% or greater than 135% of the federal poverty level.
[d] Social vulnerability indicates whether the beneficiary's county of residence ranked in the most vulnerable 20th percentile based on the Centers for Disease Control and Prevention's Social Vulnerability Index.

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Table 4. Adjusted Prevalence Ratios (APRs) of Cardiovascular Disease Among Medicare Beneficiaries With Diabetes, by Sex, Medicare Current Beneficiary Survey, 2015–2019[a]

Sociodemographic characteristic	Myocardial infarction	Stroke	Heart Failure	Composite[b]
	APR (95% CI)			
Residence urbanicity				
Rural vs urban	1.18 (0.82–1.55)	1.21 (0.93–1.48)	1.20 (0.91–1.49)	1.10 (0.92–1.27)
Food insecurity				
Food insecure vs food secure	1.37 (1.01–1.74)	1.73 (1.32–2.14)	1.31 (0.97–1.66)	1.40 (1.21–1.59)
Social vulnerability[d]				
Vulnerable vs not vulnerable	1.10 (0.79–1.41)	1.08 (0.79–1.37)	1.29 (0.95–1.64)	1.11 (0.93–1.29)

Abbreviation: NH, non-Hispanic.
[a] Logistic regression models were used to estimate the adjusted prevalence ratios, adjusted for race/ethnicity, education, income-to-poverty ratio, urbanicity, food insecurity, and social vulnerability, in addition to age and sex.
[b] The composite variable indicates that a beneficiary has any of the 3 conditions.
[c] Income-to-poverty ratio is defined as income less than or equal to 135% or greater than 135% of the federal poverty level.
[d] Social vulnerability indicates whether the beneficiary's county of residence ranked in the most vulnerable 20th percentile based on the Centers for Disease Control and Prevention's Social Vulnerability Index.

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RESEARCH BRIEF

State-Level Household Energy Insecurity and Diabetes Prevalence Among US Adults, 2020

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PEER REVIEWED

Summary

What is already known on this topic?

Energy insecurity is prevalent across the US and may be important for those with diabetes, who rely on stable energy access to reduce the impact of extreme temperatures.

What is added by this report?

Findings indicate that states with a higher prevalence of household energy insecurity had a higher prevalence of diagnosed diabetes, with the highest prevalence of both concentrated mainly among southern states.

What are the implications for public health practice?

Interventions and policies related to energy assistance may help reduce household energy insecurity, mitigate the risk of diabetes-related complications, and alleviate some of the burden of diabetes management during extreme temperatures.

Abstract

The objective of this study was to examine the state-level association between household energy insecurity and diabetes prevalence in 2020. We obtained 1) state-level data on household energy characteristics from the 2020 Residential Energy Consumption Survey and 2) diagnosed diabetes prevalence from the US Diabetes Surveillance System. We found states with a higher percentage of household energy insecurity had greater diabetes prevalence compared with states with lower percentages of energy insecurity. Interventions related to energy assistance may help reduce household energy insecurity, mitigate the risk of diabetes-related complications, and alleviate some of the burden of diabetes management during extreme temperatures.

Objective

Climate change has led to increases in heat waves and cold spells, potentially worsening health outcomes among those with diabetes (1,2). Adverse physiologic responses to heat (eg, compromised vasodilation and sweating) and cold stress (eg, impaired vasoconstriction and brown tissue activity) may be factors driving the association between exposure to extreme temperatures and increased hospitalization and emergency department visits along with illnesses (cardiovascular disease, kidney disease, and hypertension) and death among those with diabetes (1–3). The use of residential heating and air conditioning is important for buffering against the adverse effects of extreme temperatures. However, evidence from previous research suggests that energy costs from residential heating and air conditioning are a significant burden to low-income households, which could subsequently contribute to inequalities in diabetes-related outcomes (4). In 2020, approximately 33.6 million of 123.5 million US households were considered energy insecure (ie, unable to adequately meet basic household energy needs) (5). Raising visibility at the state level of where those with energy insecurity and diabetes live may be informative for developing energy policies and interventions to meet the needs of those with diabetes. Thus, this study sought to examine the association between state-level household energy insecurity and diagnosed diabetes prevalence.

Methods

We conducted cross-sectional analyses during August through October 2023 to examine the association between household energy insecurity and diabetes prevalence in 2020. We used data from the 2020 Residential Energy Consumption Survey (RECS), a nationally representative household survey that collects information on sociodemographic characteristics, energy use behaviors, and receipt of energy assistance (6). We used the Centers for Disease Control and Prevention's US Diabetes Surveillance System to obtain 2020 state-level diagnosed diabetes prevalence estimates (7). We defined household energy insecurity as reporting any of the following in the past year: reducing or forgoing food or medicine to pay energy costs, leaving the home at what respondents felt were unhealthy temperatures, receiving a disconnect or delivery stop notice, and being unable — because of cost — to use heating equipment or air-conditioning equipment. We estimated weighted percentages and 95% CIs for any household energy insecurity, each of the 5 components, and those that had ever received energy assistance, overall and by state, accounting for the RECS sampling weights (6). Prevalence estimates were age-standardized to the 2000 US Census. To illustrate the relationship between age-standardized state-level prevalence of household energy insecurity and diagnosed diabetes, we categorized these variables into tertiles and created a bivariate choropleth map using R v4.3.2 package ggspatial (v1.1.8) (R Foundation) (8). We created a similar map of those who ever received energy assistance and diabetes prevalence. We used multivariable linear regression to assess the state-level association between age-standardized household energy insecurity and diagnosed diabetes prevalence, adjusting for state-level percentages of the population who are non-Hispanic White, experiencing poverty, and living in rural areas with data from the 2016 through 2020 American Community Survey (9–11) and the 2020 Housing and Demographic Characteristics file (12). We conducted these analyses in SAS v9.4 (SAS Institute Inc) and SAS-callable SUDAAN v11.0 (Research Triangle Institute).

Results

The crude prevalence of any household energy insecurity among an estimated 123.5 million US households was 27.2% (95% CI, 26.4–28.0; range, 14.7% in Vermont to 40.4% in Mississippi), 19.9% (95% CI, 19.2–20.6) for reducing or forgoing food or medicine to pay energy costs, 9.9% (95% CI, 9.3–10.5) for leaving home at unhealthy temperatures, 10.0% (95% CI, 9.5–10.5) for receiving a disconnect or delivery stop notice, 4.0% (95% CI, 3.6–4.4) for being unable to use heating equipment, and 5.1% (95% CI, 4.7–5.5) for being unable to use air conditioning equipment (Table). The prevalence of ever receiving energy assistance was 5.3% (95% CI, 4.9–5.7; range, 3.1% in Virginia to 10.0% in California), while in 2020 alone, 3.5% (95% CI, 3.2–3.8) of US households received energy assistance (data not shown). The age-standardized bivariate choropleth map revealed that states with a higher percentage of energy insecurity also had a greater diagnosed diabetes prevalence, compared with states with lower levels of energy insecurity (Figure 1). The highest prevalence of any household energy insecurity and diabetes was found mostly in southern states (Alabama, Arkansas, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Texas, and West Virginia), as well as Indiana and Michigan. Similarly, the adjusted linear regression model showed a positive association between household energy insecurity and diagnosed diabetes prevalence ($b = 0.17$, 95% CI, 0.11–0.24, $P < .001$) (data not shown). Furthermore, the states with the lowest prevalence of ever receiving energy assistance and the highest diabetes prevalence were Indiana and southern states that include Louisiana, North Carolina, South Carolina, Tennessee, and Texas (Figure 2).

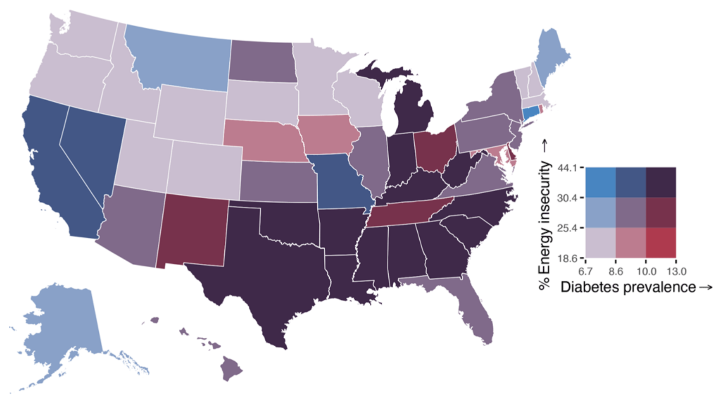

Figure 1. Bivariate map of the age-standardized percentage of any energy insecurity and diagnosed diabetes prevalence by US states, 2020. Note: Cutoffs for household energy insecurity and diabetes prevalence were established based on tertiles. Sources: 2020 Residential Energy Consumption Survey (RECS) (6); 2020 Centers for Disease Control and Prevention's US Diabetes Surveillance System.

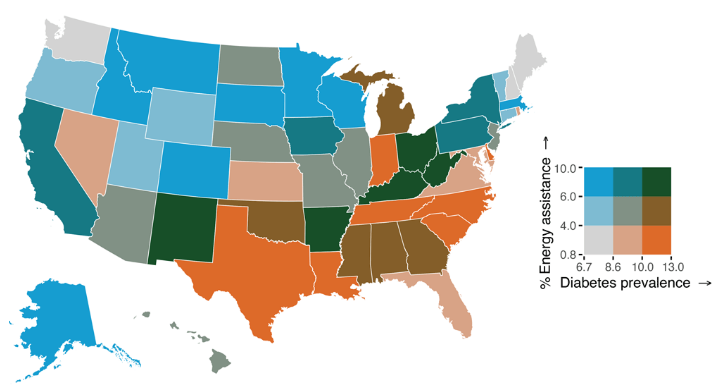

Figure 2. Bivariate map of the age-standardized percentage of ever receiving energy assistance and diagnosed diabetes prevalence by US states, 2020. Note: Cutoffs of ever receiving energy assistance and diabetes prevalence were established based on tertiles. Sources: 2020 Residential Energy Consumption Survey (RECS) (6); 2020 Centers for Disease Control and Prevention's US Diabetes Surveillance System.

Discussion

Overall, states with a higher prevalence of household energy insecurity had a higher prevalence of diagnosed diabetes, with the highest prevalence of both concentrated mainly among southern states. Diabetes prevalence has continued to increase for people with low incomes (13). These trends, overlaid with more extreme temperature events over the past several decades because of climate change, indicate a burgeoning crisis (1). Additionally, we found that reducing or forgoing food or medicine to pay energy costs was the most common form of energy insecurity. This may contribute to challenges with diabetes management (eg, insulin rationing) and increases in diabetes-related complications (14).

The low prevalence of ever receiving energy assistance highlights an opportunity to reduce energy insecurity in states with high diabetes burden. Federal policies such as the Low-Income Home Energy Assistance Program and the Weatherization Assistance Program provide financial support to families with low incomes for energy bill payments, weatherization, and energy-related home repairs (4). However, these programs have been persistently underfunded and subject to budget cuts, undermining critical access to energy-related assistance programs for low-income households (4). State policies and utility companies may also address energy insecurity, as some states have policies prohibiting utility companies from disconnecting gas or electricity for households with people who have or are at greater risk for medical conditions (eg, diabetes) or have seasonal policies that forbid disconnections during extreme weather (4). The drawback to these policies is that many are time-limited and may not adequately address the needs of people with chronic household energy insecurity. At the local level, implementation of cooling centers has shown promise in sheltering high-risk populations from extreme heat and providing heat safety education, but residents may not be aware of or have access to these resources (15). At the clinic level, screening patients with diabetes for energy insecurity and referring them to state and community level resources for energy assistance would be important given that clinical interventions addressing social needs can improve health outcomes, reduce health care costs, and increase preventive care utilization (16). Future research could examine how to better implement these various policies and interventions and their effect on diabetes outcomes.

Limitations of this study include 1) household energy and diabetes are self-reported, resulting in misclassification bias, and 2) state-level associations may not apply at the individual level. Notwithstanding these limitations, developing new policies and strengthening existing ones could help to reduce household energy insecurity and subsequently decrease disparities in diabetes-related outcomes.

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Table

Table. Crude Prevalence of Energy Insecurity Measures and Receipt of Energy Assistance by State, 2020 Residential Energy Consumption Survey

State	Any household energy insecurity,[a] % (95% CI)	Reducing or forgoing food or medicine to pay energy costs, % (95% CI)	Leaving the home at unhealthy temperature, % (95% CI)	Receiving disconnect or delivery stop notice, % (95% CI)	Unable to use heating equipment, % (95% CI)	Unable to use air conditioning equipment, % (95% CI)	Ever received energy assistance, % (95% CI)
Total	27.2 (26.4–28.0)	19.9 (19.2–20.6)	9.9 (9.3–10.5)	10.0 (9.5–10.5)	4.0 (3.6–4.4)	5.1 (4.7–5.5)	5.3 (4.9–5.7)
Alabama	33.7 (27.6–39.7)	27.2 (21.7–32.7)	14.6 (9.3–19.9)	11.2 (6.8–15.6)	7.0 (3.7–10.3)	8.7 (5.0–12.3)	3.5 (0.9–6.0)
Alaska	24.9 (20.0–29.9)	17.4 (13.3–21.6)	10.3 (6.7–13.9)	11.2 (6.6–15.7)	4.6 (2.0–7.3)	—[b]	7.9 (5.0–10.9)
Arizona	26.8 (22.9–30.7)	19.9 (16.0–23.7)	11.2 (8.3–14.2)	8.2 (5.8–10.6)	4.9 (2.9–7.0)	6.5 (4.2–8.9)	4.3 (2.1–6.6)
Arkansas	36.2 (30.0–42.4)	26.2 (20.5–31.9)	11.2 (6.3–16.0)	15.1 (10.3–19.9)	8.4 (5.0–11.9)	10.2 (6.3–14.0)	6.6 (2.7–10.4)
California	30.5 (27.8–33.3)	20.9 (18.4–23.4)	13.8 (11.7–15.8)	7.1 (5.3–8.9)	4.7 (3.4–6.0)	5.8 (4.2–7.3)	10.0 (8.1–11.8)
Colorado	23.6 (19.2–28.1)	18.3 (14.4–22.3)	7.7 (4.6–10.8)	8.0 (4.7–11.3)	3.0 (1.0–5.1)	3.8 (1.0–6.6)	5.8 (3.1–8.5)
Connecticut	27.0 (22.0–32.0)	19.7 (15.2–24.2)	13.3 (8.3–18.3)	9.2 (5.7–12.7)	5.4 (2.5–8.4)	5.3 (2.5–8.1)	5.9 (2.2–9.6)
Delaware	25.7 (17.9–33.5)	19.1 (12.5–25.7)	8.5 (3.7–13.3)	8.3 (3.7–12.9)	3.3 (0.1–6.4)	4.1 (0.8–7.3)	—[b]
District of Columbia	18.3 (12.7–23.8)	13.4 (8.4–18.4)	6.2 (3.1–9.3)	6.3 (2.5–10.0)	4.2 (1.3–7.1)	3.2 (0.8–5.6)	3.4 (0.6–6.2)
Florida	22.6 (19.4–25.7)	17.9 (14.9–20.9)	7.1 (4.6–9.5)	8.7 (6.1–11.3)	3.7 (2.2–5.2)	6.1 (4.0–8.3)	—[b]
Georgia	33.5 (28.9–38.1)	23.8 (19.2–28.5)	12.4 (8.4–16.3)	15.7 (12.0–19.4)	5.3 (2.6–7.9)	9.1 (6.3–11.9)	6.0 (3.4–8.5)
Hawaii	23.6 (18.5–28.6)	15.7 (11.2–20.1)	7.3 (4.1–10.4)	6.0 (2.7–9.3)	2.5 (0.5–4.6)	3.5 (1.2–5.8)	5.2 (2.0–8.3)
Idaho	19.3 (14.9–23.6)	14.2 (10.0–18.4)	7.1 (4.1–10.1)	7.1 (3.6–10.7)	1.5 (0.1–3.0)	3.4 (1.2–5.6)	7.4 (3.5–11.3)
Illinois	23.5 (19.3–27.6)	18.0 (14.3–21.7)	7.5 (4.9–10.1)	7.4 (4.7–10.1)	2.6 (1.1–4.1)	4.3 (2.4–6.2)	6.2 (3.8–8.5)
Indiana	28.9 (24.2–33.6)	22.4 (18.3–26.5)	8.5 (5.5–11.6)	14.9 (11.3–18.6)	4.8 (2.5–7.2)	5.1 (2.7–7.5)	3.3 (1.3–5.4)
Iowa	17.7 (13.0–22.3)	14.8 (10.3–19.3)	4.1 (1.5–6.8)	6.8 (3.7–9.9)	—[b]	—[b]	7.1 (3.5–10.6)
Kansas	25.4 (19.6–31.3)	15.2 (9.6–20.7)	8.1 (4.2–12.1)	8.4 (4.3–12.4)	2.7 (0.3–5.1)	4.5 (1.5–7.4)	—[b]
Kentucky	32.9 (27.1–38.8)	22.3 (17.3–27.2)	9.7 (6.5–12.9)	16.8 (12.3–21.3)	3.9 (2.0–5.8)	6.8 (4.1–9.4)	6.0 (3.6–8.3)
Louisiana	33.2 (28.2–38.2)	26.0 (21.0–31.1)	10.3 (7.1–13.6)	15.6 (11.4–19.8)	3.9 (1.8–6.0)	8.0 (4.7–11.3)	4.0 (1.3–6.8)
Maine	23.1 (17.4–28.8)	16.5 (11.0–22.0)	8.3 (4.2–12.3)	10.3 (4.9–15.8)	7.5 (3.6–11.4)	3.9 (1.2–6.6)	3.9 (1.3–6.4)
Maryland	22.5 (18.2–26.8)	16.7 (12.6–20.8)	9.0 (5.8–12.1)	10.0 (6.8–13.3)	2.8 (0.8–4.7)	4.0 (1.6–6.5)	3.9 (1.5–6.3)
Massachusetts	22.2 (17.4–27.1)	15.1 (10.4–19.7)	9.3 (6.4–12.2)	5.1 (3.0–7.1)	2.4 (1.0–3.8)	1.8 (0.7–3.0)	8.1 (5.2–11.0)
Michigan	29.4 (24.4–34.3)	20.9 (16.6–25.2)	9.1 (5.9–12.3)	10.9 (7.7–14.2)	3.8 (1.9–5.8)	2.6 (0.8–4.5)	5.1 (2.7–7.5)
Minnesota	16.5 (12.2–20.8)	12.6 (8.6–16.6)	4.0 (1.9–6.0)	5.3 (2.8–7.7)	—[b]	1.7 (0.3–3.1)	7.0 (3.9–10.2)
Mississippi	40.4 (32.0–48.8)	33.1 (25.5–40.8)	13.3 (8.4–18.2)	14.8 (8.6–20.9)	6.3 (2.4–10.3)	10.5 (6.2–14.7)	4.1 (0.3–8.0)
Missouri	26.8 (22.1–31.5)	21.1 (16.7–25.5)	9.3 (5.5–13.1)	15.6 (10.8–20.5)	8.5 (5.0–11.9)	6.8 (3.9–9.7)	5.1 (2.3–8.0)
Montana	24.4 (17.0–31.8)	18.3 (10.9–25.7)	7.8 (3.6–12.0)	9.0 (4.3–13.7)	—[b]	3.2 (0.3–6.2)	7.9 (2.9–13.0)
Nebraska	16.8 (10.3–23.3)	11.8 (6.2–17.4)	5.6 (1.5–9.7)	7.1 (3.1–11.0)	3.3 (0.5–6.1)	—[b]	3.8 (0.4–7.2)
Nevada	29.4 (22.0–36.9)	22.1 (15.8–28.4)	13.1 (7.3–18.9)	9.4 (5.0–13.7)	6.1 (1.7–10.5)	6.5 (2.6–10.5)	3.7 (0.3–7.0)
New Hampshire	22.6 (15.7–29.5)	12.2 (6.3–18.1)	5.6 (1.8–9.5)	9.6 (4.9–14.3)	3.0 (0.3–5.6)	5.2 (1.9–8.5)	3.1 (0.3–5.9)
New Jersey	25.3 (21.0–29.6)	18.4 (14.5–22.3)	8.6 (5.3–12.0)	10.2 (7.2–13.2)	2.7 (1.1–4.3)	4.9 (2.7–7.1)	5.3 (3.0–7.7)

[a] Defined as having 1 of these 5 experiences: having to reduce or forgo food or medicine to pay energy costs, leaving the home at unhealthy temperatures, receiving disconnect or delivery stop notice, being unable to use heating equipment due to cost, or being unable to use air-conditioning equipment because of cost.
[b] Suppressed because of a relative standard error >50%.

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Table. Crude Prevalence of Energy Insecurity Measures and Receipt of Energy Assistance by State, 2020 Residential Energy Consumption Survey

State	Any household energy insecurity,[a] % (95% CI)	Reducing or forgoing food or medicine to pay energy costs, % (95% CI)	Leaving the home at unhealthy temperature, % (95% CI)	Receiving disconnect or delivery stop notice, % (95% CI)	Unable to use heating equipment, % (95% CI)	Unable to use air conditioning equipment, % (95% CI)	Ever received energy assistance, % (95% CI)
New Mexico	25.4 (19.1–31.7)	15.7 (9.7–21.8)	11.5 (6.2–16.8)	5.7 (1.9–9.5)	4.3 (0.7–7.9)	3.2 (0.4–6.1)	7.5 (3.1–11.8)
New York	27.8 (24.8–30.8)	18.3 (15.8–20.9)	12.7 (10.3–15.0)	9.1 (7.0–11.2)	3.3 (1.9–4.8)	4.5 (2.8–6.2)	6.3 (4.5–8.0)
North Carolina	27.5 (23.3–31.6)	20.4 (16.2–24.6)	9.4 (6.3–12.5)	11.6 (8.3–15.0)	3.3 (1.3–5.2)	4.6 (2.7–6.6)	3.6 (1.8–5.4)
North Dakota	21.4 (15.7–27.0)	14.2 (9.4–18.9)	9.1 (5.3–12.9)	9.7 (6.2–13.2)	2.0 (0.4–3.6)	4.4 (1.8–7.0)	4.3 (1.8–6.9)
Ohio	26.1 (21.5–30.8)	18.2 (14.3–22.2)	7.4 (4.4–10.5)	15.3 (11.1–19.5)	4.1 (1.7–6.4)	4.4 (2.1–6.6)	6.9 (3.8–10.1)
Oklahoma	34.2 (28.0–40.5)	25.9 (20.2–31.6)	12.0 (6.5–17.5)	17.1 (11.7–22.5)	8.9 (4.5–13.3)	10.7 (6.3–15.1)	5.6 (2.3–8.9)
Oregon	21.4 (16.2–26.6)	16.7 (12.0–21.4)	9.3 (5.3–13.3)	3.7 (1.4–6.0)	3.0 (0.9–5.1)	3.6 (1.2–5.9)	3.3 (1.2–5.5)
Pennsylvania	23.9 (20.1–27.8)	17.3 (13.8–20.9)	11.0 (8.2–13.7)	7.8 (5.5–10.1)	3.8 (2.2–5.5)	2.9 (1.6–4.2)	5.7 (3.4–8.0)
Rhode Island	23.3 (15.6–31.0)	15.4 (9.3–21.5)	10.4 (4.7–16.0)	7.0 (2.3–11.7)	9.4 (4.8–14.0)	3.7 (0.3–7.2)	4.1 (1.3–7.0)
South Carolina	32.1 (26.9–37.3)	26.4 (21.6–31.2)	10.7 (6.9–14.5)	14.5 (10.6–18.5)	5.0 (2.8–7.2)	7.2 (4.1–10.4)	3.2 (1.3–5.2)
South Dakota	20.1 (12.5–27.8)	16.1 (9.2–23.0)	6.9 (2.0–11.8)	6.3 (2.4–10.2)	—[b]	2.3 (0.0–4.6)	6.7 (2.6–10.7)
Tennessee	27.5 (23.7–31.3)	22.0 (18.2–25.8)	9.8 (7.0–12.6)	11.7 (8.6–14.8)	4.1 (2.0–6.2)	6.9 (4.3–9.5)	4.0 (2.3–5.7)
Texas	34.5 (31.2–37.8)	26.2 (23.1–29.4)	10.2 (8.0–12.5)	13.0 (10.8–15.3)	4.4 (3.3–5.4)	6.0 (4.3–7.7)	3.3 (2.1–4.6)
Utah	19.1 (12.8–25.5)	11.9 (6.3–17.6)	4.6 (1.1–8.2)	9.0 (4.2–13.8)	5.2 (1.2–9.2)	4.9 (1.5–8.3)	3.6 (0.3–6.9)
Vermont	14.7 (10.4–19.0)	11.7 (7.6–15.9)	5.0 (2.3–7.7)	4.7 (2.2–7.2)	4.7 (2.1–7.3)	—[b]	4.4 (1.8–7.0)
Virginia	24.7 (20.4–28.9)	17.8 (14.0–21.5)	8.3 (5.4–11.2)	7.3 (5.0–9.6)	2.9 (1.2–4.6)	3.7 (2.0–5.4)	3.1 (1.2–5.0)
Washington	22.0 (17.3–26.6)	15.2 (11.0–19.4)	9.2 (5.9–12.5)	7.5 (4.3–10.7)	1.5 (0.3–2.6)	2.1 (0.7–3.6)	3.7 (1.9–5.6)
West Virginia	37.3 (30.4–44.2)	30.4 (24.0–36.8)	14.4 (8.9–19.8)	14.3 (9.3–19.3)	7.5 (3.6–11.4)	11.8 (6.7–16.9)	5.9 (2.6–9.2)
Wisconsin	20.5 (15.6–25.3)	15.6 (11.3–19.8)	6.6 (3.6–9.6)	4.7 (2.6–6.7)	1.3 (0.1–2.4)	3.6 (1.2–6.0)	9.1 (5.5–12.6)
Wyoming	20.7 (13.8–27.6)	14.0 (8.3–19.6)	6.7 (2.9–10.5)	7.6 (3.1–12.1)	3.6 (0.5–6.8)	—[b]	6.0 (2.5–9.4)

[a] Defined as having 1 of these 5 experiences: having to reduce or forgo food or medicine to pay energy costs, leaving the home at unhealthy temperatures, receiving disconnect or delivery stop notice, being unable to use heating equipment due to cost, or being unable to use air-conditioning equipment because of cost.
[b] Suppressed because of a relative standard error >50%.

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RESEARCH BRIEF

Telemedicine Use Among Adults With and Without Diagnosed Prediabetes or Diabetes, National Health Interview Survey, United States, 2021 and 2022

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PEER REVIEWED

Summary

What is already known on this topic?

In 2020, telemedicine use increased substantially due to the COVID-19 pandemic; however, nationally representative estimates of telemedicine use in recent years among US adults with prediabetes or diabetes are lacking.

What is added by this report?

This study's results indicate that approximately one-third to one-half of adults diagnosed with prediabetes or diabetes used telemedicine in recent years. Results also demonstrate that among adults with these conditions, disparities in telemedicine use exist according to various sociodemographic characteristics.

What are the implications for public health practice?

This study's findings suggest that disparities in telemedicine use can be reduced among select groups of adults living with prediabetes or diabetes.

Abstract

We analyzed 2021 and 2022 National Health Interview Survey data to describe the prevalence of past 12-month telemedicine use among US adults with no prediabetes or diabetes diagnosis, diagnosed prediabetes, and diagnosed diabetes. In 2021 and 2022, telemedicine use prevalence was 34.1% and 28.2% among adults without diagnosed diabetes or prediabetes, 47.6% and 37.6% among adults with prediabetes, and 52.8% and 39.4% among adults with diabetes, respectively. Differences in telemedicine use were identified by region, urbanicity, insurance status, and education among adults with prediabetes or diabetes. Findings suggest that telemedicine use can be improved among select populations with prediabetes or diabetes.

Objective

Telemedicine, the delivery of health care services at a distance, has a variety of potential benefits such as lower costs for patients, reduced strain on health care systems, and increased accessibility for select populations (eg, rural populations) (1). In particular, research suggests that telemedicine may improve diabetes-related clinical outcomes (2), enhancing the appeal for a wider application of telemedicine in the management and care of diabetes (3).

In 2021, an estimated 37.0% of US adults reported using telemedicine in the past 12 months, with use differing by several sociodemographic and geographic characteristics (4). However, nationally representative estimates of telemedicine use in recent years among US adults with prediabetes or diabetes are lacking. In this study, we aimed to describe the prevalence of past 12-month telemedicine use in 2021 and 2022 among US adults (aged 18 years or older) with no prediabetes or diabetes diagnosis, diagnosed prediabetes, and diagnosed diabetes. Additionally, since behavioral modifications related to the COVID-19 pandemic (eg, social distancing) likely influenced past 12-month telemedicine use in 2021 and 2022 differently, we also set out to identify characteristics associated with telemedicine use among each group in 2021 and 2022 separately to ascertain correlates persistently linked with use.

Methods

We used 2021 and 2022 National Health Interview Survey (NHIS) data to conduct this analysis. The NHIS is a cross-sectional survey of the civilian, noninstitutionalized US population and has been described in detail previously (5,6). Self-reported history of diagnosed prediabetes or diabetes was used to identify 3 mutually exclusive populations: 1) no diabetes or prediabetes diagnosis; 2) diagnosed prediabetes; and 3) diagnosed diabetes. Adults were defined as having diagnosed prediabetes if they responded yes to the question, "Has a doctor or other health professional ever told you that you had prediabetes or borderline diabetes?" and no to the question, "Has a doctor or other health professional ever told you that you had diabetes?" Irrespective of a prediabetes diagnosis, adults who provided a positive response to the question specific to diabetes were categorized as having diabetes. Adults who responded no to both questions were considered to have no history of prediabetes or diabetes.

Past 12-month telemedicine use was defined by an affirmative response to the question, "In the past 12 months, have you had an appointment with a doctor, nurse, or other health professional by video or by phone?" For each year, we estimated crude prevalence and 95% CIs of past 12-month telemedicine use among all 3 populations and by select characteristics. We assessed differences in overall prevalence by year among each group using χ^2 tests. We used logistic regression to calculate sex-, age-, and race and ethnicity–adjusted prevalence ratios (aPRs) to identify correlates of telemedicine use among each group. As a supplemental analysis, we repeated all analyses restricted to adults who saw a doctor or health professional within the past 12 months to describe telemedicine use patterns among adults with health care–seeking behaviors. We used SAS-callable SUDAAN (version 11.0.1, RTI International) to account for NHIS's complex survey design.

Results

In 2021 and 2022, the crude prevalence of telemedicine use in the past 12 months was, respectively, 34.1% and 28.2% among adults without diagnosed prediabetes or diabetes, 47.6% and 37.6% among adults with diagnosed prediabetes, and 52.8% and 39.4% among those with diagnosed diabetes (Figure). Across all 3 groups, telemedicine use prevalence decreased significantly between 2021 and 2022 (Figure). Among people diagnosed with diabetes, those with higher educational attainment were more likely to use telemedicine in both 2021 and 2022, whereas those who lacked insurance, lived in the Midwest or the South, or lived outside of large central or fringe metro areas were consistently less likely to use telemedicine (Table 1a and Table 1b). Among adults diagnosed with prediabetes, women and those with higher educational attainment were more likely to use telemedicine in the past 12 months, whereas adults without insurance and those living in nonmetropolitan areas, the Midwest, and the South were less likely to use telemedicine during both years. Consistent differences in telemedicine use were observed by sex, race and ethnicity, education, family income, insurance status, urbanicity, and region among adults with no prediabetes or diabetes diagnosis (Table 1a and Table 1b).

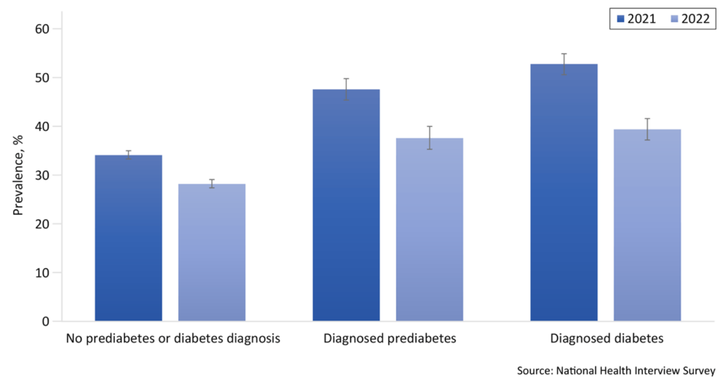

Figure. Unadjusted prevalence of telemedicine use in the past 12 months among adults with and without diagnosed prediabetes or diabetes. Prevalence (%) and associated 95% CIs are weighted; error bars indicate 95% CIs. For each population, differences between 2021 and 2022 were significant (all *P* < .05). Source: National Health Interview Survey, 2021 and 2022.

In the supplemental analysis restricted to adults who saw a doctor or health professional within the past 12 months, the prevalence of telemedicine use in 2021 and 2022, respectively, was 39.9% and 32.4% among adults without diagnosed prediabetes or diabetes, 49.8% and 39.6% among adults diagnosed with prediabetes only, and 53.3% and 39.9% among adults diagnosed with diabetes (Table 2a and Table 2b). Correlates of telemedicine use remained generally similar among these 3 populations of interest.

Discussion

Telemedicine was used by approximately half of US adults diagnosed with prediabetes or diabetes in 2021, with a noticeable decrease in use in 2022. We observed the lowest telemedicine usage among adults without these conditions. Among adults diagnosed with diabetes, we identified persistent disparities by region, urbanicity, insurance status, and educational attainment. Disparities occurred according to these factors among adults diagnosed with prediabetes as well, although female adults with prediabetes were more frequent telemedicine users than male adults.

In 2020, telemedicine use increased substantially due to the COVID-19 pandemic (7). Although nationally representative estimates of telemedicine use among US adults with prediabetes or diabetes before the COVID-19 pandemic are lacking, one previous study reported that 15.0% of US adults with diabetes used broad e-health services (eg, using email to communicate with health providers) in 2013 (8). Our study indicates that telemedicine has become common among US adults with prediabetes or diabetes, with approximately one-third to one-half of adults with these conditions using telemedicine in recent years. However, future studies may be important to characterize patterns and trends in telemedicine use among these populations.

Our study also expands on recent research of telemedicine disparities (9). For example, we observed significantly lower telemedicine use among adults with prediabetes or diabetes living in nonmetropolitan areas, which is concerning since fewer endocrinologists practice in nonmetropolitan areas (10); telemedicine could be leveraged to reduce such health care disparities. Additionally, our results indicated that telemedicine use is less common among adults with lower educational attainment, which may be related to limited digital literacy, access to technologies, or other telemedicine use barriers (11). In efforts to reduce disparities in telemedicine use (12), our study identified groups among adults with prediabetes or diabetes that could benefit from targeted interventions.

Our study has limitations. First, we used self-reported measures that may have been affected by recall and misclassification bias. Second, our data lack specific information on the purpose of the virtual health care visits. Lastly, we were unable to ascertain information on availability and preference for virtual versus in-person health care visits, which limits our ability to contextualize observed disparities.

In conclusion, our findings provide a recent snapshot of the prevalence of telemedicine use among US adults with and without prediabetes or diabetes. Additionally, we identified disparities in telemedicine use among these groups. Further research may elucidate the individual- and system-level barriers associated with telemedicine use among adults with prediabetes or diabetes.

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Tables

Table 1a. Prevalence of Telemedicine Use in the Past 12 Months Among Adults With and Without Diagnosed Prediabetes or Diabetes: National Health Interview Survey, United States, 2021[a,b]

Characteristic	No prediabetes or diabetes diagnosis (n = 23,527)[c]		Diagnosed prediabetes (n = 2,542)		Diagnosed diabetes (n = 3,096)	
	Unadjusted % (95% CI)	aPR (95% CI)	Unadjusted % (95% CI)	aPR (95% CI)	Unadjusted % (95% CI)	aPR (95% CI)
Overall	34.1 (33.3–35.0)	NA	47.6 (45.4–49.8)	NA	52.8 (50.6–54.9)	NA
Sex						
Male	28.0 (26.9–29.0)	1 [Ref]	44.6 (41.0–48.2)	1 [Ref]	52.5 (49.6–55.5)	1 [Ref]
Female	39.9 (38.7–41.1)	1.4 (1.4–1.5)[d]	49.9 (46.9–52.9)	1.1 (1.0–1.3)[d]	53.0 (50.0–56.0)	1.0 (0.9–1.1)
Age, y						
18–44	31.5 (30.3–32.6)	1 [Ref]	46.3 (41.2–51.5)	1 [Ref]	58.3 (51.6–64.6)	1 [Ref]
45–64	35.0 (33.7–36.5)	1.1 (1.0–1.1)[d]	49.1 (45.7–52.6)	1.1 (0.9–1.2)	52.7 (49.3–56.0)	0.9 (0.8–1.0)
≥65	40.3 (38.7–41.9)	1.2 (1.1–1.3)[d]	46.3 (42.9–49.8)	1.0 (0.9–1.1)	51.8 (48.8–54.8)	0.9 (0.8–1.0)
Race and ethnicity						
White, non-Hispanic	36.9 (35.9–37.9)	1 [Ref]	48.7 (45.9–51.5)	1 [Ref]	52.5 (49.7–55.2)	1 [Ref]
Black, non-Hispanic	28.3 (26.0–30.8)	0.8 (0.7–0.8)[d]	43.5 (37.6–49.5)	0.9 (0.7–1.0)	52.3 (46.8–57.8)	1.0 (0.9–1.1)
Hispanic	28.7 (27.1–30.4)	0.8 (0.8–0.9)[d]	46.0 (40.2–51.9)	0.9 (0.8–1.1)	53.2 (47.4–58.9)	1.0 (0.9–1.1)
Other[e]	30.9 (28.5–33.5)	0.9 (0.8–0.9)[d]	49.6 (42.5–56.7)	1.0 (0.9–1.2)	54.5 (46.9–61.9)	1.1 (0.9–1.2)
Education						
No high school diploma or GED	23.5 (21.2–25.8)	1 [Ref]	40.4 (32.9–48.4)	1 [Ref]	44.7 (39.6–50.0)	1 [Ref]
High school diploma or GED	26.6 (25.3–28.0)	1.1 (1.0–1.2)[d]	40.1 (35.8–44.6)	1.0 (0.8–1.3)	49.7 (45.7–53.6)	1.1 (1.0–1.3)
Some college	35.9 (34.5–37.4)	1.5 (1.3–1.6)[d]	49.7 (45.6–53.8)	1.2 (1.0–1.5)[d]	55.0 (51.3–58.5)	1.3 (1.1–1.4)[d]
Bachelor's degree or higher	40.9 (39.7–42.2)	1.7 (1.5–1.9)[d]	54.5 (50.6–58.3)	1.4 (1.1–1.7)[d]	61.1 (56.7–65.3)	1.4 (1.2–1.6)[d]
Family income, % FPL[f]						
<100	29.6 (27.4–32.0)	1 [Ref]	45.4 (38.3–52.7)	1 [Ref]	46.7 (40.8–52.6)	1 [Ref]
100 to <200	28.7 (27.0–30.5)	1.0 (0.9–1.1)	41.5 (36.0–47.3)	0.9 (0.8–1.1)	48.2 (43.6–52.7)	1.0 (0.9–1.2)
200 to <400	32.3 (30.9–33.7)	1.1 (1.0–1.2)	46.9 (42.7–51.2)	1.0 (0.9–1.3)	54.0 (50.2–57.8)	1.2 (1.0–1.4)[d]

Abbreviations: aPR, adjusted prevalence ratio; FPL, federal poverty level; GED, general educational development certificate; NA, not available.
[a] Sample sizes (n) are unweighted. Prevalence (%) and associated 95% CIs are weighted and crude. aPRs were estimated using predictive marginal proportions from logistic regression models controlling for age, sex, and race and ethnicity.
[b] Telemedicine use in the past 12 months was based on a positive response to the survey question, "In the past 12 months, have you had an appointment with a doctor, nurse, or other health professional by video or by phone?"
[c] Diagnosed prediabetes was based on a positive response to the survey question, "Has a doctor or other health professional ever told you that you had prediabetes or borderline diabetes?" and a negative response to the survey question, "Has a doctor or other health professional ever told you that you had diabetes?" Diagnosed diabetes was based on a positive response to the survey question, "Has a doctor or other health professional ever told you that you had diabetes?" irrespective of a prediabetes diagnosis. Adults who responded no to both survey questions were considered to have no prediabetes or diabetes diagnosis. Adults missing complete prediabetes and diabetes diagnosis information were excluded.
[d] $P < .05$.
[e] "Other" category is composed of people who identified as non-Hispanic Asian, non-Hispanic American Indian or Alaska Native, other single race, or multiple races.
[f] Family income was imputed when missing. Family income was reported as a percentage of the FPL based on annual weighted average thresholds published by the US Census Bureau.
[g] "Private" is adults who reported having any private insurance plan. "Public only" is adults who did not have any private coverage but who reported being covered under Medicaid, Medicare, a state-sponsored health plan, other government program, or military coverage. "Uninsured" is adults who did not report being covered under private health insurance, Medicare, Medicaid, a state-sponsored health plan, other government program, or military coverage.

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Table 1a. Prevalence of Telemedicine Use in the Past 12 Months Among Adults With and Without Diagnosed Prediabetes or Diabetes: National Health Interview Survey, United States, 2021[a,b]

Characteristic	No prediabetes or diabetes diagnosis (n = 23,527)[c]		Diagnosed prediabetes (n = 2,542)		Diagnosed diabetes (n = 3,096)	
	Unadjusted % (95% CI)	aPR (95% CI)	Unadjusted % (95% CI)	aPR (95% CI)	Unadjusted % (95% CI)	aPR (95% CI)
≥400	38.2 (37.1–39.4)	1.3 (1.2–1.4)[d]	51.3 (47.8–54.9)	1.1 (1.0–1.4)	57.6 (53.7–61.4)	1.3 (1.1–1.5)[d]
Health insurance[g]						
Private	36.1 (35.1–37.1)	1 [Ref]	48.6 (45.6–51.7)	1 [Ref]	52.9 (49.8–55.9)	1 [Ref]
Public only	39.2 (37.5–40.8)	1.1 (1.0–1.1)[d]	50.5 (46.5–54.5)	1.1 (1.0–1.2)	55.9 (52.7–59.0)	1.1 (1.0–1.2)
Uninsured	12.4 (10.8–14.1)	0.4 (0.3–0.4)[d]	22.7 (15.3–32.3)	0.5 (0.3–0.7)[d]	30.2 (22.1–39.8)	0.5 (0.4–0.7)[d]
Urban–rural residence						
Large central metro	37.2 (35.7–38.7)	1 [Ref]	51.3 (47.2–55.5)	1 [Ref]	59.2 (55.1–63.2)	1 [Ref]
Large fringe metro	37.6 (35.9–39.3)	0.9 (0.9–1.0)	51.3 (46.7–55.7)	1.0 (0.9–1.1)	54.9 (50.6–59.2)	0.9 (0.8–1.0)
Medium and small metro	31.6 (30.1–33.0)	0.8 (0.7–0.8)[d]	44.4 (40.6–48.3)	0.8 (0.8–1.0)[d]	49.3 (45.4–53.2)	0.8 (0.7–0.9)[d]
Nonmetropolitan	26.2 (24.2–28.3)	0.6 (0.6–0.7)[d]	39.8 (34.4–45.5)	0.7 (0.6–0.9)[d]	44.9 (39.6–50.3)	0.7 (0.6–0.8)[d]
US Census region						
West	38.3 (36.6–40.1)	1 [Ref]	55.4 (51.1–59.7)	1 [Ref]	67.1 (62.6–71.2)	1 [Ref]
Northeast	37.5 (35.6–39.5)	0.9 (0.9–1.0)	50.1 (44.6–55.7)	0.9 (0.8–1.0)	55.4 (49.7–61.0)	0.8 (0.7–0.9)[d]
Midwest	30.7 (28.8–32.6)	0.8 (0.7–0.8)[d]	46.8 (42.1–51.5)	0.8 (0.7–0.9)[d]	45.6 (41.4–49.9)	0.7 (0.6–0.7)[d]
South	31.7 (30.3–33.1)	0.8 (0.8–0.9)[d]	41.5 (38.1–44.9)	0.7 (0.7–0.8)[d]	48.3 (45.0–51.6)	0.7 (0.6–0.8)[d]

Abbreviations: aPR, adjusted prevalence ratio; FPL, federal poverty level; GED, general educational development certificate; NA, not available.
[a] Sample sizes (n) are unweighted. Prevalence (%) and associated 95% CIs are weighted and crude. aPRs were estimated using predictive marginal proportions from logistic regression models controlling for age, sex, and race and ethnicity.
[b] Telemedicine use in the past 12 months was based on a positive response to the survey question, “In the past 12 months, have you had an appointment with a doctor, nurse, or other health professional by video or by phone?”
[c] Diagnosed prediabetes was based on a positive response to the survey question, “Has a doctor or other health professional ever told you that you had prediabetes or borderline diabetes?” and a negative response to the survey question, “Has a doctor or other health professional ever told you that you had diabetes?” Diagnosed diabetes was based on a positive response to the survey question, “Has a doctor or other health professional ever told you that you had diabetes?” irrespective of a prediabetes diagnosis. Adults who responded no to both survey questions were considered to have no prediabetes or diabetes diagnosis. Adults missing complete prediabetes and diabetes diagnosis information were excluded.
[d] $P < .05$.
[e] “Other” category is composed of people who identified as non-Hispanic Asian, non-Hispanic American Indian or Alaska Native, other single race, or multiple races.
[f] Family income was imputed when missing. Family income was reported as a percentage of the FPL based on annual weighted average thresholds published by the US Census Bureau.
[g] “Private” is adults who reported having any private insurance plan. “Public only” is adults who did not have any private coverage but who reported being covered under Medicaid, Medicare, a state-sponsored health plan, other government program, or military coverage. “Uninsured” is adults who did not report being covered under private health insurance, Medicare, Medicaid, a state-sponsored health plan, other government program, or military coverage.

PREVENTING CHRONIC DISEASE
PUBLIC HEALTH RESEARCH, PRACTICE, AND POLICY

Table 1b. Prevalence of Telemedicine Use in the Past 12 Months Among Adults With and Without Diagnosed Prediabetes or Diabetes: National Health Interview Survey, United States, 2022[a,b]

Characteristic	No prediabetes or diabetes diagnosis (n = 21,775)[c]		Diagnosed prediabetes (n = 2,659)		Diagnosed diabetes (n = 2,905)	
	Unadjusted % (95% CI)	aPR (95% CI)	Unadjusted % (95% CI)	aPR (95% CI)	Unadjusted % (95% CI)	aPR (95% CI)
Overall	28.2 (27.4–29.1)	NA	37.6 (35.3–40.0)	NA	39.4 (37.2–41.6)	NA
Sex						
Male	24.0 (23.0–25.1)	1 [Ref]	34.2 (31.0–37.5)	1 [Ref]	37.5 (34.5–40.6)	1 [Ref]
Female	32.2 (31.0–33.3)	1.3 (1.3–1.4)[d]	40.5 (37.4–43.7)	1.2 (1.0–1.3)[d]	41.4 (38.4–44.4)	1.1 (1.0–1.2)
Age, y						
18–44	27.9 (26.8–29.1)	1 [Ref]	40.0 (34.8–45.5)	1 [Ref]	45.8 (38.8–52.9)	1 [Ref]
45–64	28.8 (27.5–30.2)	1.0 (0.9–1.1)	37.7 (34.4–41.2)	0.9 (0.8–1.1)	42.3 (38.9–45.8)	0.9 (0.8–1.1)
≥65	28.1 (26.7–29.6)	0.9 (0.9–1.0)	35.7 (32.5–39.0)	0.9 (0.8–1.1)	35.1 (32.4–37.9)	0.8 (0.6–0.9)[d]
Race and ethnicity						
White, non-Hispanic	30.2 (29.2–31.2)	1 [Ref]	37.3 (34.4–40.3)	1 [Ref]	39.4 (36.8–42.0)	1 [Ref]
Black, non-Hispanic	24.2 (22.1–26.6)	0.8 (0.7–0.9)[d]	35.5 (30.2–41.1)	0.9 (0.8–1.1)	39.8 (34.6–45.2)	1.0 (0.8–1.1)
Hispanic	24.1 (22.4–25.9)	0.8 (0.7–0.9)[d]	37.8 (32.2–43.7)	1.0 (0.8–1.2)	36.7 (31.7–42.1)	0.9 (0.8–1.1)
Other[e]	26.9 (24.4–29.5)	0.9 (0.8–1.0)[d]	41.8 (35.1–48.9)	1.1 (0.9–1.3)	44.4 (36.7–52.3)	1.1 (0.9–1.3)
Education						
No high school diploma or GED	19.7 (17.5–22.3)	1 [Ref]	27.6 (21.6–34.7)	1 [Ref]	27.4 (22.7–32.7)	1 [Ref]
High school diploma or GED	21.6 (20.2–23.0)	1.1 (0.9–1.2)	30.7 (26.6–35.2)	1.2 (0.9–1.5)	35.7 (32.1–39.6)	1.3 (1.1–1.7)[d]
Some college	29.5 (28.1–31.0)	1.4 (1.3–1.6)[d]	39.8 (36.0–43.6)	1.5 (1.2–1.9)[d]	44.4 (40.4–48.5)	1.6 (1.3–2.0)[d]
Bachelor's degree or higher	34.6 (33.4–35.9)	1.7 (1.5–1.9)[d]	45.8 (41.9–49.7)	1.7 (1.3–2.2)[d]	49.0 (44.6–53.3)	1.8 (1.5–2.2)[d]
Family income, % FPL[f]						
<100	23.9 (21.7–26.2)	1 [Ref]	42.2 (35.5–49.1)	1 [Ref]	39.6 (33.9–45.6)	1 [Ref]
100 to <200	23.6 (22.1–25.3)	1.0 (0.9–1.1)	34.6 (29.6–40.0)	0.8 (0.7–1.0)	35.4 (31.0–40.0)	0.9 (0.7–1.1)
200 to <400	25.7 (24.4–27.1)	1.1 (1.0–1.2)	35.2 (31.4–39.2)	0.9 (0.7–1.1)	38.0 (34.3–41.9)	1.0 (0.8–1.2)
≥400	32.4 (31.2–33.5)	1.3 (1.2–1.5)[d]	39.8 (36.4–43.2)	1.0 (0.8–1.2)	43.6 (39.8–47.5)	1.1 (0.9–1.4)
Health insurance[g]						

Abbreviations: aPR, adjusted prevalence ratio; FPL, federal poverty level; GED, general educational development certificate; NA, not available.

[a] Sample sizes (n) are unweighted. Prevalence (%) and associated 95% CIs are weighted and crude. Adjusted prevalence ratios (aPR) were estimated using predictive marginal proportions from logistic regression models controlling for age, sex, and race and ethnicity.

[b] Telemedicine use in the past 12 months is based on a positive response to the survey question, “In the past 12 months, have you had an appointment with a doctor, nurse, or other health professional by video or by phone?”

[c] Diagnosed prediabetes was based on a positive response to the survey question, “Has a doctor or other health professional ever told you that you had prediabetes or borderline diabetes?” and a negative response to the survey question, “Has a doctor or other health professional ever told you that you had diabetes?” Diagnosed diabetes was based on a positive response to the survey question, “Has a doctor or other health professional ever told you that you had diabetes?” irrespective of a prediabetes diagnosis. Adults who responded no to both survey questions were considered to have no prediabetes or diabetes diagnosis. Adults missing complete prediabetes and diabetes diagnosis information were excluded.

[d] $P < .05$.

[e] “Other” category is composed of people who identified as non-Hispanic Asian, non-Hispanic American Indian or Alaska Native, other single race, or multiple races.

[f] Family income was imputed when missing. Family income was reported as a percentage of the FPL based on annual weighted average thresholds published by the US Census Bureau.

[g] “Private” is adults who reported having any private insurance plan. “Public only” is adults who did not have any private coverage but who reported being covered under Medicaid, Medicare, a state-sponsored health plan, other government program, or military coverage. “Uninsured” is adults who did not report being covered under private health insurance, Medicare, Medicaid, a state-sponsored health plan, other government program, or military coverage.

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Table 1b. Prevalence of Telemedicine Use in the Past 12 Months Among Adults With and Without Diagnosed Prediabetes or Diabetes: National Health Interview Survey, United States, 2022[a,b]

Characteristic	No prediabetes or diabetes diagnosis (n = 21,775)[c]		Diagnosed prediabetes (n = 2,659)		Diagnosed diabetes (n = 2,905)	
	Unadjusted % (95% CI)	aPR (95% CI)	Unadjusted % (95% CI)	aPR (95% CI)	Unadjusted % (95% CI)	aPR (95% CI)
Private	30.1 (29.1–31.2)	1 [Ref]	36.8 (34.0–39.7)	1 [Ref]	41.1 (38.2–44.1)	1 [Ref]
Public only	31.2 (29.7–32.7)	1.1 (1.0–1.1)[d]	42.2 (38.2–46.3)	1.2 (1.0–1.3)[d]	39.8 (36.6–43.1)	1.0 (0.9–1.1)
Uninsured	10.1 (8.6–11.8)	0.3 (0.3–0.4)[d]	20.7 (14.2–29.2)	0.5 (0.4–0.7)[d]	15.6 (9.2–25.2)	0.3 (0.2–0.6)[d]
Urban–rural residence						
Large central metro	32.2 (30.8–33.7)	1 [Ref]	41.7 (37.4–46.1)	1 [Ref]	43.9 (39.6–48.3)	1 [Ref]
Large fringe metro	31.1 (29.4–32.8)	0.9 (0.9–1.0)[d]	39.6 (35.3–44.0)	0.9 (0.8–1.1)	46.1 (41.5–50.8)	1.0 (0.9–1.2)
Medium and small metro	25.5 (24.1–27.0)	0.7 (0.7–0.8)[d]	37.8 (33.5–42.3)	0.9 (0.8–1.0)	36.5 (33.3–39.9)	0.8 (0.7–0.9)[d]
Nonmetropolitan	19.4 (17.3–21.7)	0.5 (0.5–0.6)[d]	24.5 (19.7–30.0)	0.6 (0.4–0.7)[d]	28.4 (23.7–33.6)	0.6 (0.5–0.7)[d]
US Census region						
West	34.0 (31.9–36.1)	1 [Ref]	46.9 (41.7–52.1)	1 [Ref]	45.3 (40.0–50.6)	1 [Ref]
Northeast	33.3 (31.5–35.2)	0.9 (0.9–1.0)	37.6 (32.6–42.9)	0.8 (0.7–0.9)[d]	44.0 (38.4–49.7)	1.0 (0.8–1.2)
Midwest	24.6 (22.8–26.4)	0.7 (0.6–0.7)[d]	33.4 (28.8–38.4)	0.7 (0.6–0.8)[d]	38.7 (34.9–42.6)	0.8 (0.7–1.0)[d]
South	24.2 (22.8–25.5)	0.7 (0.6–0.8)[d]	32.9 (29.4–36.6)	0.7 (0.6–0.8)[d]	35.2 (31.9–38.6)	0.8 (0.7–0.9)[d]

Abbreviations: aPR, adjusted prevalence ratio; FPL, federal poverty level; GED, general educational development certificate; NA, not available.
[a] Sample sizes (n) are unweighted. Prevalence (%) and associated 95% CIs are weighted and crude. Adjusted prevalence ratios (aPR) were estimated using predictive marginal proportions from logistic regression models controlling for age, sex, and race and ethnicity.
[b] Telemedicine use in the past 12 months is based on a positive response to the survey question, "In the past 12 months, have you had an appointment with a doctor, nurse, or other health professional by video or by phone?"
[c] Diagnosed prediabetes was based on a positive response to the survey question, "Has a doctor or other health professional ever told you that you had prediabetes or borderline diabetes?" and a negative response to the survey question, "Has a doctor or other health professional ever told you that you had diabetes?" Diagnosed diabetes was based on a positive response to the survey question, "Has a doctor or other health professional ever told you that you had diabetes?" irrespective of a prediabetes diagnosis. Adults who responded no to both survey questions were considered to have no prediabetes or diabetes diagnosis. Adults missing complete prediabetes and diabetes diagnosis information were excluded.
[d] $P < .05$.
[e] "Other" category is composed of people who identified as non-Hispanic Asian, non-Hispanic American Indian or Alaska Native, other single race, or multiple races.
[f] Family income was imputed when missing. Family income was reported as a percentage of the FPL based on annual weighted average thresholds published by the US Census Bureau.
[g] "Private" is adults who reported having any private insurance plan. "Public only" is adults who did not have any private coverage but who reported being covered under Medicaid, Medicare, a state-sponsored health plan, other government program, or military coverage. "Uninsured" is adults who did not report being covered under private health insurance, Medicare, Medicaid, a state-sponsored health plan, other government program, or military coverage.

Table 2a. Prevalence of Past 12-Month Telemedicine Use Among Adults With and Without Diagnosed Prediabetes or Diabetes Who Saw a Doctor or Health Professional Within the Past 12 Months: National Health Interview Survey, United States, 2021[a,b,c]

Characteristic	No prediabetes or diabetes diagnosis (n = 19,106)[d]		Diagnosed prediabetes (n = 2,336)		Diagnosed diabetes (n = 2,989)	
	Unadjusted % (95% CI)	aPR (95% CI)	Unadjusted % (95% CI)	aPR(95% CI)	Unadjusted % (95% CI)	aPR(95% CI)
Overall	39.9 (38.9–40.8)	NA	49.8 (47.4–52.1)	NA	53.3 (51.1–55.5)	NA
Sex						
Male	34.5 (33.3–35.8)	1 [Ref]	47.4 (43.8–51.1)	1 [Ref]	53.3 (50.3–56.2)	1 [Ref]
Female	44.2 (43.0–45.5)	1.3 (1.2–1.3)[e]	51.5 (48.3–54.8)	1.1 (1.0–1.2)	53.4 (50.4–56.4)	1.0 (0.9–1.1)
Age, y						
18–44	38.4 (37.1–39.8)	1 [Ref]	51.6 (45.9–57.3)	1 [Ref]	59.9 (53.0–66.4)	1 [Ref]
45–64	40.5 (38.9–42.1)	1.0 (1.0–1.1)	51.6 (47.9–55.4)	1.0 (0.9–1.2)	53.5 (50.1–57.0)	0.9 (0.8–1.0)
≥65	42.4 (40.8–44.0)	1.1 (1.0–1.1)[e]	46.4 (42.8–50.0)	0.9 (0.8–1.0)	51.8 (48.8–54.8)	0.9 (0.8–1.0)[e]
Race and ethnicity						
White, non-Hispanic	42.2 (41.2–43.3)	1 [Ref]	49.7 (46.8–52.6)	1 [Ref]	52.9 (50.2–55.7)	1 [Ref]
Black, non-Hispanic	31.7 (29.1–34.4)	0.8 (0.7–0.8)[e]	46.6 (40.4–52.9)	0.9 (0.8–1.1)	53.9 (48.3–59.4)	1.0 (0.9–1.1)
Hispanic	36.2 (34.2–38.4)	0.9 (0.8–0.9)[e]	50.0 (43.6–56.4)	1.0 (0.8–1.1)	53.0 (47.0–59.0)	1.0 (0.9–1.1)
Other[f]	38.5 (35.4–41.7)	0.9 (0.8–1.0)[e]	54.7 (47.4–61.8)	1.1 (0.9–1.3)	55.4 (47.3–63.1)	1.1 (0.9–1.2)
Education						
No high school diploma or GED	29.9 (27.1–32.9)	1 [Ref]	41.5 (33.3–50.3)	1 [Ref]	45.1 (39.8–50.5)	1 [Ref]
High school diploma or GED	32.0 (30.4–33.7)	1.1 (1.0–1.2)	41.6 (37.1–46.4)	1.0 (0.8–1.3)	49.9 (45.8–53.9)	1.1 (1.0–1.3)
Some college	41.5 (39.9–43.2)	1.3 (1.2–1.5)[e]	52.9 (48.5–57.2)	1.3 (1.0–1.6)[e]	55.5 (51.8–59.2)	1.2 (1.1–1.4)[e]
Bachelor's degree or higher	46.3 (44.9–47.7)	1.5 (1.3–1.7)[e]	56.3 (52.5–60.1)	1.4 (1.1–1.7)[e]	61.9 (57.4–66.1)	1.4 (1.2–1.6)[e]
Family income, % FPL[g]						
<100	35.6 (33.0–38.4)	1 [Ref]	47.0 (39.5–54.7)	1 [Ref]	46.7 (40.7–52.8)	1 [Ref]
100 to <200	34.9 (32.9–37.0)	1.0 (0.9–1.1)	45.9 (39.9–52.0)	1.0 (0.8–1.2)	48.3 (43.7–52.9)	1.0 (0.9–1.2)
200 to <400	38.2 (36.6–39.8)	1.1 (1.0–1.1)	49.1 (44.6–53.7)	1.1 (0.9–1.3)	54.8 (50.9–58.7)	1.2 (1.0–1.4)[e]
≥400	43.4 (42.1–44.7)	1.2 (1.1–1.3)[e]	52.6 (49.0–56.1)	1.1 (1.0–1.4)	58.3 (54.3–62.1)	1.3 (1.1–1.5)[e]

Abbreviations: aPR, adjusted prevalence ratio; FPL, federal poverty level; GED, general educational development certificate; NA, not available.
[a] Sample sizes (n) are unweighted. Prevalence (%) and associated 95% CIs are weighted and crude. Adjusted prevalence ratios (aPR) were estimated using predictive marginal proportions from logistic regression models controlling for age, sex, and race and ethnicity.
[b] Telemedicine use in the past 12 months is based on a positive response to the survey question, "In the past 12 months, have you had an appointment with a doctor, nurse, or other health professional by video or by phone?"
[c] Restricted to adults who reported seeing a doctor or health professional about their health in the past 12 months.
[d] Diagnosed prediabetes was based on a positive response to the survey question, "Has a doctor or other health professional ever told you that you had prediabetes or borderline diabetes?" and a negative response to the survey question, "Has a doctor or other health professional ever told you that you had diabetes?" Diagnosed diabetes was based on a positive response to the survey question, "Has a doctor or other health professional ever told you that you had diabetes?" irrespective of a prediabetes diagnosis. Adults who responded no to both survey questions were considered to have no prediabetes or diabetes diagnosis. Adults missing complete prediabetes and diabetes diagnosis information were excluded.
[e] $P < .05$.
[f] "Other" category is composed of people who identified as non-Hispanic Asian, non-Hispanic American Indian or Alaska Native, other single race, or multiple races.
[g] Family income was imputed when missing. Family income was reported as a percentage of the FPL based on annual weighted average thresholds published by the US Census Bureau.
[h] "Private" is adults who reported having any private insurance plan. "Public only" is adults who did not have any private coverage but who reported being covered under Medicaid, Medicare, a state-sponsored health plan, other government program, or military coverage. "Uninsured" is adults who did not report being covered under private health insurance, Medicare, Medicaid, a state-sponsored health plan, other government program, or military coverage.

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Table 2a. Prevalence of Past 12-Month Telemedicine Use Among Adults With and Without Diagnosed Prediabetes or Diabetes Who Saw a Doctor or Health Professional Within the Past 12 Months: National Health Interview Survey, United States, 2021[a,b,c]

Characteristic	No prediabetes or diabetes diagnosis (n = 19,106)[d]		Diagnosed prediabetes (n = 2,336)		Diagnosed diabetes (n = 2,989)	
	Unadjusted % (95% CI)	aPR (95% CI)	Unadjusted % (95% CI)	aPR(95% CI)	Unadjusted % (95% CI)	aPR(95% CI)
Health insurance[h]						
Private	40.9 (39.8–42.1)	1 [Ref]	50.2 (47.1–53.3)	1 [Ref]	53.0 (50.0–56.0)	1 [Ref]
Public only	42.7 (40.9–44.5)	1.1 (1.0–1.1)[e]	51.9 (47.7–56.1)	1.1 (1.0–1.2)	56.4 (53.2–59.6)	1.1 (1.0–1.2)[e]
Uninsured	20.0 (17.4–22.9)	0.5 (0.5–0.6)[e]	29.6 (19.6–42.1)	0.6 (0.4–0.8)[e]	32.7 (23.7–43.1)	0.6 (0.4–0.8)[e]
Urban–rural residence						
Large central metro	44.4 (42.7–46.2)	1 [Ref]	54.9 (50.5–59.3)	1 [Ref]	59.9 (55.7–63.9)	1 [Ref]
Large fringe metro	42.7 (40.8–44.6)	0.9 (0.9–1.0)[e]	53.9 (49.3–58.5)	1.0 (0.9–1.1)	56.0 (51.5–60.4)	0.9 (0.8–1.0)
Medium and small metro	37.0 (35.4–38.6)	0.8 (0.7–0.8)[e]	45.9 (41.8–50.1)	0.8 (0.7–0.9)[e]	49.5 (45.5–53.4)	0.8 (0.7–0.9)[e]
Nonmetropolitan	30.6 (28.4–33.0)	0.6 (0.6–0.7)[e]	39.9 (34.7–45.3)	0.7 (0.6–0.8)[e]	45.3 (39.7–50.9)	0.7 (0.6–0.8)[e]
US Census region						
West	46.4 (44.4–48.4)	1 [Ref]	59.8 (55.1–64.4)	1 [Ref]	67.5 (62.7–71.9)	1 [Ref]
Northeast	42.7 (40.5–45.0)	0.9 (0.8–1.0)[e]	51.6 (45.6–57.6)	0.9 (0.7–1.0)[e]	56.5 (50.7–62.2)	0.8 (0.7–0.9)[e]
Midwest	35.7 (33.6–37.8)	0.7 (0.7–0.8)[e]	47.9 (43.0–52.8)	0.8 (0.7–0.9)[e]	46.1 (41.9–50.4)	0.7 (0.6–0.7)[e]
South	36.9 (35.3–38.4)	0.8 (0.7–0.8)[e]	43.3 (39.7–46.9)	0.7 (0.6–0.8)[e]	49.1 (45.8–52.4)	0.7 (0.6–0.8)[e]

Abbreviations: aPR, adjusted prevalence ratio; FPL, federal poverty level; GED, general educational development certificate; NA, not available.
[a] Sample sizes (n) are unweighted. Prevalence (%) and associated 95% CIs are weighted and crude. Adjusted prevalence ratios (aPR) were estimated using predictive marginal proportions from logistic regression models controlling for age, sex, and race and ethnicity.
[b] Telemedicine use in the past 12 months is based on a positive response to the survey question, "In the past 12 months, have you had an appointment with a doctor, nurse, or other health professional by video or by phone?"
[c] Restricted to adults who reported seeing a doctor or health professional about their health in the past 12 months.
[d] Diagnosed prediabetes was based on a positive response to the survey question, "Has a doctor or other health professional ever told you that you had prediabetes or borderline diabetes?" and a negative response to the survey question, "Has a doctor or other health professional ever told you that you had diabetes?" Diagnosed diabetes was based on a positive response to the survey question, "Has a doctor or other health professional ever told you that you had diabetes?" irrespective of a prediabetes diagnosis. Adults who responded no to both survey questions were considered to have no prediabetes or diabetes diagnosis. Adults missing complete prediabetes and diabetes diagnosis information were excluded.
[e] $P < .05$.
[f] "Other" category is composed of people who identified as non-Hispanic Asian, non-Hispanic American Indian or Alaska Native, other single race, or multiple races.
[g] Family income was imputed when missing. Family income was reported as a percentage of the FPL based on annual weighted average thresholds published by the US Census Bureau.
[h] "Private" is adults who reported having any private insurance plan. "Public only" is adults who did not have any private coverage but who reported being covered under Medicaid, Medicare, a state-sponsored health plan, other government program, or military coverage. "Uninsured" is adults who did not report being covered under private health insurance, Medicare, Medicaid, a state-sponsored health plan, other government program, or military coverage.

Table 2b. Prevalence of Past 12-Month Telemedicine Use Among Adults With and Without Diagnosed Prediabetes or Diabetes Who Saw a Doctor or Health Professional Within the Past 12 Months: National Health Interview Survey, United States, 2022[a,b,c]

Characteristic	No prediabetes or diabetes diagnosis (n = 18,037)[d]		Diagnosed prediabetes (n = 2,471)		Diagnosed diabetes (n = 2,814)	
	Unadjusted % (95% CI)	aPR (95% CI)	Unadjusted % (95% CI)	aPR (95% CI)	Unadjusted % (95% CI)	aPR (95% CI)
Overall	32.4 (31.5–33.4)	NA	39.6 (37.2–42.1)	NA	39.9 (37.7–42.1)	NA
Sex						
Male	29.1 (27.9–30.4)	1 [Ref]	36.8 (33.4–40.3)	1 [Ref]	37.8 (34.8–41.0)	1 [Ref]
Female	35.2 (33.9–36.5)	1.2 (1.2–1.3)[e]	42.0 (38.7–45.3)	1.1 (1.0–1.3)[e]	42.0 (39.0–45.0)	1.1 (1.0–1.2)[e]
Age, y						
18–44	33.6 (32.3–35.0)	1 [Ref]	45.4 (39.4–51.5)	1 [Ref]	46.0 (38.8–53.3)	1 [Ref]
45–64	32.9 (31.4–34.5)	1.0 (0.9–1.0)	39.5 (36.1–43.1)	0.9 (0.8–1.0)	43.4 (40.0–47.0)	1.0 (0.8–1.1)
≥65	29.1 (27.6–30.7)	0.8 (0.8–0.9)[e]	36.2 (33.0–39.6)	0.8 (0.7–1.0)[e]	35.2 (32.5–38.0)	0.8 (0.6–0.9)[e]
Race and ethnicity						
White, non-Hispanic	33.7 (32.6–34.9)	1 [Ref]	39.0 (36.1–42.0)	1 [Ref]	39.7 (37.1–42.4)	1 [Ref]
Black, non-Hispanic	28.2 (25.7–30.8)	0.8 (0.7–0.9)[e]	36.3 (31.0–42.0)	0.9 (0.8–1.1)	40.3 (35.0–45.8)	1.0 (0.8–1.1)
Hispanic	30.7 (28.6–32.9)	0.9 (0.8–1.0)[e]	41.6 (35.4–47.9)	1.0 (0.9–1.2)	37.7 (32.4–43.3)	0.9 (0.8–1.1)
Other[f]	31.3 (28.4–34.3)	0.9 (0.8–1.0)[e]	44.6 (37.2–52.2)	1.1 (0.9–1.3)	44.6 (36.7–52.7)	1.1 (0.9–1.3)
Education						
No high school diploma or GED	25.1 (22.2–28.2)	1 [Ref]	29.1 (22.6–36.6)	1 [Ref]	28.0 (23.1–33.4)	1 [Ref]
High school diploma or GED	25.5 (23.8–27.2)	1.0 (0.9–1.1)	32.8 (28.5–37.5)	1.2 (0.9–1.5)	36.2 (32.5–40.1)	1.3 (1.0–1.6)[e]
Some college	33.3 (31.7–35.0)	1.3 (1.1–1.5)[e]	42.5 (38.5–46.6)	1.5 (1.2–2.0)[e]	45.0 (40.9–49.1)	1.6 (1.3–2.0)[e]
Bachelor's degree or higher	38.5 (37.1–39.9)	1.5 (1.3–1.7)[e]	47.0 (43.0–51.0)	1.7 (1.3–2.2)[e]	49.2 (44.9–53.6)	1.8 (1.4–2.2)[e]
Family income, % FPL[g]						
<100	29.9 (27.2–32.7)	1 [Ref]	44.1 (37.0–51.4)	1 [Ref]	41.1 (35.2–47.3)	1 [Ref]
100 to <200	28.4 (26.5–30.4)	1.0 (0.9–1.1)	37.7 (32.4–43.3)	0.9 (0.7–1.1)	35.4 (31.0–40.1)	0.9 (0.7–1.1)
200 to <400	30.0 (28.4–31.7)	1.0 (0.9–1.1)	37.6 (33.5–41.8)	0.9 (0.7–1.1)	38.4 (34.7–42.3)	1.0 (0.8–1.2)
≥400	35.7 (34.4–37.0)	1.2 (1.1–1.3)[e]	40.9 (37.4–44.5)	1.0 (0.8–1.2)	44.0 (40.1–47.9)	1.1 (0.9–1.3)

Abbreviations: aPR, adjusted prevalence ratio; FPL, federal poverty level; GED, general educational development certificate; NA, not available.
[a] Sample sizes (n) are unweighted. Prevalence (%) and associated 95% CIs are weighted and crude. Adjusted prevalence ratios (aPR) were estimated using predictive marginal proportions from logistic regression models controlling for age, sex, and race and ethnicity.
[b] Telemedicine use in the past 12 months was based on a positive response to the survey question, "In the past 12 months, have you had an appointment with a doctor, nurse, or other health professional by video or by phone?"
[c] Restricted to adults who reported seeing a doctor or health professional about their health in the past 12 months.
[d] Diagnosed prediabetes was based on a positive response to the survey question, "Has a doctor or other health professional ever told you that you had prediabetes or borderline diabetes?" and a negative response to the survey question, "Has a doctor or other health professional ever told you that you had diabetes?" Diagnosed diabetes was based on a positive response to the survey question, "Has a doctor or other health professional ever told you that you had diabetes?" irrespective of a prediabetes diagnosis. Adults who responded no to both survey questions were considered to have no prediabetes or diabetes diagnosis. Adults missing complete prediabetes and diabetes diagnosis information were excluded.
[e] $P < .05$.
[f] "Other" category is composed of people who identified as non-Hispanic Asian, non-Hispanic American Indian Alaska Native, other single race, or multiple races.
[g] Family income was imputed when missing. Family income was reported as a percentage of the FPL based on annual weighted average thresholds published by the US Census Bureau.
[h] "Private" is adults who reported having any private insurance plan. "Public only" is adults who did not have any private coverage but who reported being covered under Medicaid, Medicare, a state-sponsored health plan, other government program, or military coverage. "Uninsured" is adults who did not report being covered under private health insurance, Medicare, Medicaid, a state-sponsored health plan, other government program, or military coverage.

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Table 2b. Prevalence of Past 12-Month Telemedicine Use Among Adults With and Without Diagnosed Prediabetes or Diabetes Who Saw a Doctor or Health Professional Within the Past 12 Months: National Health Interview Survey, United States, 2022[a,b,c]

Characteristic	No prediabetes or diabetes diagnosis (n = 18,037)[d]		Diagnosed prediabetes (n = 2,471)		Diagnosed diabetes (n = 2,814)	
	Unadjusted % (95% CI)	aPR (95% CI)	Unadjusted % (95% CI)	aPR (95% CI)	Unadjusted % (95% CI)	aPR (95% CI)
Health insurance[h]						
Private	33.5 (32.4–34.7)	1 [Ref]	37.9 (35.0–40.9)	1 [Ref]	41.3 (38.3–44.3)	1 [Ref]
Public only	33.9 (32.2–35.6)	1.1 (1.0–1.1)[e]	43.3 (39.3–47.4)	1.2 (1.0–1.3)[e]	39.9 (36.7–43.3)	1.0 (0.9–1.1)
Uninsured	16.1 (13.5–19.0)	0.5 (0.4–0.6)[e]	31.5 (21.2–44.1)	0.7 (0.5–1.1)[e]	18.3 (10.6–29.6)	0.4 (0.2–0.7)
Urban–rural residence						
Large central metro	37.5 (35.9–39.2)	1 [Ref]	44.8 (40.3–49.3)	1 [Ref]	44.2 (39.7–48.7)	1 [Ref]
Large fringe metro	35.1 (33.2–37.0)	0.9 (0.8–1.0)[e]	40.9 (36.4–45.5)	0.9 (0.8–1.0)	46.5 (41.8–51.2)	1.0 (0.9–1.2)
Medium and small metro	29.4 (27.7–31.1)	0.8 (0.7–0.8)[e]	39.6 (35.2–44.1)	0.9 (0.7–1.0)	37.3 (34.0–40.7)	0.8 (0.7–0.9)[e]
Nonmetropolitan	22.8 (20.3–25.5)	0.6 (0.5–0.6)[e]	25.8 (20.8–31.5)	0.6 (0.4–0.7)[e]	28.6 (23.8–33.9)	0.6 (0.5–0.8)[e]
US Census region						
West	40.1 (37.8–42.4)	1 [Ref]	50.0 (44.7–55.4)	1 [Ref]	45.5 (40.0–51.1)	1 [Ref]
Northeast	36.5 (34.5–38.6)	0.9 (0.8–1.0)[e]	38.5 (33.6–43.7)	0.8 (0.6–0.9)[e]	44.5 (38.9–50.3)	1.0 (0.8–1.2)
Midwest	27.9 (26.0–30.0)	0.7 (0.6–0.7)[e]	34.8 (29.8–40.2)	0.7 (0.6–0.8)[e]	39.5 (35.5–43.6)	0.8 (0.7–1.0)[e]
South	28.3 (26.7–29.9)	0.7 (0.6–0.8)[e]	35.1 (31.4–39.0)	0.7 (0.6–0.8)[e]	35.5 (32.2–39.0)	0.8 (0.7–0.9)[e]

Abbreviations: aPR, adjusted prevalence ratio; FPL, federal poverty level; GED, general educational development certificate; NA, not available.
[a] Sample sizes (n) are unweighted. Prevalence (%) and associated 95% CIs are weighted and crude. Adjusted prevalence ratios (aPR) were estimated using predictive marginal proportions from logistic regression models controlling for age, sex, and race and ethnicity.
[b] Telemedicine use in the past 12 months was based on a positive response to the survey question, "In the past 12 months, have you had an appointment with a doctor, nurse, or other health professional by video or by phone?"
[c] Restricted to adults who reported seeing a doctor or health professional about their health in the past 12 months.
[d] Diagnosed prediabetes was based on a positive response to the survey question, "Has a doctor or other health professional ever told you that you had prediabetes or borderline diabetes?" and a negative response to the survey question, "Has a doctor or other health professional ever told you that you had diabetes?" Diagnosed diabetes was based on a positive response to the survey question, "Has a doctor or other health professional ever told you that you had diabetes?" irrespective of a prediabetes diagnosis. Adults who responded no to both survey questions were considered to have no prediabetes or diabetes diagnosis. Adults missing complete prediabetes and diabetes diagnosis information were excluded.
[e] $P < .05$.
[f] "Other" category is composed of people who identified as non-Hispanic Asian, non-Hispanic American Indian Alaska Native, other single race, or multiple races.
[g] Family income was imputed when missing. Family income was reported as a percentage of the FPL based on annual weighted average thresholds published by the US Census Bureau.
[h] "Private" is adults who reported having any private insurance plan. "Public only" is adults who did not have any private coverage but who reported being covered under Medicaid, Medicare, a state-sponsored health plan, other government program, or military coverage. "Uninsured" is adults who did not report being covered under private health insurance, Medicare, Medicaid, a state-sponsored health plan, other government program, or military coverage.

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ESSAY

Breaking Barriers: CDC and American Diabetes Association Unite to Combat Diabetes

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PEER REVIEWED

Diabetes is one of the most serious health problems our country has ever faced, ranking as the eighth leading cause of death in the US (1). More than 38 million adults have diabetes, and 98 million have prediabetes (2). Medical costs for people with diabetes are double the costs for those without — in fact, diabetes is the most expensive chronic condition, with health care costs and lost work and wages totaling $413 billion a year (2). Differences in the occurrence of diabetes and its related complications depend on factors such as income, geographic location, education level, race, and ethnicity (1). To tackle these disparities, it may be essential to have a clear understanding of the social determinants of health (SDOH) that lead to them. SDOH are nonmedical factors that significantly influence health outcomes (3), including access to quality health care, stable housing conditions, safe neighborhoods, built environment features that facilitate healthy eating and physical activity, and economic stability factors such as employment and educational opportunities (4).

The toll of diabetes on our country is significant (1,2). Combatting the effects may require a comprehensive, multilayered approach encompassing leadership, research, prevention, management programs, and policies at all levels of the socio-ecological strata — individual, interpersonal, community, and society. The Centers for Disease Control and Prevention (CDC) has collaborated with the American Diabetes Association (ADA) and other national partners, federal agencies, state and local health departments, health care providers, and community organizations to address the devastating impact diabetes has on the nation (2).

For nearly 50 years, CDC's Division of Diabetes Translation (DDT) has been at the forefront of the fight against diabetes (5). To begin reversing the epidemic, CDC aims at a 1% reduction in incidence per year by the end of 2030 (6). CDC provides funding to support individual-level efforts to prevent or delay the development of type 2 diabetes among at-risk individuals and population-wide approaches to address SDOH. CDC also tracks progress toward meeting established national goals and objectives (including Healthy People 2030) and informs policy and program development.

ADA aims to stem the rise in new cases of diabetes while ensuring a reduction of diabetes complications (7). Each year, ADA identifies research priorities for investment that align with these overall goals. The yearly publication of the *ADA Standards of Care* provides clinical guidelines for preventing and treating diabetes (7). These standards are the foundation for efforts to aid professionals and people with diabetes in moving from knowledge to action. They include recommendations that clinicians should assess for SDOH or nonmedical health-related needs to inform treatment decisions. This is augmented by continuing education courses in the ADA Institute of Learning, which provides training programs for diverse learners. Guidelines are then disseminated and implemented through quality improvement projects and science-based interventions (7,8).

This commentary discusses efforts by CDC and ADA to address the upstream factors that exacerbate the incidence and complication rates of diabetes. Specific focus is on the "upstream," "midstream," and "downstream" approaches that are being taken to tackle this issue (Table) (38). Attention is also given to the potential areas of opportunity that could be leveraged to enhance public health strategies aimed at mitigating the health and economic consequences of diabetes.

Upstream Socio-Contextual Factors and Approaches

Where a person lives, works, learns, worships, and plays can significantly affect their health (39). The upstream SDOH influencing diabetes incidence and prevalence impact chronic disease overall: access to nutritious, affordable foods (40,41), opportunities to exercise and live in safe environments (42), access to quality health care (43,44), and structures and policies that support equity (38). For example, type 2 diabetes prevention and management are challenging when people must travel long distances to see a health care professional (45); cannot afford medications and technology, such as continuous glucose monitoring devices and automatized insulin delivery (16,17); or have limited access to healthy food (46,47) and safe places to engage in physical activity (17,48,49).

Congress charged the National Clinical Care Commission (NCCC) to make recommendations to leverage federal policies and programs to improve diabetes outcomes (50). A fundamental recommendation is that health equity should be integrated into all federal policies and programs that affect people at risk for or with diabetes (51). Additional recommendations focus on lifestyle change programs and medications that have the greatest likelihood of preventing diabetes in those who are at high risk for type 2 diabetes, specifically people with prediabetes, and on access to, participation in, and sustainability of these interventions (52). Simultaneously, to address the disparity in available resources for people with diabetes, recommendations include providing insurance coverage for high-value treatments and creating a quality measure that improves patient safety by reducing the intensity of treatment of high-risk patients (50).

Policies, systems, and environmental change strategies can substantially affect health outcomes at a population level (53,54). When implemented with a health equity lens, the effectiveness of these approaches can be transformative for all populations. These upstream interventions tend to be complex to institute and often take significant time and resources (17). CDC and ADA both lead programs and initiatives that deploy upstream strategies to increase access to nutritious foods, access to quality health care, services for diabetes prevention and management, and opportunities to exercise in safe environments (Table). The efforts outlined in the table are in largely formative and early implementation stages. These efforts are closely aligned with core CDC and ADA missions, which in turn contribute to fulfilling the reporting requirements stipulated by the Government Performance and Results Act (55).

A systematic approach was used to identify the selected initiatives. CDC/DDT conducted comprehensive external landscape and internal factors analyses to identify forces influencing diabetes management and prevention and develop a 5-year strategic plan (56). Key performance indicators play a crucial role in tracking progress toward goals and intended outcomes, ensuring accountability and effectiveness (55). Programs and initiatives, such as the partnership between CDC/DDT and ADA aimed at enhancing access to community–clinical linkage programs, incorporate capacity-building and evaluation components supported by established performance measures that meet CDC/DDT grant deliverables (57–59). ADA also evaluates each specific ADA program. The established evaluation plan includes short-, intermediate-, and long-term evaluation components that allow teams to scale high-impact efforts based on lessons learned. Qualitative and quantitative metrics align with key inputs and are collaboratively designed to measure progress toward long-term goals. An evaluation team meets every 2 weeks to monitor performance for continuous improvement.

Midstream Approaches to Individual-Level Type 2 Diabetes Prevention

Midstream interventions — geared toward people at high risk for type 2 diabetes — could also be advanced. Primary prevention of type 2 diabetes begins with awareness and continues through behavior change among those at risk. CDC and ADA worked with the Ad Council in 2016 to launch a national campaign to raise awareness of prediabetes (52). CDC continues to lead the *Do I Have Prediabetes?* campaign to date. Research shows that once a person is aware that they have prediabetes, they are more likely to make healthy lifestyle changes to prevent or delay type 2 diabetes (52).

CDC's National Diabetes Prevention Program (National DPP) is a partnership of public and private organizations working to build a nationwide delivery system for a lifestyle change program proven to prevent or delay onset of type 2 diabetes in adults at high risk. CDC aims to increase the availability of quality programs, uptake from at-risk populations, referrals from health care providers, and coverage by public and private payers as well as by employers. Since April 2018, the National DPP lifestyle change program has been a covered preventive service for eligible Medicare beneficiaries under the Medicare Diabetes Prevention Program (MDPP). ADA, in collaboration with CDC, has been actively working on enhancing the infrastructure to support the widespread expansion of the National DPP and MDPP.

Downstream Approaches to Diabetes Management and Prevention of Diabetes-Related Complications

Varied downstream approaches may also be necessary to improve the care of people with diabetes and to prevent and manage complications. Diabetes is frequently associated with macrovascular (eg, heart disease, stroke) and microvascular (eg, retinopathy, nephropathy, neuropathy) complications, lower-extremity amputations, and acute events such as diabetic ketoacidosis. Despite new treatments and technologies for people with diabetes, many of these outcomes have not substantially improved (eg, lower-limb amputation rates). For example, between 2000 and 2018, the percentage of diabetes-related hospitalizations out of all hospitalizations in the US increased from 17.1% to 27.3% (60). Hospitalizations are more prevalent among certain demographic groups (eg, low income), suggesting the differential distribution of diabetes-related complications or inequalities in health care access and usage. As patients with diabetes live longer, the burden of complications and consequent hospitalization rates are expected to increase (2).

Both CDC and ADA are leading multilevel initiatives to address health care and educational needs of individuals with diabetes to better manage their disease and prevent complications. Through diabetes self-management education and support (DSMES) services, people with diabetes learn and develop new skills in monitoring blood glucose, healthy eating, physical activity, coping, medication adherence, risk reduction, and problem-solving. While DSMES services are effective in preventing or delaying diabetes complications, fewer than 7% of people participate within the first year of their diabetes diagnosis (61). CDC and ADA (a national accrediting organization for DSMES) are working with partners and providers to increase the referrals to these programs and help people access culturally and linguistically appropriate services.

Looking to the Future

Our organizations are united in the long-term goal of seeing a world free from the devastation of diabetes. However, that can only happen when we work together across all sectors to eliminate disparities and address obstacles that keep people from taking those critical first steps to prevent or manage their diabetes. To meaningfully address the complexities at all levels — upstream, midstream, and downstream — strategies that include policy, systems, and environmental change can be essential. Such strategies may include the following:

- Evidence-based interventions that support the prevention of type 2 diabetes and help people with diabetes to live well.
- Activities such as 1) expanding the role of pharmacies and team-based care approaches, including less traditional providers (eg, pharmacists, dentists and dental hygienists, behavioral health and community health workers [CHWs]) as part of the team in delivery of DSMES and the National DPP lifestyle intervention program; 2) innovative service delivery and payment models; 3) infrastructure to support these providers; 4) two-way information exchange between health care and community-based organizations; and 5) partnerships with AARP and Centers for Medicare and Medicaid Services to increase enrollment and retention for the MDPP.
- Environmental change strategies that ensure that all people in the US, regardless of life circumstances, have access to healthy food and the ability to be physically active.

We recognize that significant challenges face us as we forge ahead with these strategies. However, we remain optimistic. The evidence shows that there are strategies that can successfully address these challenges (17). We are committed to bringing together partners from governmental and private sectors, public health, and clinical medicine, along with engaged individuals, in a united effort to reduce the risk for type 2 diabetes and to provide those living with diabetes the support they need to manage the disease and live well. Through public health leadership, partnership, research, programs, and policies that translate science into practice, CDC and the ADA are united in achieving our mission to reduce the preventable burden of type 2 diabetes in the US.

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Table

Table. Upstream, Midstream, and Downstream Approaches the Centers for Disease Control and Prevention's (CDC's) Division of Diabetes Translation (DDT) and the American Diabetes Association (ADA) Are Leading to Address the Socio-Contextual Factors That Exacerbate the Incidence and Complication Rates of Diabetes

Approach and organization	Activities
Upstream — population-level activities addressing social determinants of health (SDOH)	
CDC/DDT	• Increase access to food programs as part of the National Diabetes Prevention Program (National DPP) lifestyle change program (9). • Enhance access to community–clinical linkage programs by developing multidirectional e-referral systems that support the electronic exchange of information between health care and community-based organizations (10). • Improve the capacity of the diabetes workforce to address factors related to SDOH that affect outcomes for priority populations with and at risk for diabetes (10). • Implement through the Simulation Model of Interventions Linking Evidence to SDOH (SMILES) Simulation Project various interventions, policies, and strategies that effectively reduce inequities in chronic outcomes (11). • Develop a portfolio of evidence-based change strategies through a knowledge to practice project aimed to address policy and systems-level approaches, including early diagnosis, immediate linkage to care, retention in care, and improved clinical outcomes.[a]
ADA	• Advocate for access to healthy food (12). • Expand accessible treatments and technology (13). • Train and expand use of community health workers to help address SDOH barriers (14,15). • Fund research and implement health equity initiatives (16). • Empower communities and people living with diabetes with information on healthy lifestyles (17). • Scale innovative community engagements (18).
Midstream — individual-level type 2 diabetes prevention activities	
CDC/DDT	• Raise awareness of prediabetes and risk for type 2 diabetes through the nationwide campaign, "Do I Have Prediabetes?" The campaign aims to help people take steps to prevent or delay type 2 diabetes by taking the 1-minute prediabetes risk test and knowing their risk (19). • Increase enrollment and retention of priority populations in the National DPP and Medicare Diabetes Prevention Program lifestyle interventions (10). • Work with partners to expand access to the National DPP lifestyle intervention as a covered health benefit (10). • Build capacity for National DPP program suppliers to bill via umbrella hub arrangements. • Address childhood obesity and diabetes risk reduction by expanding access to family healthy weight programs (10). • Develop an open research agenda through the Lifestyle Change Implementation Research Network to improve the equity of enrollment and retention in lifestyle change interventions.[a]
ADA	• Expand diagnosis and treatment of obesity and prediabetes (18). • Work to improve access to diabetes anti-obesity medications (13). • Fund research to identify long-term approaches to healthier lifestyles (20).
Downstream — management and care for people with diabetes; prevention of diabetes-related complications	
CDC/DDT	• Fund programs to increase access to nutritious food for people with, or at risk for, diabetes, heart disease, obesity, cancer, and kidney failure (eg, Food is Medicine) (9,21). • Strengthen self-care practices by improving access and participation in diabetes self-management education and support (DSMES) services (10). • Develop an integrated DSMES data system to support coordination of programs across the country.[a] • Prevent diabetes complications for priority populations through early detection of chronic kidney disease and diabetic retinopathy (10). • Improve quality of care for priority populations with diabetes, including • Increasing adoption or enhancement of team-based care for people with diabetes supported by sustainable payment models (22–24). • Increasing adoption and use of clinical systems and care practices (eg, health information technology and electronic health records, clinical decision-support tools, learning collaboratives) (25–28). • Build and strengthen a sustainable infrastructure for community health workers to expand their involvement in evidence-based diabetes management programs and services (10,15). • Conduct surveillance and publish CDC's National Diabetes Statistics Report (1).

[a] These activities are in the early stages of program development. Public access is forthcoming.

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Table. Upstream, Midstream, and Downstream Approaches the Centers for Disease Control and Prevention's (CDC's) Division of Diabetes Translation (DDT) and the American Diabetes Association (ADA) Are Leading to Address the Socio-Contextual Factors That Exacerbate the Incidence and Complication Rates of Diabetes

Approach and organization	Activities
	• Support health-related social needs screening in prevention and management (10). • Increase participation of Black or African American persons with diabetes in DSMES programs through demonstration projects such as Communities United Together to Manage Diabetes (CUT2MD) and Communities United Together for Health (CUT4Health), which integrate barbers and stylists as trusted community members in interventions (29,30).
ADA	• Provide authoritative guidance on therapeutic diabetes education worldwide through the diabetes Education Recognition Programs (ERP), ensuring broad adoption of the standards of DSMES services (31). • Provide support to over 3,700 sites, serving around 800,000 people with diabetes per year with the latest innovations delivered via ERP (31). • Provide support to ensure the latest innovations were adopted (31,32). • Increase access to DSMES in areas with high prevalence of diabetes (31,33). • Increase referrals to DSMES by providers and expand services in primary care (34,35). • Expand the availability of the ADA-recognized DSMES services as a covered health benefit for Medicaid beneficiaries (34,35). • Use DSMES data to develop training and technical assistance to improve outcomes.[a] • Increase access to continuous glucose monitoring for those at highest risk for diabetes-related complications (32). • Develop and implement a health professional education campaign (through the ADA Institute for Learning) to screen, treat, and refer patients with diabetes for diabetes-related complications and for SDOH needs (36). • Publish the annual Standards of Care and the Abridged Standards of Care, which target primary care professionals, to be more interactive and easily digestible for busy health care professionals (7). • Fund translational research that emphasizes interventions to reduce inequities (20). • Publish latest research on addressing health disparities (20). • Advocate for federal law that gives students the right to receive the diabetes care they need to be safe and participate in school activities just like any other child. Help families receive equal access to care through the Safe at School program (37). • Engage community health workers through the establishment of learning opportunities in diabetes and prediabetes through the ADA Institute of Learning and in community settings. Highlight the value of community health workers in the Standards of Care, to provide the evidence base that is leading to reimbursement for their services (14,15,36).

[a] These activities are in the early stages of program development. Public access is forthcoming.

PCD

PREVENTING CHRONIC DISEASE