



Current Perspectives on the Impact of the National Diabetes Prevention Program: Building on Successes and Overcoming Challenges

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Abstract: To address the public health and economic burden of type 2 diabetes, the Centers for Disease Control and Prevention (CDC) began dissemination of the National Diabetes Prevention Program (NDPP) in the United States in 2010. Based on the intensive lifestyle intervention from a large efficacy trial, the NDPP aims to reduce incidence through lifestyle change and weight loss. This narrative review summarizes evidence on reach, effectiveness, and sustainability of the NDPP, while highlighting opportunities to overcome challenges in these areas. Major successes include reaching hundreds of thousands of at-risk individuals across the nation, with notable effectiveness upon full participation and widespread insurance coverage. Yet, more work is needed to ensure greater public health impact, particularly among priority populations at heightened risk who also experience disparities in program outcomes. Preliminary evidence suggests a number of strategies may improve reach and effectiveness of the NDPP, often with more rigorous study needed prior to widespread uptake. Updating the NDPP to better match the current evidence-base may also be important, such as directly targeting glycemia with a patient-centered approach and promoting metformin as an adjunct or second-line treatment. Finally, revisiting pay-for-performance reimbursement models may be critical to sustainability by ensuring adequate availability of suppliers and ultimately reducing diabetes prevalence.

Keywords: obesity, type 2 diabetes mellitus, prediabetes, lifestyle modification, prevention

Introduction

Diabetes affects 13% of adults in the US,¹ imposing major public health and economic burdens. Another 34.5% of US adults are estimated to have prediabetes,¹ or elevated blood glucose that may progress to type 2 diabetes without intervention. The National Diabetes Prevention Program (NDPP) is an evidence-based intervention to prevent diabetes in at-risk populations in the US that has been disseminated nationwide since 2010 under Centers for Disease Control and Prevention (CDC) leadership,² with the first participants served in 2012.³ The NDPP is a translation of the intensive lifestyle intervention from the Diabetes Prevention Program (DPP) trial, which demonstrated a 58% reduction in incidence over 3 years,⁴ with benefits persisting up to 15 years.^{5,6} Using a lower-cost scalable model, the NDPP promotes $\geq 5\%$ weight loss over one year via in-person classes, distance learning, online programming, or a combination of modalities. Participants may include overweight/obese adults with prediabetes or other risk factors such as past gestational diabetes. This narrative review examines the current impact of NDPP dissemination in the US based on recent literature and reports, including successes

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as well as opportunities to overcome challenges regarding reach, effectiveness, and sustainability.

Reach

Successes with Reach

The NDPP has achieved impressive scaling with over 1,500 sites as of 2020, per the CDC's registry of organizations participating in their Diabetes Prevention and Recognition Program (DPRP) that monitors fidelity and quality.^{7,8} This reflects an exceptional degree of adoption for a prevention program that transitioned from a clinical trial to translation into communities.⁹ There are currently NDPP sites in all 50 US states, the District of Columbia, and most US territories.⁷ Sites include community-based organizations, healthcare clinics and systems, pharmacies, health plans, public health and other governmental institutions, universities, and private wellness companies,⁷ uniquely providing a variety of settings in which to access the program. In turn, population reach has been fast increasing from about 35,000 eligible participants served as of 2016³ to over 324,000 by early 2019.¹⁰ Whereas the inherently limited capacity of in-person sites might cap potential growth, online and distance learning models have also been approved by the CDC since 2015 and 2018, respectively,¹⁰ with more limitless potential to expand reach. Indeed, despite fewer online than in-person NDPP suppliers⁷ and later approval for dissemination, online delivery exceeds the reach of in-person programs.¹⁰ Such virtual delivery can also ensure wide geographic reach to fill the many gaps where in-person sites are unavailable.^{11,12}

Overcoming Challenges with Reach

Increasing Awareness of Diabetes Risks

As 88 million US adults are estimated to have prediabetes,¹ reach to hundreds of thousands of at-risk persons with the NDPP is highly commendable, but not yet scaled for population health impact. An upstream issue is that few adults with prediabetes are aware of their condition (15.3%),¹ although it is encouraging that risk awareness has been increasing over time. Self-reports of perceived risk for diabetes due to a variety of factors increased from 30% in 2011 to 45% in 2016.¹³ Moreover, when individuals become aware of having prediabetes, they are likely to take preventative action as 71% report efforts to reduce the likelihood of diabetes onset.¹³ Media campaigns are a common approach to increase widespread risk awareness and promote the NDPP (i.e., 90.2% of NDPP sites reported use of mass media as a recruitment strategy),¹⁴ yet resulting uptake appears limited,¹⁵ and cost-effectiveness

is unclear. Increasing awareness and reach of the NDPP through systematic screening and referrals has arisen as a more promising scalable strategy.

Increasing Provider Referrals to the NDPP

A large study led by the American Medical Association found 56% enrollment upon point-of-care referrals to the NDPP and 11% enrollment using a retrospective, algorithm-based approach to referrals.¹⁶ These results are fully consistent with the first known study of NDPP uptake with provider referrals.¹⁷ Despite the comparably low rate of engagement upon algorithmic referrals, the potential to automate this approach is important for scalability, as well as reducing provider burden to meet US Preventive Services Task Force recommendations to refer at-risk individuals to intensive lifestyle interventions.^{18,19} Relatively few point-of-care referrals to the NDPP are made currently.¹⁶ First, many providers are unaware of the NDPP as a resource for their patients. A 2016 survey of over 1,200 primary care providers found that only 38% were aware of the NDPP, and fewer (23%) had referred patients to the program.²⁰ To address this issue, NDPP sites can proactively seek to establish referral networks with providers. Indeed, the majority of NDPP sites participating in a recent CDC-led evaluation (70.1%) were found to use provider referrals for recruitment,¹⁴ and there are ongoing efforts to support systematic linkages between clinical providers and community-based NDPPs (e.g., a study funded by the Agency for Healthcare Research and Quality; R18HS026172).

Addressing Disparities in Reach

A challenge is that men and younger individuals are under-represented in the NDPP, and additional participation gaps exist for priority populations. In a 2019 CDC report, only 24.7% of NDPP participants were men,¹⁰ despite their higher prevalence of prediabetes compared to women (37.4% vs. 29.2%).¹ There may also be a missed opportunity for lifelong diabetes prevention among the 28.7 million US adults under age 45 with prediabetes,¹ as the average age of participants is 55.1.³ Another challenge is high initial "no shows" among enrollees overall (25–60%),^{21–23} which appear higher yet for racial/ethnic minority, low-income, and younger participants. Specifically, Latino enrollees were half as likely to initially attend as compared to non-Hispanic white enrollees,²¹ and women <40 years were about a quarter as likely to attend as their older counterparts (men were not included in this study).²² Other data suggest lower show rates for Medicaid beneficiaries (69.6%) versus enrollees with other types of

insurance (77.7%; no p-value reported).²³ Low intervention uptake in these groups is likely related to previously identified factors including social support, transportation/costs, beliefs about illness and lifestyle change,²⁴ as well as social and economic disadvantages.²⁵ To increase reach, encouraging enrollment alongside a partner or family member may be beneficial, as likelihood of initial attendance was three-fold greater than with individual enrollment, which especially benefited men and Latinos (indicating potential to address their reach gaps).²⁶ Qualitative studies have further suggested strategies including more education and motivational interventions at referral and/or enrollment, providing childcare and transportation, offering classes solely for similar target populations, and using a more flexible and interactive class format.^{27,28} In turn, more empirical work is needed to fully demonstrate the potential benefits of these and other strategies.

Effectiveness

Successes with Effective Implementation

The NDPP was closely based on successes demonstrated with the lifestyle arm of the DPP clinical trial, in which participants achieved 4.9% mean weight loss by the end of intervention through low-fat diet and increased physical activity.²⁹ The NDPP similarly promotes $\geq 5\%$ weight loss through lifestyle change to reduce risk.³⁰ Reports show a promising 4.2% mean weight loss for in-person NDPP classes³ and 4.3% weight loss for virtual programs.³¹ These are impressive outcomes given delivery to the general population of adults with diabetes risks, in contrast to extensive eligibility criteria in the original DPP trial, including completion of a 3-week run-in to ensure compliance.³² Although incident type 2 diabetes has not yet been systematically examined as a program outcome, it is nonetheless encouraging that each kilogram of weight loss was associated with 16% decreased incidence among lifestyle intervention participants in the DPP trial,³³ suggesting considerable benefit is likely.

Additional successes with NDPP implementation include evidence that adults age 65 and older have remarkable weight loss (e.g., 6.4% median weight loss after ≥ 6 months in the program³), consistent with the exceptional benefit observed for seniors in the DPP's lifestyle arm,⁴ and important given high age-related risks.¹ Further, while the DPP trial required elevated blood glucose at enrollment,³² individuals who qualify for the NDPP

based on broader definitions of risk appear to have positive outcomes. Specifically, no significant differences in weight loss were observed for participating women with and without a history of gestational diabetes,³⁴ or for participants who qualified based on a risk survey versus confirmed prediabetes and/or prior gestational diabetes.³ Moreover, the original DPP trial largely excluded women in their childbearing years,³² yet early evidence suggests that participating women who become pregnant appear to have favorable obstetric and neonatal outcomes.³⁵ Together, these findings suggest that the NDPP's broad eligibility criteria enable many individuals to benefit from intervention, and might even be leveraged to break the transgenerational disease cycle.³⁶

Overcoming Challenges with Effective Implementation

Improving Outcomes for All

Nearly three-quarters of participants (71.7%) do not achieve the $\geq 5\%$ weight loss goal according to a CDC report.¹⁰ Of further concern, disparately low weight loss is observed for women, younger adults, and racial/ethnic minority and low-income participants, who lose about half as much weight as their counterparts.^{3,21,37} Improving retention appears key overall to ensuring beneficial weight loss outcomes (e.g., each session attended is associated with 0.3% more weight loss).³ Yet median attendance is only 134 days, such that most participants complete less than half of the yearlong program.³⁸ In many cases, greater attendance mitigates, or at least attenuates, weight loss disparities.^{10,21,22} Improved retention has been observed with a variety of implementation strategies, including delivering a motivational session before the NDPP begins (+100 days for "pre-session" attendees), attending with a partner (+35 days), provider referrals (+34 days), special population tailoring (e.g., culture- and gender-specific adaptations; +30 days), and non-monetary incentives (e.g., gym memberships; +28 days).^{14,26} Evidence for monetary incentives is mixed with no greater retention observed in a report comparing site-level strategies,¹⁴ while increased attendance was found specifically among Medicaid beneficiaries in another study, but without greater weight loss.³⁹ Overall, it remains important to consider feasibility, cost, and utility of these strategies for specific settings and populations.

In addition to increasing reach, virtually-delivered programming also has potential to address barriers to

retention given findings that 61% of enrollees anticipated challenges attending in-person classes due to other responsibilities (e.g., work, school, dependent care) and 30% anticipated challenges with transportation.⁴⁰ Yet, despite high rates of early engagement in online NDPPs, only 19% of participants attended for ≥ 9 months, and patterns of disparate weight loss outcomes among subgroups remained a concern.⁴¹ Thus, online delivery alone does not appear to resolve effectiveness challenges. Low retention rates in both in-person and online NDPPs likely affect reported outcomes, as data are typically examined for only those who attend a minimum number of sessions or have a minimum number of recorded weights, which often varies from one report to another (particularly as CDC standards for evaluating NDPP outcomes have been revised over time).^{3,10} Supplementing online interventions with in-person coaching was shown to improve weight loss (mean = 4.6%).³¹ A less resource-intensive approach of supplemental text message support did not improve retention or weight loss in the in-person NDPP.⁴² Reducing the intervention to delivery via short text messages demonstrated high retention but also was insufficiently effective.⁴³ Overall, further research appears needed, including to examine what specific virtual components are beneficial, and to what extent additional in-person or other “real” interaction with a lifestyle coach may yield optimal results. As of 2019, less than 1% of participants receive combined in-person and virtual delivery approaches,¹⁰ which may be an important area for future growth.

Opportunities to Modernize the NDPP

While achieving all lifestyle goals was associated with the greatest risk reduction in the DPP, few (17%) were able to do so.³³ Evidence continues to confirm the majority of participants are unable to achieve the recommended lifestyle goals of the NDPP.¹⁰ Thus, an opportunity for improvement is updating the NDPP to ensure generalizability, while incorporating more current evidence. Otherwise, there is tremendous risk of many participants being “set up to fail,” which may contribute to learned helplessness⁴⁴ and dissuade future behavior change attempts. Dietary guidance merits reconsideration as achieving $\leq 25\%$ of calories from fat appeared to be the least protective DPP goal. For example, achieving the low-fat dietary goal, on top of physical activity and weight loss goals, appeared to add minimal or even reduced benefit in terms of resulting diabetes incidence.³³ Although the

newest CDC-published curriculum (Prevent T2)⁴⁵ relaxes the dietary goal to $\leq 30\%$ of calories from fat without required dietary monitoring, the NDPP continues to promote a low-fat diet that nutrition science has generally evolved away from.⁴⁶ Newer evidence suggests that various eating plans reduce risk and individualization is needed.⁴⁷ An inflexible physical activity goal may also inadvertently deter retention, as NDPP participants were 25% less likely to return after not meeting the current goal of ≥ 150 weekly minutes in a prior session.⁴⁸ Weight loss was the most protective goal in the DPP lifestyle intervention,³³ but regain begins even during intervention,⁴⁹ and much is regained over time,^{5,6} which is likely problematic. Moreover, despite aiming to prevent diabetes, glycemia is minimally addressed in CDC-published NDPP curricula.⁴⁵

Incorporating a Health at Every Size (HAES) approach⁵⁰ may allow a more flexible focus on long-term risk reduction (i.e., lowered glycemia) over temporary weight loss, with guidance on intuitive eating (i.e., eating in response to internal cues without a prescribed diet) and reframing physical activity as a tool for well-being. HAES-aligned interventions have shown better retention than traditional weight loss interventions,⁵¹ which may have important implications for the NDPP. This approach would also likely benefit participants with binge eating behavior,⁵² reported by nearly 10% of the DPP sample.⁵³ Adding quarterly monitoring of glycated hemoglobin (A1C) using point-of-care instruments⁵⁴ could enable sites to meaningfully incorporate glycemia testing into their NDPP delivery, or participants could seek laboratory testing. At least annual testing is recommended to detect diabetes onset among individuals with prediabetes,⁵⁵ which would help evaluate the NDPP, although more frequent testing could be used for biofeedback during the yearlong program. Continuous glucose monitoring could also be considered as a newer technology to inform risk reduction behavior, but is relatively costly,⁵⁶ and not likely covered by insurance for this purpose. Additionally, there is substantial evidence for metformin to reduce risk, including as an adjunct treatment to lifestyle intervention, yet it is infrequently adopted in real-world practice to prevent diabetes⁵⁷ and unaddressed in the current NDPP curricula.⁴⁵ Participants could be advised to discuss metformin with their providers upon joining the NDPP, which may be especially important to ensure continued treatment for the many individuals unable to complete the program. Overall, encouraging participants to adopt a range of

preferred behaviors and treatment strategies that lower glycemia on an individual basis may be more beneficial, patient-centered, and better align with precision medicine initiatives⁵⁸ than a one-size-fits-all approach.

Sustainability

Successes with Payer Coverage

Long-term sustainability of the NDPP is likely dependent on payer coverage as initial dissemination appears largely supported by time-limited grant funding. Payer coverage was established as an early priority and has required a remarkable collaboration of government, academic, community, health-care, and payer sectors.⁹ For example, United Health Group was collaborating by 2009 to demonstrate payer involvement with an early translation of the NDPP in community settings of the Young Men's Christian Association.⁵⁹ Subsequently, nearly 50 insurers began to cover NDPP services by 2016.¹⁴ Notably, Medicare coverage began in April 2018,⁶⁰ offering

unprecedented opportunity to prevent diabetes among the estimated 46.6% of seniors with prediabetes.¹ The adapted Medicare-covered model, the Medicare Diabetes Prevention Program (MDPP), is near-identical to the in-person NDPP. Additionally, the MDPP provides a second year of services beyond the one-year NDPP model disseminated by the CDC, offering an enhanced opportunity to support weight loss maintenance.^{60,61} In turn, Medicare coverage has tremendous potential to further bolster private payer coverage by setting industry standards, and ensure expanded Medicaid coverage that has become available for 11 states as of January 2020).⁶² A common feature of these coverage models is requiring adherence to CDC-established standards for NDPP delivery.^{60,62}

Ensuring payer coverage is facilitated by strong return on investment (ROI) findings. Early projections suggested that providing the NDPP could yield 5.7 billion USD in savings over 25 years.⁶³ More current estimates of future healthcare

Table 1 Overview of Suggested Strategies to Build on Successes and Overcome Challenges to Impact of the National Diabetes Prevention Program

	Current Challenges	Potential Solutions
Reach	<ul style="list-style-type: none"> • Not yet at reach level needed for population health impact • Men and younger adults are under-represented, plus more initial no-shows for low-income, racial/ethnic minority and younger participants 	<ul style="list-style-type: none"> • Adopt automated, algorithmic referral approach linking clinical providers and NDPP services • Make program more appealing, personally relevant, and convenient
Effectiveness	<ul style="list-style-type: none"> • Three-quarters of participants do not achieve $\geq 5\%$ weight loss goal • Disparately low weight loss for women, younger adults, and racial/ethnic minority and low-income participants • One-size-fits-all approach to intervention is ineffective for majority of participants • Weight regain begins during intervention and much is all is regained over time • Risk of participants being "set up to fail" may dissuade future behavior change • Effectiveness in terms of glycemia and incident diabetes is largely unknown 	<ul style="list-style-type: none"> • Improving retention appears key overall and may be accomplished with a variety of targeted implementation strategies • Further research to examine what specific virtual delivery and hybrid models are optimal • Individualization to align with newer evidence and precision medicine initiatives • Incorporate Health at Every Size approach to focus on long-term risk reduction (i.e., lowered glycemia) over temporary weight loss • Consider recommending metformin as an adjunct or second-line treatment • Add testing to evaluate glycemia and incident diabetes outcomes, and provide biofeedback to inform participant behavior
Sustainability	<ul style="list-style-type: none"> • Pay-for-performance rates are below costs, especially for in-person delivery • A concerning trend that half of previous NDPP sites have extinguished services, likely after grant-funding has ended • Insufficient reimbursement may be a deterrent to sustaining and growing access, especially in high-need areas • Low payments afford short-term benefits to payers, but missed opportunity for substantial long-term savings from reduced diabetes prevalence 	<ul style="list-style-type: none"> • Increased rates and risk-adjusted payment models appear needed • Expanded coverage of virtually-delivered programs may also help

cost savings have continued to demonstrate that the NDPP is a high-value service.^{64–66} For a commercially-insured population, 3-year ROI was up to 42% based on maximum net savings of 35,037 USD.⁶⁶ For Medicare beneficiaries, a 2017 report calculated an average reduction in Medicare Part A and B expenditures of 278 USD per quarter, or 1112 USD per member per year, over the 3 years following NDPP enrollment relative to a comparison group of beneficiaries. Cost-effectiveness has also been demonstrated in a Medicaid beneficiary population, particularly if considering a time horizon greater than 10 years.⁶⁷

Overcoming Challenges with Payer Coverage

Addressing Low Payment Rates

Pay-for-performance reimbursement rates appear insufficient relative to reported costs, limiting sustainability. For a private payer example, cost of delivering an early version of the in-person NDPP appeared to range from 275–425 USD per participant⁶⁸ with average reimbursement of 212 USD,⁵⁹ leaving a gap of 63–213 USD. With Medicare, reported delivery costs (for first-year, in-person services) were 553–800 USD with average reimbursement of only 108–190 per participant,^{69,70} resulting in a gap of 363–792 USD. Medicaid reimbursement rates tend to be comparably low, producing an especially wide gap. For example, costs for in-person NDPP delivery to Minnesota Medicaid beneficiaries was 767–915 USD per participant,⁶⁷ with estimated average reimbursement of 163 USD (based on 13.62 USD reimbursed per session⁷¹ and 12 sessions attended on average),⁶⁷ producing a large gap of 604–752 USD to suppliers for each beneficiary they serve. How or why low payment rates came to be established is unclear, especially given compelling evidence for ROI, yet they are likely detrimental to achieving a sufficient number of suppliers relative to the need. Although low reimbursement rates benefit third-party payers in the short-term,⁷² they are likely to miss opportunity for substantial long-term savings from reduced diabetes prevalence. More evidence also appears needed to assess the sustainability of virtual NDPP delivery. Costs for online programming are generally not reported (possibly for proprietary protections in for-profit business models), but were found to be about one-third of in-person delivery costs in one evaluation yet still produced an unsustainable gap after reimbursement of 206 USD per participant.⁷³

Addressing Limited Suppliers

Insufficient reimbursement relative to costs may be a deterrent to maintaining and growing NDPP access.

Half of suppliers who previously offered the NDPP appear to have since extinguished their services. Over 3000 organizations provided the NDPP between 2012–2019,¹⁰ whereas only half remain in 2020.⁷ Regarding Medicare suppliers, a report found relatively few locations where beneficiaries could receive services over a year after coverage began, with only 1 site per 100,000 beneficiaries on average.⁷⁴ Specifically, 75% of US states/territories had no MDPP sites, <1 site per 100,000 beneficiaries, and/or availability limited to a single municipality. Another concern is that suppliers may be dissuaded from entering markets with especially high-risk populations who are less likely to achieve performance payment milestones.^{69,75} In fact, severe shortages of MDPP sites were observed in states/territories with largest populations of racial/ethnic minority beneficiaries,⁷⁴ continuing patterns observed with NDPP availability.¹¹ While it is encouraging that MDPP suppliers since appear to be increasing,⁷⁶ the overall downward trend in NDPP sites may be further problematic. Although value-based care is important, increased rates and risk-adjusted payment models appear needed to attract more suppliers. Expanded coverage of virtually-delivered programs may also help.

Conclusion

Over the past decade, the CDC has successfully led the translation of an efficacious lifestyle intervention into a nationwide program reaching hundreds of thousands of individuals at risk for type 2 diabetes, with notable effectiveness upon full participation and widespread insurance coverage. Nonetheless, working to overcome challenges in reach, effectiveness, and sustainability of the NDPP appears needed to achieve substantial public health impact, as summarized in [Table 1](#). These challenges will likely demand continued collaboration of cross-sector stakeholders that enabled successes to date,⁹ which can be difficult given differing priorities at times.⁷² There is particular urgency to capitalize on the incredible growth of NDPP dissemination before critical momentum is lost. For example, Medicare coverage of the NDPP remains under the umbrella of the Centers for Medicare and Medicaid Services Innovation Center, and coverage may be discontinued if the model is unsuccessful. Resolving low reimbursement rates may be an especially critical factor, such that market forces can in turn drive improved reach and effectiveness. The NDPP must be withstanding in the years to come, as having enormous resources again dedicated to scaling the next promising intervention in the US is otherwise unlikely, such that NDPP is a must-

succeed effort both to prevent diabetes and forge a path for future public health initiatives.

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